Segmented Money Markets and CIP Arbitrage

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What we do in this paper . . .

A: Study main arbitrageurs

- In-depth study of CIP **Arb** strategies
  - ▸ **Risk-less** round-trip strategies   (vs. *LOOP*)
  - ▸ Careful treatment of arbitrageurs' **funding costs**

B: Study challenges of FX swap market makers

- Balance FX swap **Order Flow**
- Challenge of **segmentation** in money markets (post-GFC)

Main results in a nutshell

1. Proper funding cost $\Rightarrow$ No **Arb** profits (for most)

2. Risk-less **Arb** for banks with *best funding* and ability to place at *CB deposit* rate
    - Equilibrium as market maker balance (finite) flows
    - **Funding Liquidity Premia**
    - Segmented USD money markets
      $\Rightarrow$ Dispersion of USD rates across banks
    - Excess liquidity (QE) in non-USD markets
      $\Rightarrow$ Compression of rates towards CB deposit

3. First to study FX **Swap Order Flow** (into USD)
   CIP dislocations $\nearrow$ Price impact $\nearrow$

Funding constraints in USD markets limits Arb

CIP: excess liquidity & liquidity premia

$$\frac{F}{S} = \frac{\overbrace{1+r_\$}^{1+r_\$^f+\widetilde{cr}_\$+\widetilde{lp}_\$}}{\underbrace{1+r_\star}_{1+r_\star^f+\widetilde{cr}_\star+\widetilde{lp}_\star}}$$

"Normal" times:

$$\left.\begin{array}{c} \widetilde{lp}_\$ = \widetilde{lp}_\star \\ \widetilde{cr}_\$ = \widetilde{cr}_\star \end{array}\right\} \Rightarrow CIP \text{ holds}$$

CIP: excess liquidity & liquidity premia

$$\frac{F}{S} = \frac{1 + r_\$^f + \widetilde{cr}_\$ + \widetilde{lp}_\$}{1 + r_\star^f + \widetilde{cr}_\star + \widetilde{lp}_\star}$$
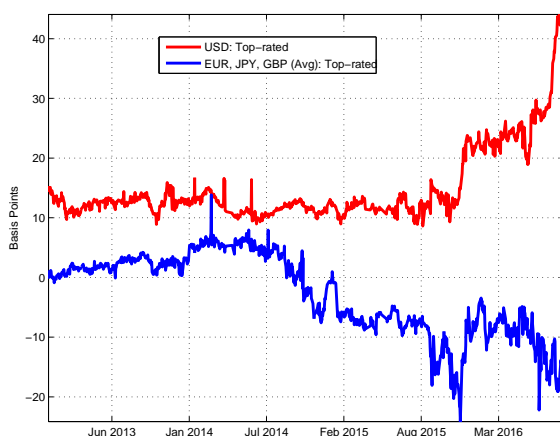
Post-GFC environment:

QE $+$ Heterogeneity in banks' funding costs:

- Cross-currency differences in **Funding Liquidity Premia**: $\widetilde{lp}_\$ > 0, \qquad \widetilde{lp}_\star \searrow 0$

- Full allotment of liquidity: *as if* $\widetilde{lp}_\star + \widetilde{cr}_\star \searrow 0$
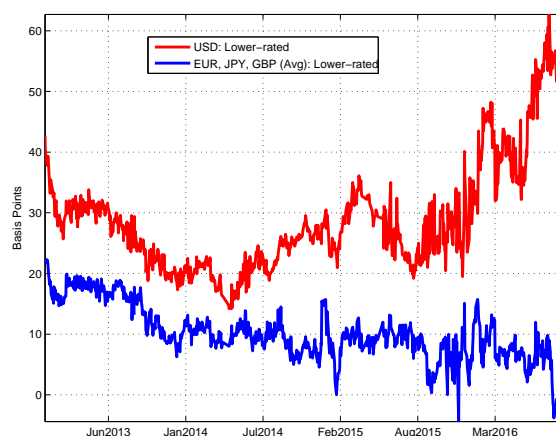
$\implies$ **LOOP can't hold for all rates simultaneously**

Funding cost heterogeneity

Commercial Paper (CP) rates - OIS rates: **USD** vs **Other Major Currencies**

(a) Top-rated banks

(b) Lower-rated banks

▸ More

Data requirements for CIP arbitrage

Funding side: Post-GFC environment

⇒ Critical to use actual *marginal funding rates*

  ● ~~OIS, GC Repo or IBOR~~

⇒ Turn to wholesale **non-bank** funding sources:

  Commercial Paper (CP) & **Certificates of Deposit (CD)**

Investment side:　　　　CIP: absence of *risk-free* Arb

⇒ Need to place funds risk-free

⇒ Safe investment (zero R.W.) - no capital costs

  ● **CB deposits** (restricted access) *in*sensitive to Liquidity Premiums
  ● **T-bills** (widely accessible) responsive to excess liquidity and Liquidity Premium compression

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Data

Hi-Freq data from Reuters:

