Segmented Money Markets and CIP Arbitrage

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ECB Money Market Workshop

Disclaimer: Any views presented here are those of the authors and do not necessarily reflect those of the BIS or Norges Bank
Crucial in study of CIP

Get the ARBITRAGE right!

- **WHO** are the main arbitrageurs? **BANKS**!
- **WHAT** are the main strategies?
  - Risk-less round-trip **CIP LOOP**
  - Relative value
- **HOW** is it done?
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- **WHO** are the main arbitrageurs? **BANKS!**
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  - Relative value
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Borrow 1 $
Crucial in study of CIP

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- **WHAT** are the main strategies?
  - Risk-less round-trip
  - Relative value
- **HOW** is it done?

\[ \begin{align*}
  &\text{Borrow } 1 \text{ $} \\
  &t = 0 \\
  &\text{Buy } 1/S, \\
  &\text{Lend } i_{eur}
\end{align*} \]
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- **WHO** are the main arbitrageurs?  
  **BANKS!**

- **WHAT** are the main strategies?  
  - Risk-less round-trip  
  - Relative value

- **HOW** is it done?

Borrow $1$

Buy $1/S$

Lend $i_{eur}$

Forward $F$

$t = 0$

$t = 0$

$F_{t=0} = 0$

$F = S_{t=1} - e_{eur}(1 + i_{eur})$

$e_{eur}$
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- **WHAT** are the main strategies?
  - Risk-less round-trip
  - Relative value
- **HOW** is it done?

\[
\begin{align*}
\text{Borrow} & \quad t = 0 \\
\text{Buy} & \quad 1/S, \text{Lend} \quad i_{eur} \\
\text{Forward} & \quad F \\
\text{Repay} & \quad 1 + i_S \\
\text{Maturity,} & \quad \frac{1 + i_{eur}}{S} F
\end{align*}
\]
Crucial in study of CIP

Get the ARBITRAGE right!

- **WHO** are the main arbitrageurs?  
  - BANKS!

- **WHAT** are the main strategies?  
  - Risk-less round-trip
  - Relative value

- **HOW** is it done?

\[
\frac{F}{S} \left(1 + i_{eur}\right) - (1 + i_{\$}) = 0
\]

No Arbitrage (CIP)
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Get the ARBITRAGE right!

- **WHO** are the main arbitrageurs? **BANKS!**
- **WHAT** are the main strategies?
  - Risk-less round-trip
  - Relative value
- **HOW** is it done?

\[
\frac{F^b}{S^a} \left(1 + i^b_{eur}\right) - \left(1 + i^a_S\right) = 0
\]
Crucial in study of CIP

Get the ARBITRAGE right!

- **WHO** are the main arbitrageurs? **BANKS!**
- **WHAT** are the main strategies?
  - Risk-less round-trip
  - Relative value
- **HOW** is it done?

\[ \frac{F^b}{S^a} (1 + i_{eur}^a) - (1 + i_\$^a) = 0 \]
Importance of different interest rates

LOOP-deviation. Average across EUR, GBP, JPY. (2013-2016q1)

OIS
IBOR
IB deposit
CP

Basis points
Activity in US interbank markets

USD billions


DR/AS/OS
CIP
## True CIP Arb (Post-crisis)

Funded via USD CP and investing in T-bills (basis points)

<table>
<thead>
<tr>
<th>Low rating (A-2/P-2)</th>
<th>Good rating (A-1/P-1)</th>
<th>Top rating (A-1+/P-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (%D)</td>
<td>Median (%D)</td>
<td>Median (%D)</td>
</tr>
<tr>
<td>AUD</td>
<td>-47.7</td>
<td>-34.5</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>CAD</td>
<td>-29.5</td>
<td>-16.1</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>CHF</td>
<td>-12.8</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>14%</td>
<td>53%</td>
</tr>
<tr>
<td>EUR</td>
<td>-15.7</td>
<td>-1.4</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>42%</td>
</tr>
<tr>
<td>GBP</td>
<td>-32.0</td>
<td>-18.7</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>JPY</td>
<td>-4.9</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>32%</td>
<td>90%</td>
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</tbody>
</table>
## True CIP Arb (Post-crisis)

Funded via USD CP and placing funds with foreign CB (basis points)

<table>
<thead>
<tr>
<th></th>
<th>Low rating (A-2/P-2)</th>
<th>Good rating (A-1/P-1)</th>
<th>Top rating (A-1+/P-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>(%D)</td>
<td>Median</td>
<td>Median</td>
</tr>
<tr>
<td>AUD</td>
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<td>-43.8</td>
<td>-37.7</td>
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<td>CAD</td>
<td>-20.2</td>
<td>-7.7</td>
<td>-1.2</td>
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<tr>
<td>CHF</td>
<td>1.4</td>
<td>14.2</td>
<td>19.8</td>
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<tr>
<td>EUR</td>
<td>-22.0</td>
<td>-6.8</td>
<td>-1.3</td>
</tr>
<tr>
<td>GBP</td>
<td>-14.1</td>
<td>-0.3</td>
<td>6.6</td>
</tr>
<tr>
<td>JPY</td>
<td>4.6</td>
<td>14.2</td>
<td>19.9</td>
</tr>
</tbody>
</table>
US Money Market Funds

