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 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 \( \gamma \): 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
- \( \gamma \neq 1 \): Intertemporal hedging (Campbell [1993], Kondor and Vayanos [2019])
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 $c$:

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

- $r_{t,0,\tau}, r_{t,0,\tau}^$: $\tau$-month log rates at time $t$. $s_t$, $f_{t,\tau}$: spot and $\tau$-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.
Forward Covered Interest Parity

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

$$x_{t,h,\tau}^c = r_{t,h,\tau}^s - r_{t,h,\tau}^c + \frac{12}{\tau} \left( f_{t,\tau+h}^c - f_{t,h}^c \right)$$

$$= \frac{h + \tau}{\tau} x_{t,0,h+\tau}^c - \frac{h}{\tau} x_{t,0,h}^c$$

- $r_{t,h,\tau}, r_{t,h,\tau}^s$: $h$-month forward $\tau$-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

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Forward CIP Trading Strategy

1. Initiate \( h \)-month forward \( \tau \)-month forward CIP trade

2. \( h \)-months later, unwind

- Profits for the holding period \( h \):
  \[
  \pi_{t+h}^C \approx \frac{\tau}{12} \left( x_{t+h,\tau}^c - x_{t+h,0,\tau}^c \right)
  \]

- \( \frac{\tau}{12} \) 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
Table 1: Portfolio Returns on OIS 1M-forward 3M Forward CIP Trading Strategy

<table>
<thead>
<tr>
<th></th>
<th>Mean (bps)</th>
<th>Sharpe Ratio</th>
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<tbody>
<tr>
<td></td>
<td>Pre-Crisis</td>
<td>Post-</td>
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<tr>
<td>Carry</td>
<td>2.44</td>
<td>-4.37</td>
</tr>
<tr>
<td>s.e.</td>
<td>(1.34)</td>
<td>(10.79)</td>
</tr>
<tr>
<td>Dollar</td>
<td>-1.46</td>
<td>6.16</td>
</tr>
<tr>
<td>s.e.</td>
<td>(0.77)</td>
<td>(16.53)</td>
</tr>
</tbody>
</table>

- 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

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First PC of other arbitrage bases (lhs)
3M AUDJPY OIS basis (rhs)
• Basis factor rescaled (0.05 = 50 bps CIP violation)
Asset Pricing Interpretations

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

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

<table>
<thead>
<tr>
<th></th>
<th>Intermediary return</th>
<th>Forward CIP return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of risk (mean excess return)</td>
<td>0.610*</td>
<td>0.048***</td>
</tr>
<tr>
<td></td>
<td>(0.288)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>SDF parameters ($\gamma, \xi$)</td>
<td>0.658</td>
<td>305***</td>
</tr>
<tr>
<td></td>
<td>(1.768)</td>
<td>(91.7)</td>
</tr>
</tbody>
</table>

- 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 ($r_{t+1}^x$) should earn excess returns.
- Cross-sectional test, building on He et al. [2017] (HKM):

$$R_{t+1}^i - R_t^f = \mu_i + \beta_w^i (R_{t+1}^w - R_t^f) + \beta_x^i r_{t+1}^x + \epsilon_{t+1}^i,$$

$$E[R_{t+1}^i - R_t^f] = \alpha + \beta_w^i \lambda_w + \beta_x^i \lambda_x.$$  

- From mean return, we expect $\lambda_x = -4.8 \text{bps}$, $\lambda_w = 61 \text{bps}$.
- 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

<table>
<thead>
<tr>
<th></th>
<th>US</th>
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<th>Options</th>
<th>FwdArb</th>
<th>AllexFF</th>
<th>FwdArb</th>
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<tbody>
<tr>
<td>Int. Equity</td>
<td>0.499</td>
<td>1.363</td>
<td>1.845***</td>
<td>0.601</td>
<td>1.031*</td>
<td>1.377**</td>
<td>0.0857</td>
<td>0.999***</td>
<td>1.996***</td>
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<tr>
<td></td>
<td>(0.898)</td>
<td>(0.782)</td>
<td>(0.425)</td>
<td>(0.558)</td>
<td>(0.425)</td>
<td>(0.422)</td>
<td>(0.968)</td>
<td>(0.221)</td>
<td>(0.110)</td>
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<tr>
<td>Basis Shock</td>
<td>-0.150</td>
<td>-0.0784</td>
<td>-0.0718</td>
<td>0.0271</td>
<td>-0.0171</td>
<td>-0.134**</td>
<td>-0.0487**</td>
<td>-0.0482***</td>
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<tr>
<td></td>
<td>(0.0781)</td>
<td>(0.0502)</td>
<td>(0.0465)</td>
<td>(0.0628)</td>
<td>(0.0221)</td>
<td>(0.0410)</td>
<td>(0.0153)</td>
<td>(0.0138)</td>
<td></td>
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<tr>
<td>Intercepts</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>MAPE (%)</td>
<td>0.021</td>
<td>0.022</td>
<td>0.060</td>
<td>0.142</td>
<td>0.363</td>
<td>0.143</td>
<td>0.007</td>
<td>0.008</td>
<td></td>
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<tr>
<td>H1 p-value</td>
<td>0.417</td>
<td>0.166</td>
<td>0.005</td>
<td>0.345</td>
<td>0.174</td>
<td>0.012</td>
<td>0.785</td>
<td>0.217</td>
<td>0.000</td>
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<tr>
<td>N (assets)</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>25</td>
<td>23</td>
<td>18</td>
<td>10</td>
<td>77</td>
<td>10</td>
</tr>
<tr>
<td>N (beta, mos.)</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>N (mean, mos.)</td>
<td>360</td>
<td>283</td>
<td>418</td>
<td>1106</td>
<td>331</td>
<td>264</td>
<td>98</td>
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Cross-Sectional Asset Pricing Test, 3-Factor

