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?
- Direct test: does betting on arbitrage violations shrinking earn a risk premium?
- Yes: there is a significant risk premium
  - This risk factor is correlated with other near-arbitrages and intermediary wealth
  - Exposure to this risk factor is priced in the cross-section

Model and Hypothesis

- We build an intermediary-based asset pricing model:
  - Built on He and Krishnamurthy (2011 and 2017) and Campbell (1993)
  - Intermediaries faces a regulatory constraint (which creates CIP violation)
  - CIP violation reveals shadow price (multiplier) of this constraint, and also represents investment opportunities.

- We use the model to motivate a log SDF:

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

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

How to Test It?

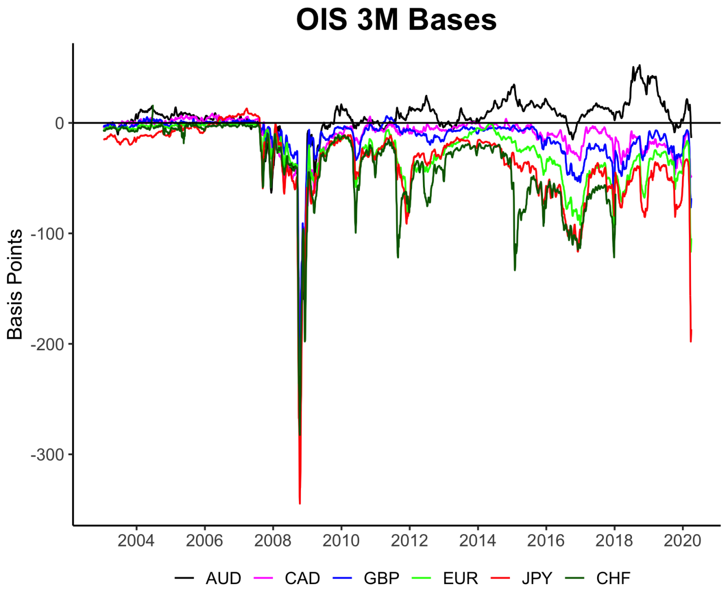
- Model implications:
  - focus on largest CIP violation (fortunately, doesn't change sign)
  - CIP should be correlated with other arbitrages/near-arbitrages
  - CIP shocks could be supply, demand, or regulation
  - CIP shocks and wealth returns likely correlated
- Test: trading strategy that bets on 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
  - Check whether this trading strategy earns a significant risk premium

Covered Interest Parity

(Log) Spot CIP Basis, currency c:

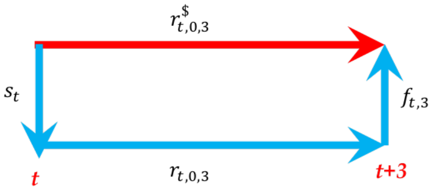
$$x_{t,0,\tau}^{c,\$} = r_{t,0,\tau}^{\$} - r_{t,0,\tau}^{c} + \frac{12}{\tau}(f_{t,\tau}^{c,\$} - s_{t}^{c,\$})$$

- $r_{t,0,\tau}, r_{t,0,\tau}^{\$}$: 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, Tepper and Verdelhan (2018))
- All FX and rate data from Bloomberg: Benchmark results use OIS rates. Robustness results use IBOR, FRA rates.
- Pre-GFC: Jan 2003-June 2007, GFC: July 2007-June 2010, Post-GFC: July 2010-Aug 2018

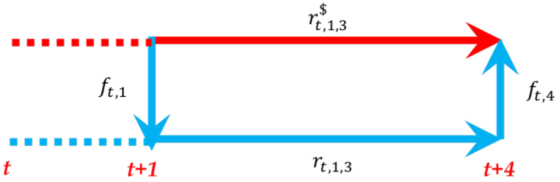

OIS 3M Bases
Basis Points
0
-100
-200
-300
2004
2006
2008
2010
2012
2014
2016
2018
2020
AUD
CAD
GBP
EUR
JPY
CHF

Spot and Forward CIP

Spot 3M basis at t: $x_{t,0,3} = r^{\$}_{t,0,3} - r_{t,0,3} - \frac{12}{3}(s_t - f_{t,3})$



1M forward 3M basis at t: $x_{t,1,3} = r^{\$}_{t,1,3} - r_{t,1,3} - \frac{12}{3}(f_{t,1} - f_{t,4})$