Money Market Fund reform and Asset Contraction

(lhs) US Prime Money Market Funds. Net Assets under Management
(rhs) Issued amount by foreign financials in the U.S. CP market
## True CIP Arb (Asset contraction)

Funded via USD CP and investing in T-bills (basis points)

<table>
<thead>
<tr>
<th>Currency</th>
<th>Low rating (A-2/P-2)</th>
<th>Good rating (A-1/P-1)</th>
<th>Top rating (A-1+/P-1)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Median (%D)</td>
<td>Median (%D)</td>
<td>Median (%D)</td>
</tr>
<tr>
<td>AUD</td>
<td>-54.2</td>
<td>-33.6</td>
<td>-21.7</td>
</tr>
<tr>
<td>CAD</td>
<td>-30.5</td>
<td>-14.9</td>
<td>-3.7</td>
</tr>
<tr>
<td>CHF</td>
<td>4.8</td>
<td>22.6</td>
<td>34.7</td>
</tr>
<tr>
<td>EUR</td>
<td>-11.6</td>
<td>4.4</td>
<td>16.1</td>
</tr>
<tr>
<td>GBP</td>
<td>-24.7</td>
<td>-7.4</td>
<td>3.9</td>
</tr>
<tr>
<td>JPY</td>
<td>15.2</td>
<td>31.6</td>
<td>40.6</td>
</tr>
</tbody>
</table>

Note: The table shows the median percentage change (%D) for different currencies under low, good, and top ratings.
### True CIP Arb (Asset contraction)

Funded via USD CP and placing funds with foreign CB (basis points)

<table>
<thead>
<tr>
<th></th>
<th>Low rating (A-2/P-2)</th>
<th>Good rating (A-1/P-1)</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (%D)</td>
<td>Median (%D)</td>
<td>Median (%D)</td>
</tr>
<tr>
<td>AUD</td>
<td>-67.6</td>
<td>-49.6</td>
<td>-38.9</td>
</tr>
<tr>
<td>CAD</td>
<td>-30.0</td>
<td>-14.6</td>
<td>-2.1</td>
</tr>
<tr>
<td>CHF</td>
<td>21.5</td>
<td>38.8</td>
<td>51.5</td>
</tr>
<tr>
<td>EUR</td>
<td>4.3</td>
<td>21.8</td>
<td>31.9</td>
</tr>
<tr>
<td>GBP</td>
<td>-10.9</td>
<td>5.2</td>
<td>18.3</td>
</tr>
<tr>
<td>JPY</td>
<td>30.4</td>
<td>49.6</td>
<td>59.1</td>
</tr>
</tbody>
</table>

|          | 0%                    | 0%                     | 0%                    |
| CAD      | 0%                    | 0%                     | 33%                   |
| CHF      | 97%                   | 100%                   | 100%                  |
| EUR      | 60%                   | 100%                   | 100%                  |
| GBP      | 18%                   | 71%                    | 100%                  |
| JPY      | 100%                  | 100%                   | 100%                  |
FX Swap Market

(a) “Normal” situation: Equilibrium, No Arb, No Flow imbalance

US rates

Foreign rates

Top
Mid
Low

Top
Mid
Low

US rates

Foreign rates

Top
Mid
Low

Top
Mid
Low
Deposit inflow in wake of ECB-QE

Billions euro

- Total assets (left)
- Deposits from Euro-area residents (right)
FX Swap Market

(b) Example of no equilibrium with excess liquidity

US rates

Low

Mid

Top

Foreign rates

Low

Mid

Top

CB

Mid’s LOOP gain

Low’s LOOP gain

No dev for Top

Mid and Low LOOP
FX Swap Market

(c) Excess liquidity: Equilibrium swap rate

US rates

Foreign rates

Top

Mid

Low

No dev for Mid

Top

Mid

Low

CB
FX Swap Market

(d) Excess liquidity: Equilibrium flows

US rates

Low
Mid
Top

Foreign rates

Low
Mid
Top
CB

Loop gain

Top’s CIP

Low’s CIP profit
EUR CIP deviations

OIS and CP-based 3m deviations

(basis points)

(a) OIS & CP-TB

(b) OIS & CP-CB
FX Swap Market

(d) Excess liquidity: Equilibrium flows

US rates

Low
Mid
Top

Low’s LOOP gain

Foreign rates

Low
Mid
Top

Top’s CIP profit

Top CIP

DR/AS/OS
CIP
CIP arb and Swap Order Flow

Panel regression (CrossX FE, CrossX clustering)

\[
\Delta CIP_{i,t}^{dev} = \alpha_i + \gamma \cdot CIP_{i,t-1}^{dev} \\
+ D_{i,t} \cdot \beta_i \cdot OF_{swap}^{i,t} + Controls + \varepsilon_{i,t}
\]