  ● 2005-Dec.2015
  ● Tenors 1w-3m
  ● AUD, CAD, CHF, EUR, GBP, JPY vs. USD
  ● Market conventions & bid-ask-spreads
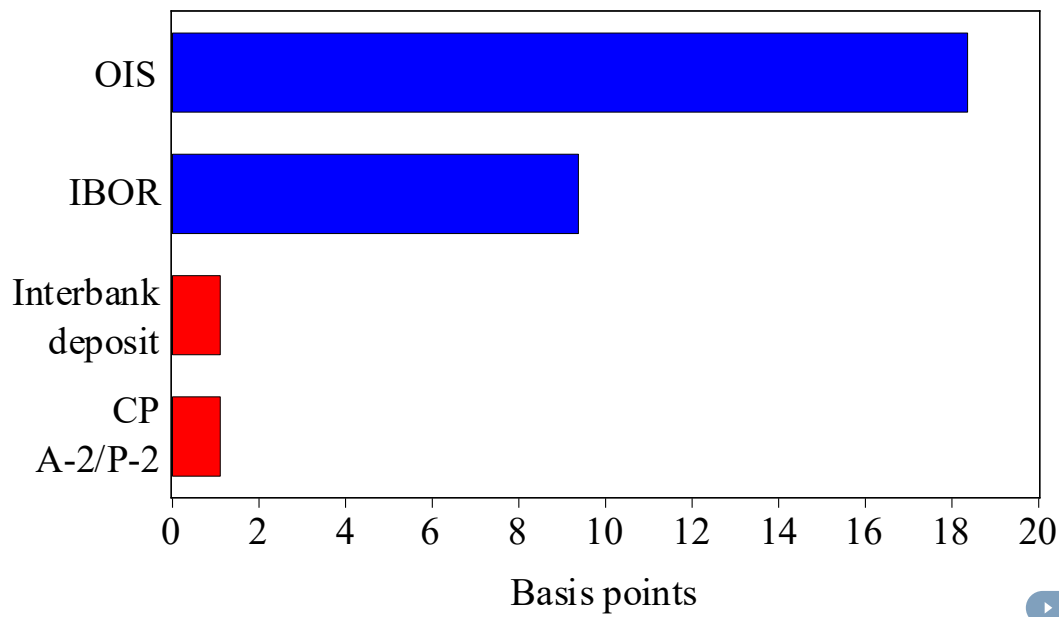
  ▸ More

Further data:

  ● FX Swap Order Flow (*Reuters Dealing*)
  ● CP-rates (TradeWeb)
    ▸ Best-rated: A-1+/P-1
    ▸ Top-rated: A-1/P-1
    ▸ Lower: A-2/P-2
  ● CD rates and issuance
  ● Bank of Japan deposit holdings

  ▸ More

LOOP deviation for different rates

Average across EUR, GBP, JPY.   **Post-crisis**
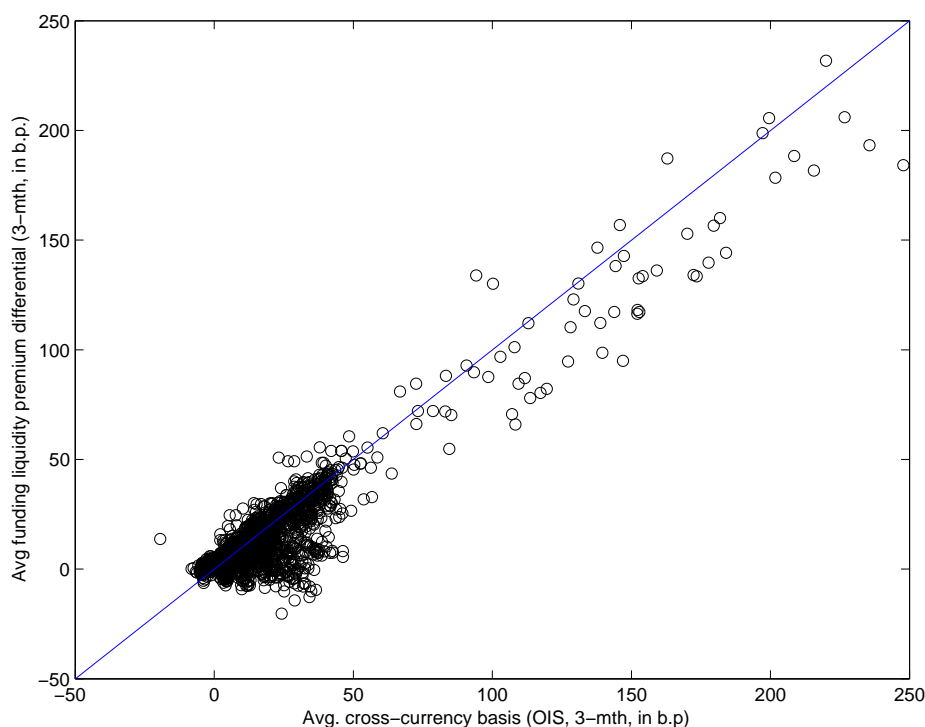
Measure Funding Liquidity Premia

$$r_{i;\$} = r_{\$}^{f} + cr_i + \widetilde{lp_{\$}}$$

- Panel-data on 3-mth interbank deposit rates (r_i) across currencies
- Proxy r^f by OIS-rate; Assume cr_i is bank-specific

$\Rightarrow$ Extract Funding Liquidity Premium differential

$$\widetilde{lp}_{\$} - \widetilde{lp}_{\star} = \frac{1}{J_t}\sum_{i=1}^{J_t}\left[\left(r_{i;\$} - r_{\$}^{OIS}\right) - \left(r_{i;\star} - r_{\star}^{OIS}\right)\right]$$

OIS basis and Liquidity Premia diff

▸ More

True CIP Arb   (Post-crisis)

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

	A-2/P-2		A-1/P-1		A-1+/P-1	
	Median	(%D)	Median	(%D)	Median	(%D)
AUD	**-38.9**	0 %	**-25.9**	0 %	**-21.0**	18 %
CAD	**-28.6**	0 %	**-15.5**	1 %	**-9.3**	5 %
CHF	**-13.6**	9 %	**-0.2**	49 %	**6.0**	78 %
EUR	**-23.2**	1 %	**-9.3**	6 %	**-3.4**	32 %
GBP	**-25.3**	0 %	**-12.5**	7 %	**-6.5**	21 %
JPY	**-4.8**	30 %	**6.3**	95 %	**12.5**	100 %