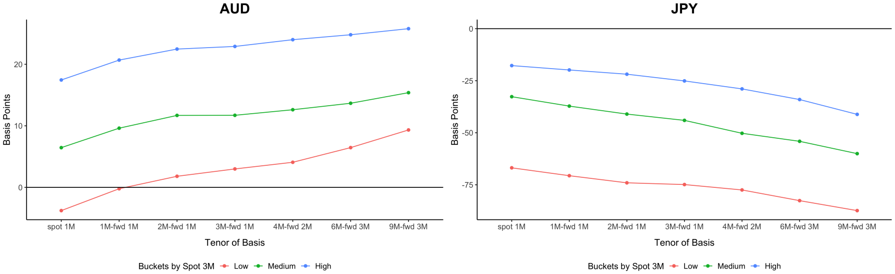
Forward Covered Interest Parity

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

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

- $r_{t,h,\tau}, r^{\$}_{t,h,\tau}$: h-month forward τ-month log rates at time t
- Note analogy to forward interest rates, term structure

Term Structure of Forward CIP



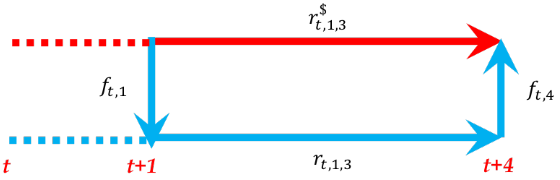
Forward CIP Trading Strategy

1. Initiate h-month forward τ-month forward CIP trade (long cash \$, short synthetic \$)
2. h-months later, unwind

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

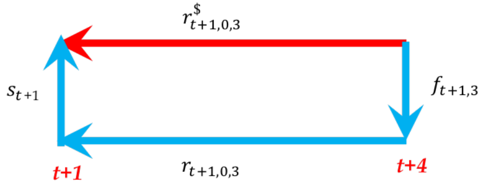
Long 1M forward 3M basis at t:

$$x_{t,1,3} = r^{\$}_{t\ 1,3} - r_{t,1,3} - \frac{12}{3}(f_{t,1} - f_{t,4})$$



Short Spot 3M basis at t+1:

$$-x_{t+1,0,3} = r_{t+1,0,3} + \frac{12}{3}(s_{t+1} - f_{t+1,3}) - r^{\$}_{t+1,0,3}$$



Monthly profit per \$1 notional on the forward CIP trading strategy at t+1:

$$\pi_{t+1,1,3} = \frac{3}{12}(x_{t,1,3} - x_{t+1,0,3})$$

Annualized profits and Sharpe ratio vs. the USD

	Mean (bps)			Sharpe Ratio		
	Pre-GFC	GFC	Post-GFC	Pre-GFC	GFC	Post-GFC
AUD_USD	1.06	3.71	4.73***	0.28	0.10	0.90**
	(0.98)	(19.41)	(1.78)	(0.27)	(0.50)	(0.37)
CAD_USD	-0.93	1.50	5.56***	-0.26	0.05	1.10***
	(1.57)	(15.50)	(1.57)	(0.44)	(0.48)	(0.32)
GBP_USD	-1.47*	9.27	4.26***	-0.48*	0.27	0.84***
	(0.77)	(16.13)	(1.67)	(0.27)	(0.42)	(0.31)
EUR_USD	-1.15*	14.29	-1.35	-0.60**	0.34	-0.17
	(0.60)	(20.07)	(2.54)	(0.30)	(0.40)	(0.33)
CHF_USD	-1.34	5.97	-3.60	-0.35	0.14	-0.25
	(0.86)	(18.14)	(4.72)	(0.26)	(0.40)	(0.36)
JPY_USD	-1.97**	8.18	-9.53***	-0.81**	0.17	-1.04***
	(0.97)	(22.78)	(3.11)	(0.39)	(0.44)	(0.33)

Properties of USD Pairs post-GFC

	Mean Fwd Trad. Ret.	Average Slope	Average Interest Diff.	Corr SPX and FX
AUD_USD	4.73	5.81	2.27	0.51
CAD_USD	5.56	5.63	0.48	0.49
GBP_USD	4.26	4.34	0.02	0.31
EUR_USD	-1.35	-1.22	-0.33	0.15
CHF_USD	-3.60	-3.69	-0.62	-0.07
JPY_USD	-9.53	-8.98	-0.37	-0.31