- \(OF_{swap}\): measures demand pressure to raise USD through swaps (standardized)

- Lagged dependent variable: “error-correction”

- 2 regimes, deviation-dummy: \(\beta_i = [\beta_i^{Dev}, \beta_i^{NoDev}]\)
# Order flow regressions

<table>
<thead>
<tr>
<th></th>
<th>A-2/P-2</th>
<th>A-1/P-1</th>
<th>A-1/P-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Deviation, level lagged</td>
<td>-0.04</td>
<td>-0.07</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>(-2.31)</td>
<td>(-4.62)</td>
<td>(-6.69)</td>
</tr>
<tr>
<td>Swap OF, both dev</td>
<td>2.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.70)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swap OF, dev</td>
<td>3.26</td>
<td>0.75</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>(3.09)</td>
<td>(2.45)</td>
<td>(4.42)</td>
</tr>
<tr>
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<td>0.49</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>(2.87)</td>
<td>(2.41)</td>
<td>(1.97)</td>
</tr>
</tbody>
</table>

*Additional controls ... (see Appendix)*
**Order flow regressions**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>(1) Deviation, level lagged</td>
<td>-0.04</td>
<td>-0.07</td>
<td>-0.07</td>
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<tr>
<td></td>
<td>(-2.31)</td>
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<td></td>
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<td>(2.41)</td>
<td>(1.97)</td>
</tr>
</tbody>
</table>

*Additional controls ... (see Appendix)*
Yen CIP Arbitrage

Cash deposits of foreign’ banks with Bank of Japan

(a) Top-rated banks
(b) Lower-rated banks

Net HQ funding
BoJ deposits
Total assets

JPY trillions
Top Banks Arb Flows are Bounded
Dispersion in top-rated banks USD funding costs (USD CD issuance)

Asian banks except Japanese
Rest Of World
Max USD rate for arbitrage in BoJ
Max USD rate for arbitrage in ECB

Basis points

2012 2013 2014 2015
Excess liquidity and the “new LOOP”

Some evidence from the ECB’s Asset Purchase Program
Conclusions

1. No CIP Arb profits (for most) when using actual marginal *funding cost* and *riskfree lending*.

2. Risk-free CIP Arb for top-rated banks emerge as *equilibrium outcome*.

Main forces for recent market “dislocation”:

- **Funding liquidity risk** in USD money markets
- **Heterogeneity** in USD money markets
- **Excess liquidity** + **Segmentation** in non-USD

⇒ **Funding Liquidity Premia** differences
Part II

Additional material
Literature

Classics and pre-crisis evidence
Taylor (1987), Akram, Rime, and Sarno (2008): tiny dev (when data are sampled correctly)

CIP and the global financial crisis
e.g. Baba, Packer, and Nagano (2008); Baba and Packer (2009); Coffey, Hrung, Nguyen, and Sarkar (2009); Goldberg, Kennedy, and Miu (2011); Griffoli and Ranaldo (2009); McGuire and von Peter (2012); Bottazzi, Luque, Pascoa, and Sundaresan (2012); Syrstad (2014)

The CIP puzzle in the post-GFC period
e.g. Du, Tepper, and Verdelhan (2016); Sushko, Borio, McCauley, and McGuire (2016); Avdjiev, Du, Koch, and Shin (2016); Iida, Kimura, and Sudo (2016)

⇒ Large & persistent deviations, yet no turmoil!
Covered Interest Parity (CIP)

Borrow 1 USD

Buy 1/$, Lend at rate $i_{EUR}$

Forward contract $F$

Repay debt $1 + i_{USD}$

Receive at maturity, $rac{1+i_{EUR}}{S}F$

No Arbitrage

$F = S \frac{1+i_{USD}}{1+i_{EUR}}$
CIP (LOOP) with bid-ask spreads

CIP arbitrage is *not* profitable . . .

\[
(1 + r^a_d) \geq \frac{F^b}{S^a} (1 + r^b_f) \quad (1)
\]

\[
(1 + r^a_f) \geq \frac{S^b}{F^a} (1 + r^b_d) \quad (2)
\]

1. Borrowing rate (ask) in domestic currency has to be equal or higher than implied lending rate (bid) measured in domestic currency

2. LOOP: same price for both interest rates (weaker)
Market conventions and the cross-currency basis

\[
Dev^b_{CIP} = -i^a_d + \left[ \frac{S^a + F^b - S^a/10^4}{S^a} \left( 100 + i^b_f \frac{D}{360} \right) - 100 \right] \frac{360}{D},
\]

\[
Dev^a_{CIP} = -i^a_f - \left[ \frac{S^b}{S^b + F^a - S^b/10^4} \left( 100 + i^b_d \frac{D}{360} \right) - 100 \right] \frac{360}{D}.
\]

- Swap, represented by \( F^b - S^a \) (here at bid), not forward
- \( D \) – days to maturity and \( 10^4 \) – factor scaling the swap since it is quoted in “swap points”
- CIP deviation as the cross-currency basis
Part III