▸ More

True CIP Arb   (Post-crisis)

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

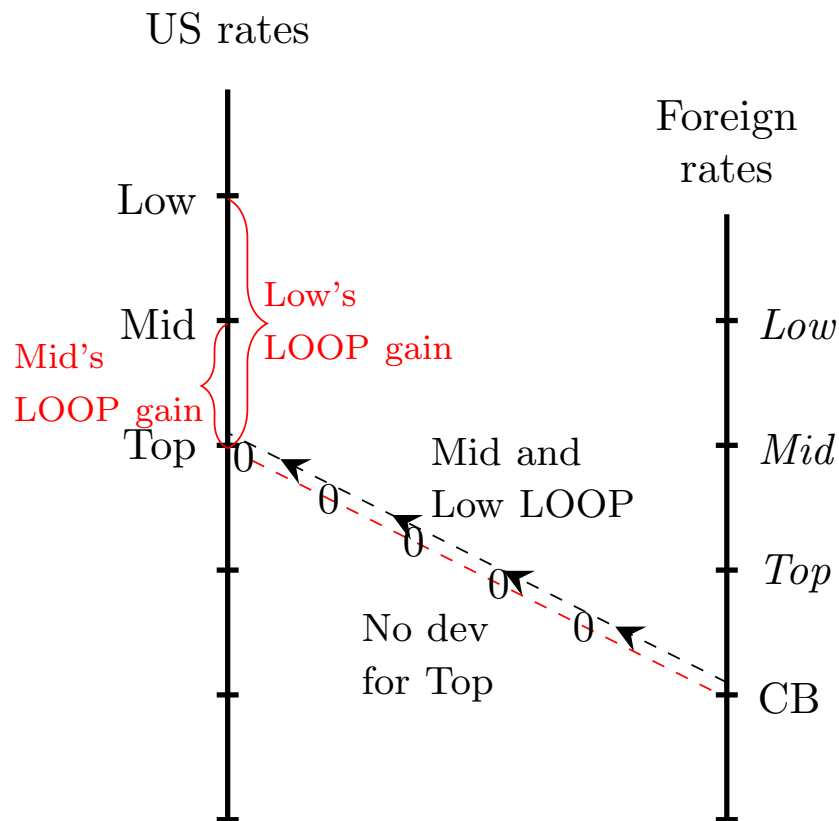|	A-2/P-2		A-1/P-1		A-1+/P-1	
	Median	(%D)	Median	(%D)	Median	(%D)
AUD	**-53.5**	0 %	**-42.6**	0 %	**-35.9**	0 %
CAD	**-20.1**	0 %	**-7.5**	14 %	**-1.5**	35 %
CHF	**0.5**	53 %	**13.1**	100 %	**18.7**	100 %
EUR	**-22.9**	7 %	**-9.7**	29 %	**-3.6**	44 %
GBP	**-12.9**	1 %	**0.6**	59 %	**7.4**	98 %
JPY	**4.0**	65 %	**13.3**	100 %	**18.8**	100 %

▸ More

FX Swap Market

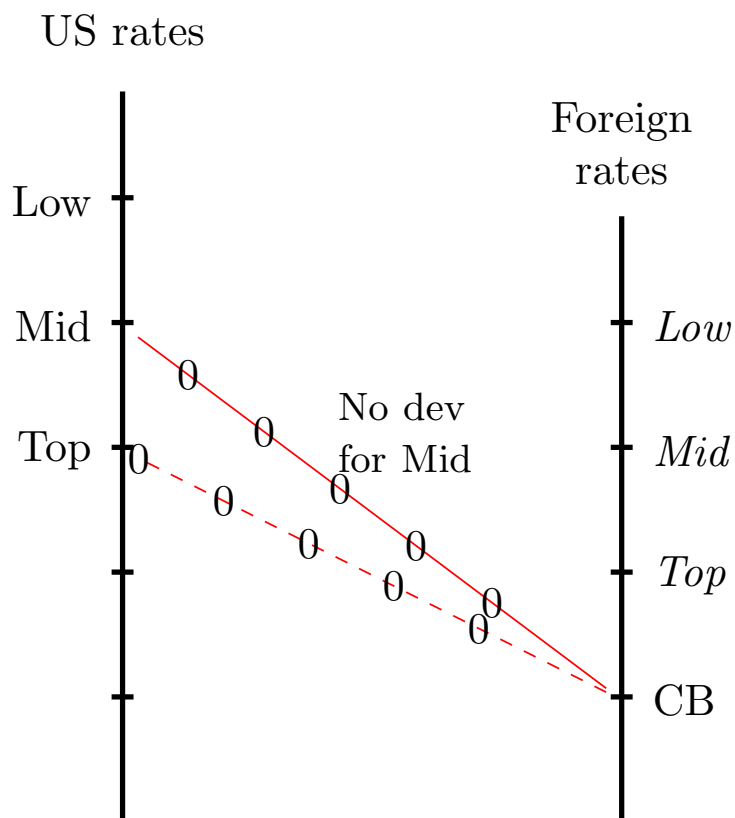**(a) "Normal" situation: Equilibrium, No Arb, No Flow imbalance**
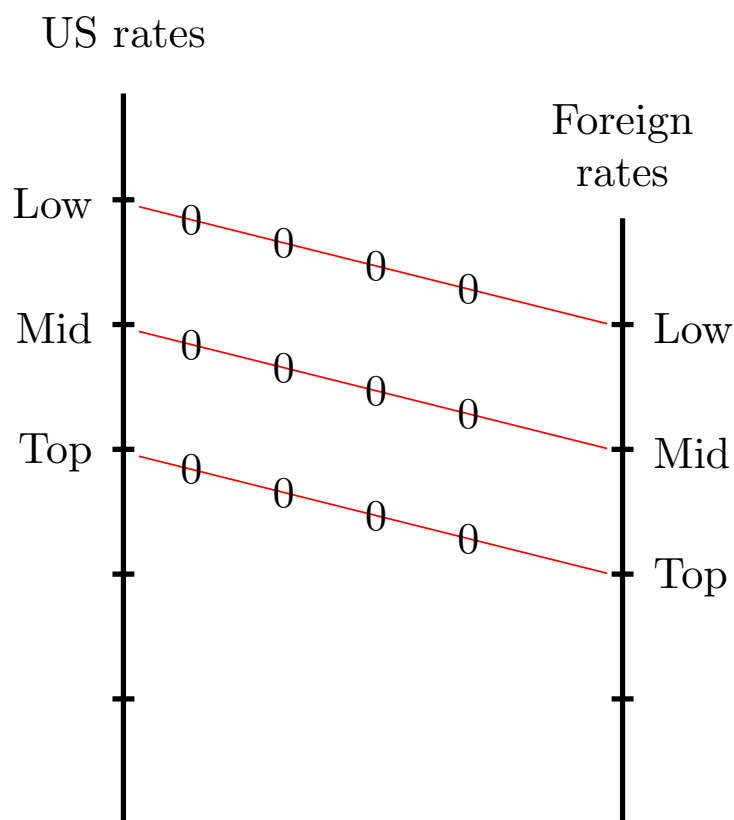
FX Swap Market