Top FX Pairs with Largest Spot CIP Deviations

	Mean (bps)			Sharpe Ratio		
	Pre-GFC	GFC	Post-GFC	Pre-GFC	GFC	Post-GFC
AUD_CHF	2.47**	-1.92	9.82*	0.50*	-0.06	0.64
	(1.06)	(10.49)	(5.15)	(0.26)	(0.34)	(0.40)
AUD_JPY	2.44*	-4.37	14.27***	0.61*	-0.16	1.38***
	(1.37)	(10.40)	(3.40)	(0.35)	(0.36)	(0.35)
USD_CHF	1.34	-5.97	3.60	0.35	-0.14	0.25
	(0.86)	(18.14)	(4.72)	(0.26)	(0.40)	(0.36)
CAD_CHF	1.01	-4.37	9.08**	0.20	-0.16	0.67*
	(1.78)	(8.41)	(4.39)	(0.39)	(0.29)	(0.40)
AUD_EUR	2.27***	-10.27	6.06**	0.62***	-0.41	0.68*
	(0.88)	(9.01)	(2.93)	(0.24)	(0.32)	(0.35)
USD_JPY	1.97**	-8.18	9.53***	0.81**	-0.17	1.04***
	(0.97)	(22.78)	(3.11)	(0.39)	(0.44)	(0.33)
GBP_CHF	0.16	3.17	8.16*	0.04	0.14	0.61
	(0.91)	(7.03)	(4.29)	(0.20)	(0.33)	(0.39)
CAD_JPY	-0.08	-6.66	15.01***	-0.02	-0.23	1.69***
	(1.41)	(11.11)	(2.89)	(0.37)	(0.36)	(0.35)

Portfolio Returns

	Mean (bps)			Sharpe Ratio		
	Pre-	GFC	Post-	Pre-	GFC	Post-
Classic Carry (AUD-JPY)	2.44*	-4.37	14.27***	0.61*	-0.16	1.38***
	(1.37)	(10.40)	(3.40)	(0.35)	(0.36)	(0.35)
3 Currency Carry	0.32	-4.59	9.77***	0.14	-0.24	1.28***
	(0.88)	(7.09)	(2.59)	(0.39)	(0.33)	(0.41)
Dynamic Top5 Basis	1.83***	0.18	11.36***	0.79**	0.01	1.11***
	(0.76)	(14.21)	(3.33)	(0.34)	(0.44)	(0.41)
Top 10 Basis	0.84	-5.32	9.00***	0.38	-0.21	1.06***
	(0.72)	(10.01)	(2.86)	(0.36)	(0.36)	(0.40)
Simple Dollar	-0.95	7.37	-0.06	-0.51	0.20	-0.01
	(1.09)	(18.17)	(1.86)	(0.56)	(0.45)	(0.35)

Return Predictability

- Term structure literature: upward slope doesn't materialize, and slope predicts the magnitude of returns (Campbell and Shiller, 1991)
- Let's try the analogous idea here:

$$\underbrace{x^{c}_{t,h,\tau} - x^{c}_{t+h,0,\tau}}_{\text{Fwd CIP Trading Profit}} = \alpha + \beta \underbrace{\left(x^{c}_{t,h,\tau} - x^{c}_{t,0,\tau}\right)}_{\text{Slope}} + \epsilon^{x}_{t+h}$$

- Like using slope of term structure to predict long horizon bond returns
- Note: $x^{x}_{t,h,\tau}$ appears in profit and slope
  - We try instrumenting with lagged slope

Return Predictability

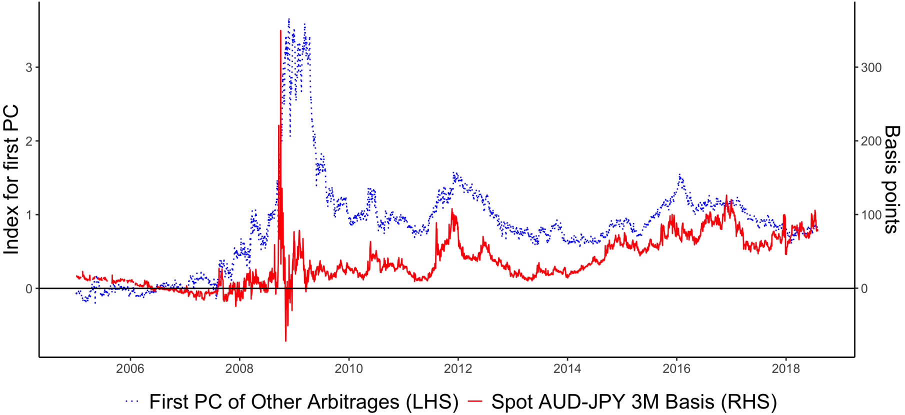
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Spread		0.710***	0.554***	0.509***	0.584***	0.507***	0.588**	0.772*
		(0.127)	(0.122)	(0.106)	(0.113)	(0.127)	(0.194)	(0.303)
Spot				0.0534*	0.0945*	0.0533*	0.0469	0.0339
				(0.0208)	(0.0396)	(0.0225)	(0.0272)	(0.0355)
Cons.	0.0476***		0.0202		-0.0300			
	(0.0113)		(0.0111)		(0.0207)			
RMSE	0.119	0.115	0.114	0.112	0.112	0.112	0.112	0.114
1st F						1005.0	153.0	61.48
Lag						1	5	10
Obs	2099	2099	2099	2099	2099	2092	2092	2092

Why CIP?