Data and Funding cost heterogeneity
Funding cost heterogeneity

US money market spreads (3-mth)

(a) USD commercial paper

(b) USD LIBOR-OIS vs other currencies
Heterogenous funding costs
Evidence from the LIBOR panel
## Data overview

### FX

<table>
<thead>
<tr>
<th></th>
<th>Trade-able</th>
<th>Risk-free</th>
<th>High-freq</th>
<th>Tenors Tenors</th>
<th>Currencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot (D2)</td>
<td>Y</td>
<td>–</td>
<td>Y</td>
<td>–</td>
<td>AUD, CAD, CHF, EUR, GBP, JPY</td>
</tr>
<tr>
<td>FX Swaps</td>
<td>N</td>
<td>–</td>
<td>Y</td>
<td>1W-3M</td>
<td>AUD, CAD, CHF, EUR, GBP, JPY</td>
</tr>
<tr>
<td>FX Swaps (D3)</td>
<td>Y</td>
<td>–</td>
<td>Y</td>
<td>1W-3W</td>
<td>AUD, CAD, CHF, EUR, GBP, JPY</td>
</tr>
</tbody>
</table>
# Data overview

## Interest rates

<table>
<thead>
<tr>
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<th>Trade-</th>
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<th>Tenors</th>
<th>Currencies</th>
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<tr>
<td></td>
<td>able</td>
<td>free</td>
<td>freq</td>
<td>Tenors</td>
<td></td>
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</tbody>
</table>

### Secured

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>Y</th>
<th>Y</th>
<th>1W-3M</th>
<th>USD, EUR, GBP*, JPY*</th>
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</thead>
<tbody>
<tr>
<td><strong>OIS</strong></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>1W-3M USD, EUR, GBP*, JPY*</td>
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<tr>
<td><strong>Repo (GC)</strong></td>
<td>Y</td>
<td>Y</td>
<td>D</td>
<td>1M, 3M</td>
<td>USD, EUR</td>
</tr>
<tr>
<td><strong>T-bills</strong></td>
<td>Y</td>
<td>Y</td>
<td>D</td>
<td>1M, 3M</td>
<td>USD, AUD, CAD, CHF, EUR, GBP, JPY</td>
</tr>
<tr>
<td><strong>CB deposits</strong></td>
<td>Y</td>
<td>Y</td>
<td>D</td>
<td>1M, 3M</td>
<td>USD, AUD, CAD, CHF, EUR, GBP, JPY</td>
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</tbody>
</table>

### Unsecured

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>N</th>
<th>N</th>
<th>1W-3M</th>
<th>USD, AUD, CAD, CHF, EUR, GBP, JPY</th>
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</thead>
<tbody>
<tr>
<td><strong>Deposit</strong></td>
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<td>N</td>
<td>Y</td>
<td>1W-3M</td>
<td>USD, AUD, CAD, CHF, EUR, GBP, JPY</td>
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<tr>
<td><strong>IBOR</strong></td>
<td>N</td>
<td>N</td>
<td>D</td>
<td>3M</td>
<td>USD, AUD*, CAD, CHF, EUR, GBP, JPY</td>
</tr>
<tr>
<td><strong>CP</strong></td>
<td>Y</td>
<td>N</td>
<td>D</td>
<td>1M, 3M</td>
<td>USD, AUD, CAD, EUR, GBP, JPY</td>
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</tbody>
</table>
## Descriptives

Money market spreads (over OIS)

<table>
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<th>Deposit</th>
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<th>IBOR</th>
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<tr>
<td><strong>Mean</strong></td>
<td>0.324</td>
<td>-0.105</td>
<td>0.291</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>0.174</td>
<td>-0.095</td>
<td>0.145</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>4.776</td>
<td>0.341</td>
<td>3.663</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>-0.140</td>
<td>-1.464</td>
<td>0.025</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>0.478</td>
<td>0.136</td>
<td>0.391</td>
</tr>
<tr>
<td><strong>Skewness</strong></td>
<td>4.334</td>
<td>-2.331</td>
<td>3.949</td>
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<tr>
<td><strong>Kurtosis</strong></td>
<td>28.453</td>
<td>16.746</td>
<td>24.023</td>
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<tr>
<td><strong>Observations</strong></td>
<td>2801</td>
<td>1740</td>
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Part IV

OIS, GC Repo and FTP
Roundtrip Arb based on OIS contracts

1. Borrow funds overnight (O/N) in borrowing currency (e.g. USD)

2. Roll over O/N loan daily over preferred maturity and hedge IR risk by paying the (fixed) OIS-rate of the same maturity

3. Enter into FX swap with same maturity as OIS

4. Invest lending currency O/N (e.g. JPY)

5. Roll over O/N investment and hedge IR risk by receiving the OIS-rate in the lending currency

⇒ Rolling over short-term O/N funding allows arbitrageur to reduce funding cost

⇒ But, this comes at the cost of taking on additional liquidity risk in the borrowing currency ...
## Roundtrip cross-currency basis arbitrage with OIS rates (I)