(b) Example of no equilibrium with excess liquidity

FX Swap Market

(c) Excess liquidity: Equilibrium swap rate

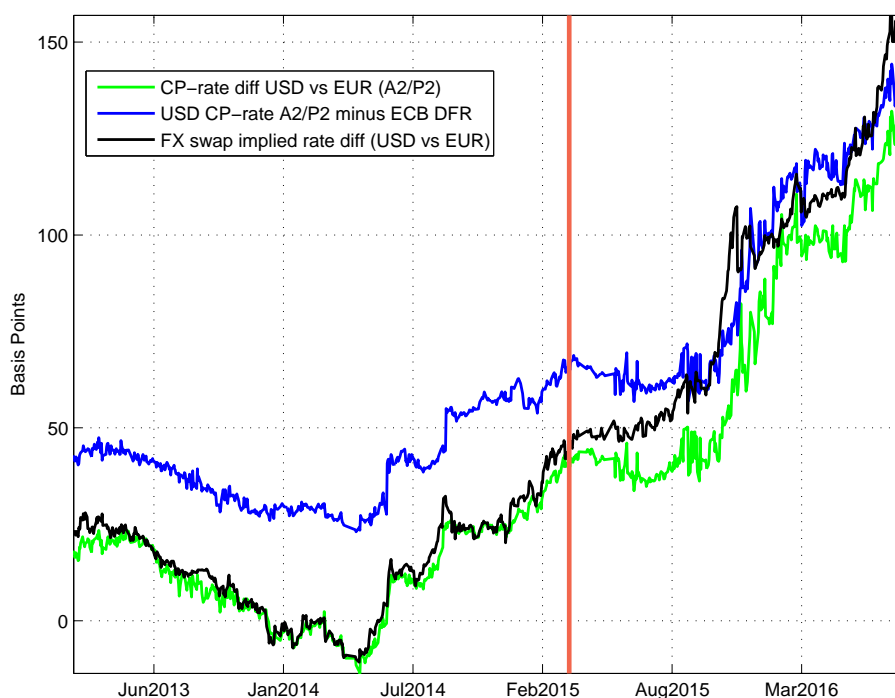# FX Swap Market
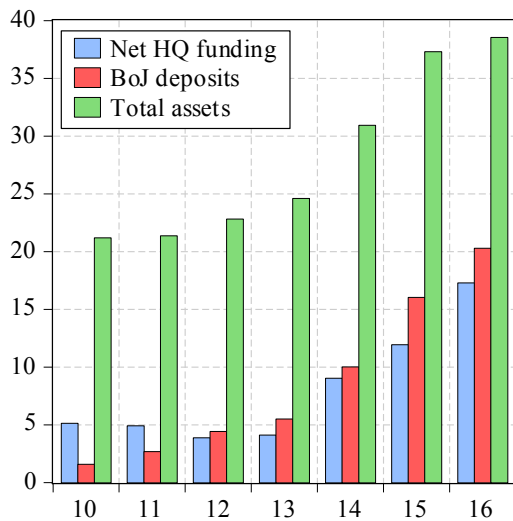
(d) Excess liquidity: Equilibrium flows
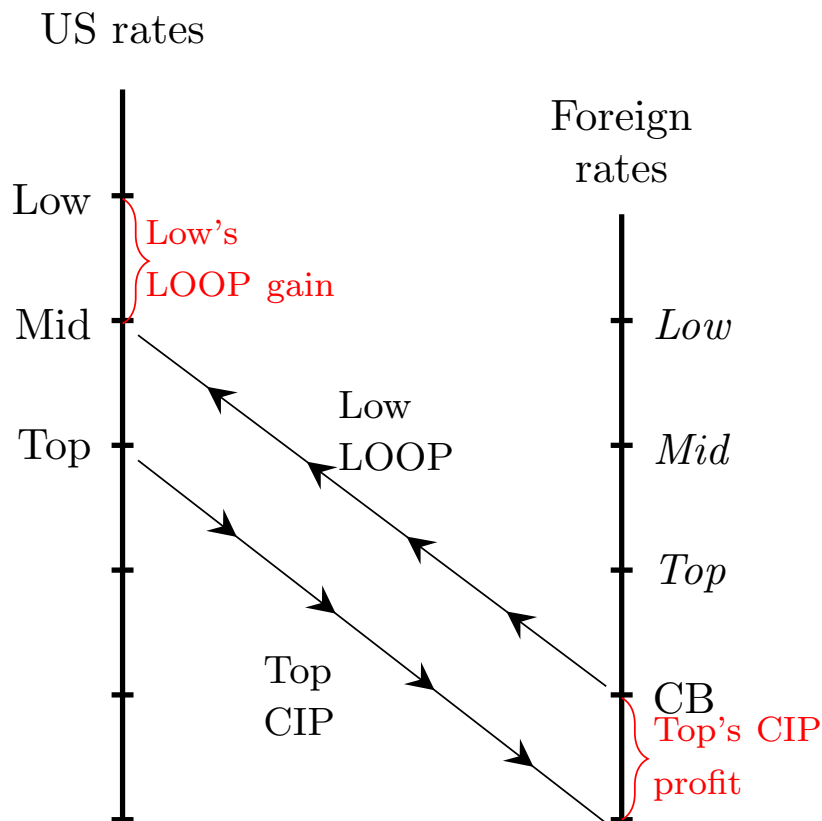
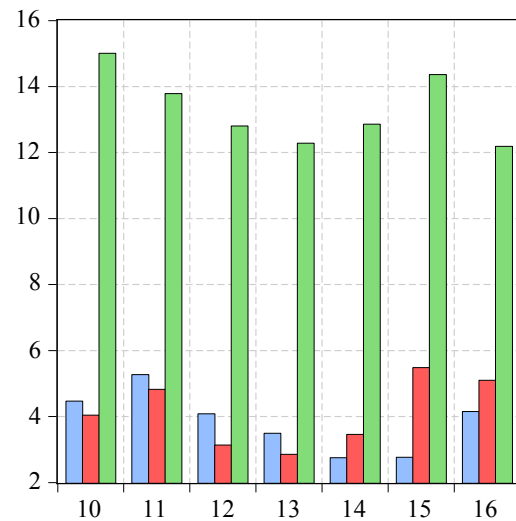
Excess liquidity and the new LOOP