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<th>AllexFF</th>
<th>FwdArb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>1.007*</td>
<td>0.459</td>
<td>0.887***</td>
<td>-0.0248</td>
<td>0.627***</td>
<td>0.464**</td>
<td>-4.223</td>
<td>0.453***</td>
<td>2.206***</td>
</tr>
<tr>
<td></td>
<td>(0.483)</td>
<td>(0.483)</td>
<td>(0.176)</td>
<td>(0.524)</td>
<td>(0.180)</td>
<td>(0.148)</td>
<td>(4.215)</td>
<td>(0.100)</td>
<td>(0.208)</td>
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<td>HKM Factor</td>
<td>-1.274</td>
<td>1.712</td>
<td>0.399</td>
<td>0.529</td>
<td>0.766</td>
<td>2.973</td>
<td>-2.572</td>
<td>0.383</td>
<td>2.083***</td>
</tr>
<tr>
<td></td>
<td>(0.958)</td>
<td>(1.365)</td>
<td>(1.259)</td>
<td>(0.541)</td>
<td>(0.580)</td>
<td>(2.044)</td>
<td>(2.726)</td>
<td>(0.505)</td>
<td>(0.110)</td>
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<tr>
<td>Basis Shock</td>
<td>-0.0504</td>
<td>-0.0605</td>
<td>-0.0588</td>
<td>0.0345</td>
<td>-0.0064</td>
<td>-0.0849</td>
<td>-0.0834*</td>
<td>-0.0498***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0804)</td>
<td>(0.0465)</td>
<td>(0.0339)</td>
<td>(0.0539)</td>
<td>(0.0263)</td>
<td>(0.0541)</td>
<td>(0.0411)</td>
<td>(0.0107)</td>
<td></td>
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<tr>
<td>Intercepts</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MAPE (%)</td>
<td>0.008</td>
<td>0.021</td>
<td>0.062</td>
<td>0.149</td>
<td>0.349</td>
<td>0.146</td>
<td>0.005</td>
<td>0.009</td>
<td></td>
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<tr>
<td>H1 p-value</td>
<td>0.658</td>
<td>0.906</td>
<td>0.358</td>
<td>0.223</td>
<td>0.119</td>
<td>0.364</td>
<td>0.483</td>
<td>0.098</td>
<td>0.000</td>
</tr>
<tr>
<td>N (assets)</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>25</td>
<td>23</td>
<td>18</td>
<td>10</td>
<td>77</td>
<td>10</td>
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</tbody>
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## Cross-Sectional Asset Pricing Test, 2-Factor PC1

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<th>AllexFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int. Equity</td>
<td>0.362</td>
<td>1.237</td>
<td>1.561**</td>
<td>0.825</td>
<td>1.177**</td>
<td>1.708***</td>
<td>-0.645</td>
<td>1.204***</td>
</tr>
<tr>
<td>(0.440)</td>
<td>(0.668)</td>
<td>(0.492)</td>
<td>(0.629)</td>
<td>(0.447)</td>
<td>(0.371)</td>
<td>(1.375)</td>
<td>(0.257)</td>
<td></td>
</tr>
<tr>
<td>AR1 Resid of PC1</td>
<td>-0.0654***</td>
<td>-0.0793***</td>
<td>0.0441</td>
<td>-0.0288</td>
<td>-0.0236</td>
<td>-0.0807***</td>
<td>-0.0856**</td>
<td>-0.0438***</td>
</tr>
<tr>
<td></td>
<td>(0.0151)</td>
<td>(0.0212)</td>
<td>(0.0325)</td>
<td>(0.0927)</td>
<td>(0.0251)</td>
<td>(0.0207)</td>
<td>(0.0310)</td>
<td>(0.00978)</td>
</tr>
</tbody>
</table>

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

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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
References
Nicola Borri and Adrien Verdelhan. Sovereign risk premia. 2015.