<table>
<thead>
<tr>
<th>GFC and EUR crisis</th>
<th>Direction</th>
<th>Median</th>
<th>Std.</th>
<th>(%D)</th>
<th>(%W)</th>
<th>(%M)</th>
<th>Obs.</th>
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</thead>
<tbody>
<tr>
<td>EUR FCU ⇒ USD</td>
<td>-29.8</td>
<td>38.2</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1566</td>
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<tr>
<td>USD ⇒ FCU</td>
<td>23.5</td>
<td>35.4</td>
<td>92%</td>
<td>91%</td>
<td>88%</td>
<td>1566</td>
<td></td>
</tr>
<tr>
<td>GBP FCU ⇒ USD</td>
<td>-13.6</td>
<td>34.7</td>
<td>3%</td>
<td>2%</td>
<td>0%</td>
<td>1395</td>
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<td>79%</td>
<td>61%</td>
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<tr>
<td>JPY FCU ⇒ USD</td>
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<td>0%</td>
<td>796</td>
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<tr>
<td>USD ⇒ FCU</td>
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<td>100%</td>
<td>99%</td>
<td>97%</td>
<td>796</td>
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Round-trip arb based on OIS rates and B/A adjustment in all legs of trade sequence

“Direction” indicates if round-trip goes “USD ⇒ FCU” or “FCU ⇒ USD” at spot leg of swap
## Roundtrip cross-currency basis arbitrage with OIS rates (II)

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<th>Direction</th>
<th>Deviation</th>
<th>Post-crisis</th>
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<td><strong>USD ⇒ FCU</strong></td>
<td>12.8</td>
</tr>
<tr>
<td>GBP</td>
<td><strong>FCU ⇒ USD</strong></td>
<td>-8.1</td>
</tr>
<tr>
<td></td>
<td><strong>USD ⇒ FCU</strong></td>
<td>3.1</td>
</tr>
<tr>
<td>JPY</td>
<td><strong>FCU ⇒ USD</strong></td>
<td>-23.8</td>
</tr>
<tr>
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<td><strong>USD ⇒ FCU</strong></td>
<td>19.9</td>
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</table>

Round-trip Arb based on OIS rates and B/A adjustment in all legs of trade sequence

“Direction” indicates if round-trip goes “USD ⇒ FCU” or “FCU ⇒ USD” at spot leg of swap
# Roundtrip cross-currency basis arbitrage with OIS rates (III)

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</table>

Round-trip Arb based on OIS rates and B/A adjustment in all legs of trade sequence

“Direction” indicates if round-trip goes “USD ⇒ FCU” or “FCU ⇒ USD” at spot leg of swap
OIS is not Marginal Funding Rate

An Overnight-Index-Swap is a derivative, not a funding instrument

- Use for CIP calculations (implicitly) assumes a complex series of trades
- Need to roll over O/N borrowing
- Arbitrageur remains exposed to \textit{rollover} and \textit{liquidity risks}

⇒ Fluctuations of OIS FX swap basis largely reflect relative term \textit{funding liquidity premiums} \textit{vis-a-vis} USD ...
⇒ Can’t make judgement about validity of a no-Arb condition like CIP
⇒ Similar arguments apply to FX swap basis constructed from GC repo rates
**GC repo rates in CIP calculations**

Like in case of OIS, there are hidden costs when relying on GC repo rates in CIP calculations ...

- Collateral used in repo is ultimately financed unsecured
- For use in arbitrage trade, collateral needs to be unencumbered
- Otherwise, requirements of self-financing Arb trade not met

→ To capture marginal funding costs for repo-based CP arbitrage, it is necessary to adjust for the (unsecured) funding cost of the collateral
How do banks price funds internally?

The principle of Funds Transfer Pricing (FTP)

- Transfer IR and liquidity risk to central location (Treasury unit)
- Immunize remaining units against these risk factors
- Treasury “buys” funds from units managing the banks’ liability side
- And, it “sells” funds to units investing in banking assets
- The corresponding “prices” charged by the Treasury are related to the cost of obtaining the funds
The FTP interest rate curve

- To determine FTP, the Treasury unit constructs an IR curve, incorporating the marginal cost of using funds across maturities.
- Make sure business units face net interest margin from:
  1. Funding spread between deposit rates faced by banks’ customers and internal price (liability side).
  2. Spread between internal price and return on the banking assets (asset side).
- Rely on interbank deposit rates $< 1y$ and IRS curve $> 1y$
- Interbank deposit rate regarded as a reasonable proxy for the marginal cost of using funds for banks.
FTP: Implications

- Banks’ internal pricing needs to be closely aligned with LOOP

- Otherwise, internal business units may exploit inconsistency

  ⇒ Choice of MM rates guided by banks’ internal no-Arb condition across currencies ...