Some evidence from the ECB's Asset Purchase Program

Cash deposits of foreign' banks with Bank of Japan

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

▸ More

CD issuance in US Dollars

Dispersion in USD funding costs - top-rated banks
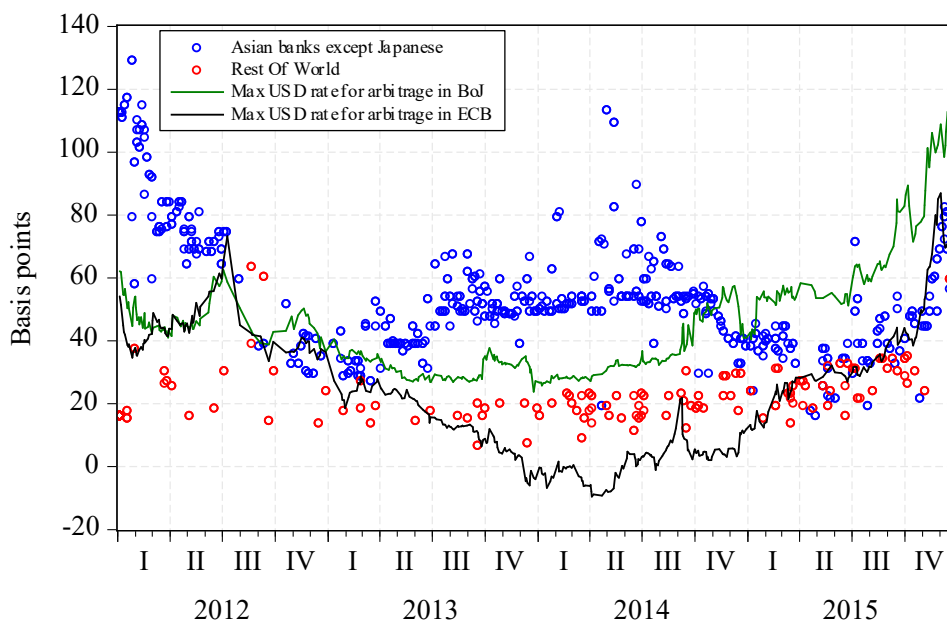
▸ More

CIP arb and Swap Order Flow

$$\Delta CIP^{dev}_{i,t} = \alpha_i + \gamma \cdot CIP^{dev}_{i,t-1}$$
$$+ D_{i,t} \cdot \beta_{swapOF} OF^{swap}_{i,t} / \text{sd}(OF^{swap}_{i,t}) + Controls + \varepsilon_{i,t}$$

- Panel regression (CrossX FE, CrossX clustering)
- Lagged dependent variable: "error-correction"
- 2 regimes, deviation-dummy: $\beta_i = \left[\beta^{Dev}_i, \beta^{NoDev}_i \right]$
- OF_{swap}: measures demand pressure to raise USD through swaps *(standardized)*

▸ More

Order flow regressions

	A-2/P-2 (1)	A-1/P-1 (2)	A-1/P-1 (3)
Deviation, level lagged	-0.04	-0.07	-0.07
	(-2.31)	(-4.62)	(-6.69)
Swap OF, both dev			2.75
			(2.70)
Swap OF, dev	3.26	0.75	0.65
	(3.09)	(2.45)	(4.42)
Swap OF, no dev	0.91	0.49	0.26
	(2.87)	(2.41)	(1.97)

Additonal controls . . . (see Appendix)

Conclusions

Main forces for recent FX swap market "dislocations"

1. **Segmentation** + tiering in international money markets

2. **Funding Liquidity Premia** evolution differ across currency areas

$\rightarrow$ Substantial heterogeneity in banks' funding costs across (and within) major currency areas ...