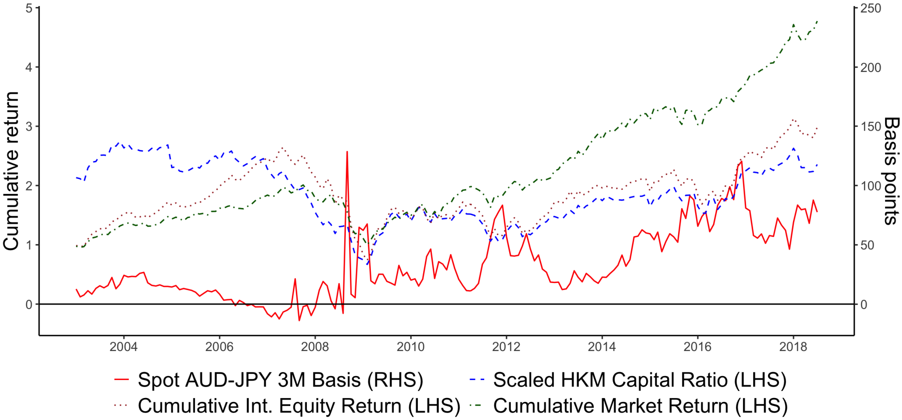
- In our model, nothing is special about CIP per se
  - Any arbitrage can be used to measure shadow price on regulatory constraint
  - Consequently, all arbitrages should co-move
- In the real world, CIP is particularly clean:
  - It was zero pre-GFC, and can be measured accurately
  - It doesn't involve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

Comparing CIP Deviations and Other Arbitrages

- We check for co-movement with other near-arbitrages:
  - bond-CDS, CDS-CDX, Libor tenor basis, 30Y swap spread, KfW vs Bunds, Refco vs Treasurys, TIPS vs. nominal treasury with inflation swaps
- High correlation correlation between 1st PC and AUD-JPY 3M spot basis



CIP Deviations and Proxies for Intermediary Wealth



Forward CIP Returns and Intermediary Wealth

	Daily Overlapping Returns				Monthly Returns	
	(1)	(2)	(3)	(4)	(5)	(6)
Market		0.007*		−0.0003		−0.001
		(0.004)		(0.004)		(0.005)
Int. Equity			0.006***	0.006**		
			(0.002)	(0.003)		
HKM Factor						0.004
						(0.003)
Constant	**0.048*** **	**0.038*** **	**0.042*** **	**0.042*** **	**0.053*** **	**0.052*** **
	(0.011)	(0.012)	(0.011)	(0.012)	(0.013)	(0.014)

- Formal Bayesian tests (Barillas and Shanken (2018) and Chib, Zeng and Zhao (2020)) show that the SDF includes both intermediary wealth and forward CIP returns fit the data better.

Cross-Sectional Implications

- Forward CIP trading profits directly test if the risk of the basis widening is priced
- Our model, however, gives an SDF:

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

  - All assets exposed to forward CIP returns (r^x_{t+1}) should earn excess returns
- Cross-sectional test, building on He, Kelly and Manela (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 $\lambda_x = -4.8 bps$, $\lambda_w = 61 bps$
  - We formally test this alternative hypothesis

Cross-Sectional Details

- We study Fama-French Size x Value 25, US Tsy/Corp. Bonds, FX Portfolios, Sovereign bonds, Equity Options, CDS, Commodity Futures
  - Also use non-AUD/JPY forward forward CIP trading strategy returns as test assets
- 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

	(1) US	(2) Sov	(3) FX	(4) Opt	(5) CDS	(6) FwdCIP	(7) FF6	(8) Comm	(9) 1-6
Int. Equity	0.182	1.363	1.845	1.485	2.330	-0.0337	0.301	1.031	0.728
	(0.746)	(1.565)	(0.639)	(0.996)	(1.016)	(2.206)	(4.148)	(0.694)	(0.466)
Neg. Fwd CIP Ret.	-0.174	-0.0784	-0.0718	-0.126	-0.0274	-0.0621	0.0839	-0.0171	-0.0725
	(0.114)	(0.0661)	(0.0508)	(0.0492)	(0.0660)	(0.0371)	(0.341)	(0.0277)	(0.0332)
Intercepts	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MAPE (%/mo.)	0.030	0.022	0.060	0.034	0.017	0.007	0.106	0.363	
H1 p-value	0.436	0.716	0.150	0.289	0.144	0.955	0.186	0.373	0.813
KZ p-value	0.079	0.379	0.107	0.035	0.355	0.226	0.780	0.780	0.041
N (assets)	11	6	11	18	5	9	6	23	60
N (beta, mos.)	98	98	98	98	98	98	98	98	
N (mean, mos.)	360	283	418	272	170	98	1106	331	

Standard errors in parentheses

Conclusion

- The risk that CIP violations become bigger is priced, strongly supportive of intermediary asset pricing theory.
- 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