- Interbank deposit rates as a reasonable proxy for the internal price

- Account for term funding liquidity, credit premium and balance sheet cost of using additional funds

- TC-adjustment feasible (unlike IBOR)

  ⇒ Expect CIP to hold to a close approximation between interbank deposit rates (after TC-adjustment) ...
Funds Transfer Pricing

Figure 7
Fund Transfer Pricing (FTP)

Treasury
FTP Book: FTP all assets and liabilities
Hedge Book: Compose the bank-wide interest rate risk profile and execute hedging
Liquidity Management: Compose the bank-wide maturity mismatch profile and manage funding needs

Liquidity Management:
Compose the bank-wide maturity mismatch profile and manage funding needs

FTP Book:
FTP all assets and liabilities

Liquidity Management:
Compose the bank-wide maturity mismatch profile and manage funding needs

Capital Markets

Notes: Figure shows the principle of Fund Transfer Pricing (FTP). Source: Tumasyan (2016).
Part V

LOOP
## LOOP and IBOR

(i) \[ y_\$ - y_{FCU\rightarrow\$} \]

Direct $-rate  
Swap-implied $-rate

(ii) \[ y_{FCU\rightarrow\$} - y_{\$\rightarrow FCU} \]

Direct FCU -rate  
Swap-implied FCU-rate

### GFC and EUR crisis

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<tr>
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### Post-crisis

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<td>Std.</td>
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<td>(%W)</td>
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</tr>
<tr>
<td>(ii)</td>
<td>14.3</td>
<td>12.6</td>
</tr>
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</table>
**LOOP and interbank deposit**

(i) \( y^\$ - y^{FCU\rightarrow\$} \)

- **Direct \$-rate**
- **Swap-implied \$-rate**

(ii) \( y^{FCU\rightarrow\$} - y^{\$\rightarrow FCU} \)

- **Direct FCU -rate**
- **Swap-implied FCU-rate**

---

<table>
<thead>
<tr>
<th>Currency</th>
<th>GFC and EUR crisis</th>
<th>Post-crisis</th>
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<td>9.9</td>
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<tr>
<td></td>
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<td>9.9</td>
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<tr>
<td>GBP</td>
<td>-4.5</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td>3.7</td>
<td>7.2</td>
</tr>
<tr>
<td>JPY</td>
<td>-2.0</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>4.9</td>
</tr>
</tbody>
</table>
### LOOP for CP rates (A-2/P-2)

1. $(i)$
   - \( y^\$ \)
   - \( y^{FCU \rightarrow \$} \)
   - Direct $\$ - rate
   - Swap-implied $\$ - rate

2. $(ii)$
   - \( y^{FCU \rightarrow \$} \)
   - \( y^{\$ \rightarrow FCU} \)
   - Direct FCU - rate
   - Swap-implied FCU-rate

<table>
<thead>
<tr>
<th>Currency</th>
<th>Deviation</th>
<th>Median</th>
<th>Std.</th>
<th>(%D)</th>
<th>(%W)</th>
<th>(%M)</th>
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<td>8.6</td>
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<td>0%</td>
<td>0%</td>
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<td>$(ii)$</td>
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<td>79%</td>
<td>54%</td>
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<td>44%</td>
<td>22%</td>
<td>8%</td>
<td>716</td>
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<td>4.1</td>
<td>43%</td>
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<td>716</td>
</tr>
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<td>714</td>
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<td>6.1</td>
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<td>28%</td>
<td>8%</td>
<td>714</td>
</tr>
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</table>
Part VI

Funding Liquidity Premia
Funding liquidity premia and the basis

![Graph showing funding liquidity premia and the basis](image-url)
Funding liquidity premia and the basis

![Graph showing cross-currency basis and funding liquidity premium differential for various currencies.](image)

- Y-axis: Funding liquidity premium differential (3-month, in b.p.)
- X-axis: Cross-currency basis (OIS, 3-month, in b.p.)
- Currencies represented: JPY, EUR, AUD, CAD, CHF, GBP
Funding liquidity premia and the basis

Commercial paper

---

The graph shows the basis points for commercial paper from June 2013 to September 2016. It compares the funding liquidity premia for lower-rated banks and top-rated banks. The basis points fluctuate over time, with a noticeable increase from February 2015 onwards.
Part VII

True CIP Arbitrage
### True CIP Arb (Post-crisis)

Funded via USD CP and investing in T-Bills

**Lower-rated** banks (A-2/P-2)

<table>
<thead>
<tr>
<th>Currency</th>
<th>Median</th>
<th>Std.</th>
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<td>0%</td>
<td>0%</td>
<td>691</td>
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<tr>
<td>CHF</td>
<td>-13.6</td>
<td>10.7</td>
<td>9%</td>
<td>6%</td>
<td>3%</td>
<td>679</td>
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<td>0%</td>
<td>713</td>
</tr>
<tr>
<td>GBP</td>
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<td>0%</td>
<td>0%</td>
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<tr>
<td>JPY</td>
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<td>30%</td>
<td>18%</td>
<td>9%</td>
<td>497</td>
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</table>
### True CIP Arb (Post-crisis)