$\rightarrow$ Narrow set of banks enjoys risk-free CIP Arb

$\rightarrow$ But, not easy to scale the arbitrage ...

$\Rightarrow$ **Equilibrium outcome** in post-GFC environment with segmented markets and excess liquidity

Part II

Additional material

Literature

Classics and pre-crisis evidence
Branson (1969), Frenkel and Levich (1975, 1977): large deviations
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)

$\Rightarrow$ Large & persistent deviations, yet **no turmoil!**

$t = 0$ — **Borrow 1 USD**

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

$t = 0$ — **Forward contract F**

No Arbitrage
$$F = S\frac{1+i_{USD}}{1+i_{EUR}}$$

Repay debt $1 + i_{USD}$

$t = 1$

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

▸ Back
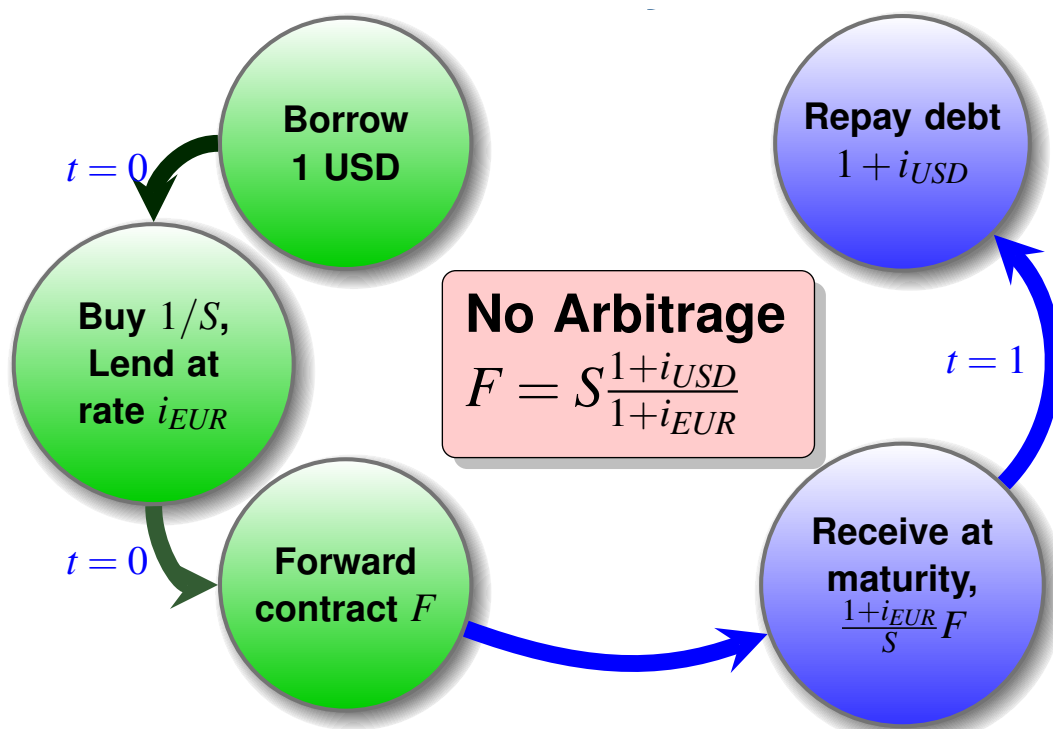
CIP (LOOP) with bid-ask spreads

CIP arbitrage is *not* profitable . . .

$$(1 + r_d^a) \geqslant \frac{F^b}{S^a}(1 + r_f^b) \qquad (1)$$

$$(1 + r_f^a) \geqslant \frac{S^b}{F^a}(1 + r_d^b) \qquad (2)$$

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)

▸ Back

Market conventions and the cross-currency basis

$$Dev_{CIP}^b = -i_d^a + \left[\frac{S^a + \overline{F^b - S^a}/10^4}{S^a}\left(100 + i_f^b\frac{D}{360}\right) - 100\right]\frac{360}{D},$$

$$Dev_{CIP}^a = -i_f^a - \left[\frac{S^b}{S^b + \overline{F^a - S^b}/10^4}\left(100 + i_d^b\frac{D}{360}\right) - 100\right]\frac{360}{D}.$$

- Swap, represented by $\overline{F^b - S^a}$ (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

▸ Back

Part III

Data and Funding cost heterogeneity

Funding cost heterogeneity

US money market spreads (3-mth)
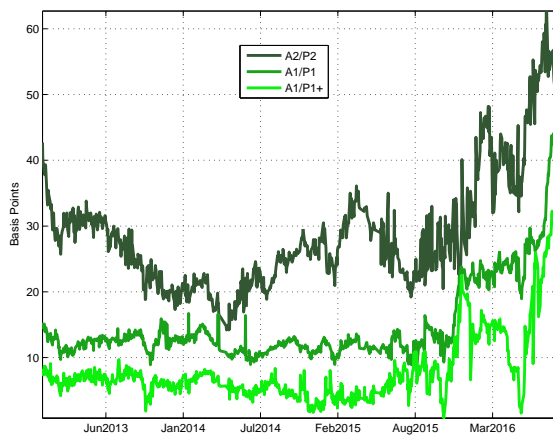
(a) USD commercial paper
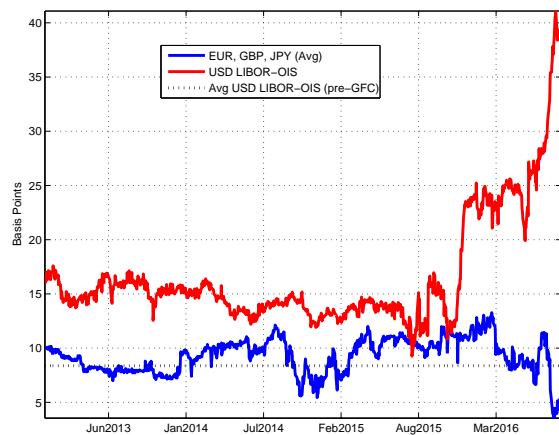
(b) USD LIBOR-OIS vs other currencies