Funded via USD CP and investing in T-Bills

<table>
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<th>Median</th>
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<th>(%W)</th>
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<tr>
<td>CAD</td>
<td>-15.5</td>
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<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>691</td>
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<tr>
<td>CHF</td>
<td>-0.2</td>
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<td>28%</td>
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<td>3%</td>
<td>688</td>
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<td>10.6</td>
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<td>88%</td>
<td>80%</td>
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</table>
True CIP Arb (Post-crisis)
Funded via USD CP and investing in T-Bills

Best-rated banks (A-1+/P-1)

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<td>13%</td>
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<tr>
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<td>100%</td>
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</table>
True CIP Arb (Post-crisis)
Funded via USD CP and placing funds with foreign CB

Lower-rated banks (A-2/P-2)

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<td>0%</td>
<td>696</td>
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<td>53%</td>
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<td>31%</td>
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<td>60%</td>
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<td>699</td>
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</table>
**True CIP Arb** (Post-crisis)

Funded via USD CP and placing funds with foreign CB

<table>
<thead>
<tr>
<th>Top-rated banks (A-1/P-1)</th>
<th>Median</th>
<th>Std.</th>
<th>(%D)</th>
<th>(%W)</th>
<th>(%M)</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD</td>
<td>-42.6</td>
<td>11.4</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>639</td>
</tr>
<tr>
<td>CAD</td>
<td>-7.5</td>
<td>5.6</td>
<td>14%</td>
<td>9%</td>
<td>2%</td>
<td>696</td>
</tr>
<tr>
<td>CHF</td>
<td>13.1</td>
<td>17.9</td>
<td>100%</td>
<td>99%</td>
<td>97%</td>
<td>699</td>
</tr>
<tr>
<td>EUR</td>
<td>-9.7</td>
<td>13.1</td>
<td>29%</td>
<td>25%</td>
<td>19%</td>
<td>696</td>
</tr>
<tr>
<td>GBP</td>
<td>0.6</td>
<td>3.5</td>
<td>59%</td>
<td>46%</td>
<td>28%</td>
<td>698</td>
</tr>
<tr>
<td>JPY</td>
<td>13.3</td>
<td>14.6</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>699</td>
</tr>
</tbody>
</table>
**True CIP Arb**  
*(Post-crisis)*

Funded via USD CP and placing funds with foreign CB

**Best-rated banks (A-1+/P-1)**

<table>
<thead>
<tr>
<th>Currency</th>
<th>Median</th>
<th>Std.</th>
<th>(%D)</th>
<th>(%W)</th>
<th>(%M)</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD</td>
<td>-35.9</td>
<td>11.3</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>631</td>
</tr>
<tr>
<td>CAD</td>
<td>-1.5</td>
<td>5.6</td>
<td>35%</td>
<td>24%</td>
<td>12%</td>
<td>688</td>
</tr>
<tr>
<td>CHF</td>
<td>18.7</td>
<td>18.1</td>
<td>100%</td>
<td>99%</td>
<td>97%</td>
<td>691</td>
</tr>
<tr>
<td>EUR</td>
<td>-3.6</td>
<td>12.9</td>
<td>44%</td>
<td>42%</td>
<td>37%</td>
<td>688</td>
</tr>
<tr>
<td>GBP</td>
<td>7.4</td>
<td>3.7</td>
<td>98%</td>
<td>96%</td>
<td>92%</td>
<td>690</td>
</tr>
<tr>
<td>JPY</td>
<td>18.8</td>
<td>14.8</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>691</td>
</tr>
</tbody>
</table>
Cash deposits of foreign banks with Bank of Japan

Panel regression: \( \frac{BoJ\text{Cash} - \text{Funding}}{\text{TotAssets}} \)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
<td>-0.019</td>
<td>-0.019</td>
<td>-0.018</td>
<td>-0.019</td>
</tr>
<tr>
<td></td>
<td>(-2.44)</td>
<td>(-2.41)</td>
<td>(-2.32)</td>
<td>(-2.33)</td>
</tr>
<tr>
<td>CIP, top rating</td>
<td>0.295</td>
<td></td>
<td>0.150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.83)</td>
<td></td>
<td>(1.00)</td>
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<tr>
<td>CIP, low rating</td>
<td></td>
<td>0.109</td>
<td>0.089</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(3.81)</td>
<td>(4.47)</td>
<td></td>
</tr>
</tbody>
</table>
CD issuance in US Dollars
Dispersion in USD funding costs - low-rated banks

Mean A-2/P-2 banks CD funding costs (issuances)
A-2/P-2 CP-rate from Tradeweb
Max USD rate for arbitrage in BoJ