Heterogenous funding costs

Evidence from the LIBOR panel
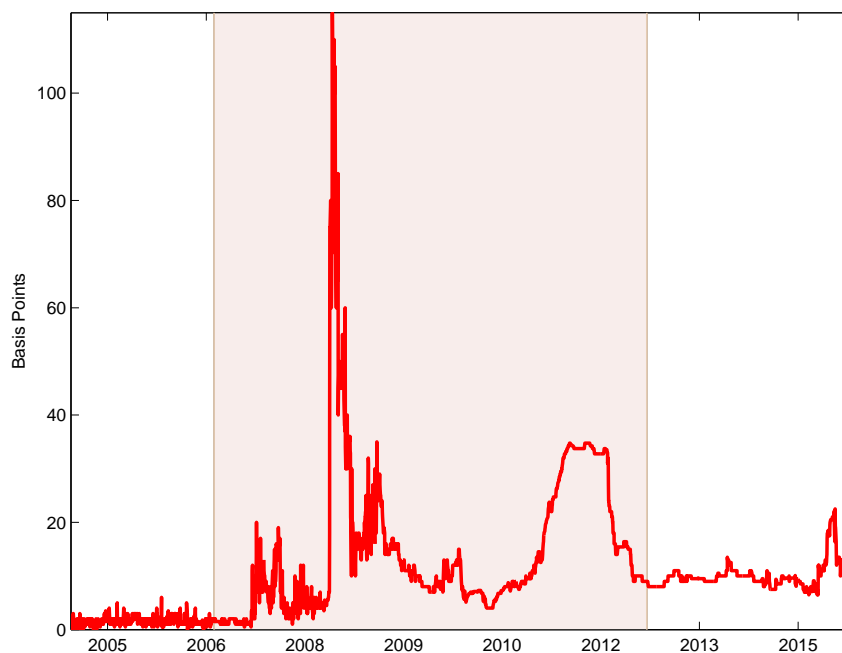
Data overview

FX

	Trade-able	Risk-free	High-freq	Tenors Tenors	Currencies
Spot (D2)	Y	–	Y	–	AUD, CAD, CHF, EUR, GBP, JPY
FX Swaps	N	–	Y	1W-3M	AUD, CAD, CHF, EUR, GBP, JPY
FX Swaps (D3)	Y	–	Y	1W-3W	AUD, CAD, CHF, EUR, GBP, JPY

Data overview

Interest rates

	Trade-able	Risk-free	High-freq	Tenors Tenors	Currencies
Secured					
OIS	Y	Y	Y	1W-3M	USD, EUR, GBP*, JPY*
			Y	1M-3M	AUD, CAD, CHF
Repo (GC)	Y	Y	D	1M, 3M	USD, EUR
T-bills	Y	Y	D	1M, 3M	USD, AUD, CAD, CHF, EUR, GBP, JPY
CB deposits	Y	Y	D	1M, 3M	USD, AUD, CAD, CHF, EUR, GBP, JPY
Unsecured					
Deposit	N	N	Y	1W-3M	USD, AUD, CAD, CHF, EUR, GBP, JPY
IBOR	N	N	D	3M	USD, AUD*, CAD, CHF, EUR, GBP, JPY
CP	Y	N	D	1M, 3M	USD, AUD, CAD, EUR, GBP, JPY

Descriptives

Money market spreads (over OIS)

	Deposit	Repo	IBOR
Mean	0.324	-0.105	0.291
Median	0.174	-0.095	0.145
Maximum	4.776	0.341	3.663
Minimum	-0.140	-1.464	0.025
Std. Dev.	0.478	0.136	0.391
Skewness	4.334	-2.331	3.949
Kurtosis	28.453	16.746	24.023
Observations	2801	1740	2733

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

$\Rightarrow$ Rolling over short-term O/N funding allows arbitrageur to reduce funding cost

$\Rightarrow$ But, this comes at the cost of taking on additional *liquidity risk* in the borrowing currency ...

▸ Back

Roundtrip cross-currency basis arbitrage with OIS rates (I)

	Direction	GFC and EUR crisis		Deviation			
		Median	Std.	(%D)	(%W)	(%M)	Obs.
EUR	$FCU \Rightarrow USD$	-29.8	38.2	0%	0%	0%	1566
	$USD \Rightarrow FCU$	23.5	35.4	92%	91%	88%	1566
GBP	$FCU \Rightarrow USD$	-13.6	34.7	3%	2%	0%	1395
	$USD \Rightarrow FCU$	7.5	31.3	87%	79%	61%	1395
JPY	$FCU \Rightarrow USD$	-31.1	16.6	0%	0%	0%	796
	$USD \Rightarrow FCU$	25.7	16.7	100%	99%	97%	796

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

"Direction" indicates if round-trip goes "$USD \Rightarrow FCU$" or "$FCU \Rightarrow USD$" at spot leg of swap

▸ More

Roundtrip cross-currency basis arbitrage with OIS rates (II)