Basis points

Activity in US interbank markets
# Global banks and their ratings

<table>
<thead>
<tr>
<th>Rating category</th>
<th>A-1+/P-1</th>
<th>A-1/P-1</th>
<th>A-2/P-2</th>
<th>Lower/No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A: Non-Asian banks, including Japanese banks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average size</td>
<td>749</td>
<td>861</td>
<td>877</td>
<td>310</td>
</tr>
<tr>
<td>Total size</td>
<td>8,990</td>
<td>35,301</td>
<td>14,907</td>
<td>19,519</td>
</tr>
<tr>
<td># banks</td>
<td>12</td>
<td>41</td>
<td>17</td>
<td>63</td>
</tr>
<tr>
<td><strong>B: Asian banks, excluding Japanese banks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average size</td>
<td>301</td>
<td>1,026</td>
<td>473</td>
<td>342</td>
</tr>
<tr>
<td>Total size</td>
<td>1,803</td>
<td>11,282</td>
<td>3,311</td>
<td>6,155</td>
</tr>
<tr>
<td># banks</td>
<td>6</td>
<td>11</td>
<td>7</td>
<td>18</td>
</tr>
</tbody>
</table>
Part VIII

Swap Order Flow
Order flow regressions

Interpretation

- Rise in funding liquidity premia ("USD more scarce")
- Turn to swap-market for funding in USD (especially for low-tier) → CIP-deviations widen ...
- Reflects rising pressure (on $f - s$) as price impact of swap order flow imbalance rises

Other results:
- Similar for OIS roundtrip deviations
## Order flow regressions (Cont.)

<table>
<thead>
<tr>
<th></th>
<th>A2/P2 (1)</th>
<th>A1/P1 (2)</th>
<th>A1/P1 (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot return, dev</td>
<td>1.45</td>
<td>-0.60</td>
<td>-0.19</td>
</tr>
<tr>
<td></td>
<td>(1.25)</td>
<td>(-1.38)</td>
<td>(-0.62)</td>
</tr>
<tr>
<td>Spot return, no dev</td>
<td>-0.54</td>
<td>-1.25</td>
<td>-0.89</td>
</tr>
<tr>
<td></td>
<td>(-0.93)</td>
<td>(-2.15)</td>
<td>(-2.87)</td>
</tr>
<tr>
<td>Spot OF, dev</td>
<td>-0.10</td>
<td>-0.01</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>(-0.37)</td>
<td>(-0.03)</td>
<td>(-0.51)</td>
</tr>
<tr>
<td>Spot OF, no dev</td>
<td>-0.21</td>
<td>-0.27</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(-1.40)</td>
<td>(-2.22)</td>
<td>(-0.11)</td>
</tr>
<tr>
<td>Liq-premia diff, dev</td>
<td>0.06</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>(2.54)</td>
<td>(3.10)</td>
<td>(3.37)</td>
</tr>
<tr>
<td>Liq-premia diff, no dev</td>
<td>-0.01</td>
<td>-0.16</td>
<td>-0.07</td>
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<tr>
<td></td>
<td>(-0.56)</td>
<td>(-2.82)</td>
<td>(-4.99)</td>
</tr>
<tr>
<td>Obs.</td>
<td>1,143</td>
<td>2,598</td>
<td>1,237</td>
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<tr>
<td>adj.R2</td>
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<td>0.10</td>
<td>0.07</td>
</tr>
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<td>Back</td>
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</table>
## OF: Robustness

<table>
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<tr>
<th></th>
<th>A-2/P-2 (1)</th>
<th>A-2/P-2 (2)</th>
<th>A-1/P-1 (3)</th>
<th>A-1/P-1 (4)</th>
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</thead>
<tbody>
<tr>
<td>Swap OF, dev</td>
<td>1.54</td>
<td>1.81</td>
<td>0.58</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>(2.37)</td>
<td>(2.49)</td>
<td>(2.38)</td>
<td>(9.14)</td>
</tr>
<tr>
<td>Swap OF, no dev</td>
<td>0.17</td>
<td>0.16</td>
<td>0.21</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>(3.87)</td>
<td>(3.62)</td>
<td>(2.20)</td>
<td>(1.91)</td>
</tr>
<tr>
<td>Spot index, dev</td>
<td>1.44</td>
<td></td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.68)</td>
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<td>(1.32)</td>
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<tr>
<td>Spot index, no dev</td>
<td>0.03</td>
<td></td>
<td>-1.66</td>
<td></td>
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<tr>
<td></td>
<td>(0.11)</td>
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<td>(-2.92)</td>
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<td>Spot, dev</td>
<td></td>
<td>1.05</td>
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<td>0.28</td>
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<td></td>
<td>(0.92)</td>
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<td>(2.06)</td>
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<td>-0.64</td>
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<tr>
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<td>(-3.77)</td>
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<tr>
<td>LP diff, dev</td>
<td>0.13</td>
<td></td>
<td>0.16</td>
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</tr>
<tr>
<td></td>
<td>(5.28)</td>
<td></td>
<td>(5.82)</td>
<td></td>
</tr>
<tr>
<td>LP diff, no dev</td>
<td>0.06</td>
<td></td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.58)</td>
<td></td>
<td>(0.35)</td>
<td></td>
</tr>
</tbody>
</table>


References III


References IV


Tommaso Mancini Griffoli and Angelo Ranaldo. Deviations from covered interest parity during the crisis; a story of funding liquidity constraints. typescript, Swiss National Bank, 2009.

References V