	Direction	Post-crisis		Deviation			
		Median	Std.	(%D)	(%W)	(%M)	Obs.
EUR	$FCU \Rightarrow USD$	-18.8	16.0	0%	0%	0%	728
	$USD \Rightarrow FCU$	12.8	9.3	94%	92%	87%	728
GBP	$FCU \Rightarrow USD$	-8.1	3.7	0%	0%	0%	725
	$USD \Rightarrow FCU$	3.1	3.6	99%	97%	95%	725
JPY	$FCU \Rightarrow USD$	-23.8	14.4	0%	0%	0%	694
	$USD \Rightarrow FCU$	19.9	14.2	100%	100%	100%	694

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

"Direction" indicates if round-trip goes "$USD \Rightarrow FCU$" or "$FCU \Rightarrow USD$" at spot leg of swap

▸ More

Roundtrip cross-currency basis arbitrage with OIS rates (III)

	Direction	GFC and EUR crisis					Post-crisis				
		Median	Std.	(%D)	(%W)	(%M)	Median	Std.	(%D)	(%W)	(%M)
AUD	$FCU \Rightarrow USD$	-10.2	40.4	18%	14%	7%	6.9	9.6	64%	61%	56%
	$USD \Rightarrow FCU$	2.5	38.2	61%	52%	41%	-12.3	9.5	13%	11%	7%
CAD	$FCU \Rightarrow USD$	-13.0	37.3	1%	0%	0%	-7.7	4.0	1%	0%	0%
	$USD \Rightarrow FCU$	6.0	31.2	88%	79%	62%	2.4	3.8	76%	67%	47%
CHF	$FCU \Rightarrow USD$	-41.3	31.4	0%	0%	0%	-31.2	28.3	0%	0%	0%
	$USD \Rightarrow FCU$	32.3	27.9	100%	100%	98%	23.9	24.8	100%	100%	100%

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

"Direction" indicates if round-trip goes "$USD \Rightarrow FCU$" or "$FCU \Rightarrow USD$" at spot leg of swap

▸ Back

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 **rollover** and **liquidity risks**   ▸ Evidence

$\Rightarrow$ Fluctuations of OIS FX swap basis largely reflect relative **term funding liquidity premiums** vis-a-vis USD ...

$\Rightarrow$ Can't make judgement about validity of a no-Arb condition like CIP

$\Rightarrow$ Similar arguments apply to FX swap basis constructed from GC repo rates

▸ Arb trade sequence w OIS   ▸ Repo   ▸ Funding liquidity premia

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

$\rightarrow$ To capture marginal funding costs for repo-based CP arbitrage, it is necessary to adjust for the (unsecured) funding cost of the collateral

▸ Back

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

▸ Back

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

▸ Back

FTP: Implications

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

- Otherwise, internal business units may exploit inconsistency

$\Rightarrow$ 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)

$\Rightarrow$ Expect CIP to hold to a close approximation between interbank deposit rates (after TC-adjustment) ...

Funds Transfer Pricing

Treasury

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

Capital Markets

← Hedge

Raise funds →

Capital Markets

FTP Book: FTP all assets and liabilities

FTP assets

FTP liabilities

FTP assets

FTP liabilities

Loans

Deposit

Loans

Deposit

Business A

Business B

▸ Back

Part V

LOOP

LOOP and IBOR

$$(i) \quad \underbrace{y^{\$}}_{\text{Direct \$-rate}} - \underbrace{y^{FCU \to \$}}_{\text{Swap-implied \$-rate}}$$

$$(ii) \quad \underbrace{y^{FCU}}_{\text{Direct FCU -rate}} - \underbrace{y^{\$ \to FCU}}_{\text{Swap-implied FCU-rate}}$$

		GFC and EUR crisis						Post-crisis					
				Deviation						Deviation			
		Median	Std.	(%D)	(%W)	(%M)	Obs.	Median	Std.	(%D)	(%W)	(%M)	Obs.
EUR	(i)	**-33.7**	33.3	11%	8%	3%	1422	**-13.7**	9.1	1%	0%	0%	711
	(ii)	**31.6**	31.4	88%	85%	77%	1422	**12.4**	8.8	98%	97%	90%	711
GBP	(i)	**-17.0**	30.3	5%	1%	0%	1422	**-2.1**	4.1	12%	7%	1%	711
	(ii)	**15.3**	27.4	91%	85%	76%	1422	**1.4**	4.0	80%	71%	53%	711
JPY	(i)	**-18.5**	20.1	11%	6%	2%	1500	**-15.4**	12.9	0%	0%	0%	729
	(ii)	**16.2**	19.0	84%	77%	68%	1500	**14.3**	12.6	100%	100%	100%	729

▸ Back

LOOP and interbank deposit

$$(i) \quad \underbrace{y^\$}_{\text{Direct \$-rate}} - \underbrace{y^{FCU\to\$}}_{\text{Swap-implied \$-rate}}$$

$$(ii) \quad \underbrace{y^{FCU}}_{\text{Direct FCU -rate}} - \underbrace{y^{\$\to FCU}}_{\text{Swap-implied FCU-rate}}$$

| | | GFC and EUR crisis | | | | | | Post-crisis | | | | | |
| | | | | Deviation | | | | | | Deviation | | | |
		Median	Std.	(%D)	(%W)	(%M)	Obs.	Median	Std.	(%D)	(%W)	(%M)	Obs.
EUR	(i)	**-4.0**	9.9	11%	1%	0%	1488	**-0.8**	2.4	13%	0%	0%	728
	(ii)	**3.2**	9.9	81%	62%	40%	1488	**0.4**	2.4	75%	44%	17%	728
GBP	(i)	**-4.5**	7.7	21%	8%	4%	1472	**-0.8**	2.9	26%	5%	0%	725
	(ii)	**3.7**	7.2	74%	53%	32%	1472	**0.6**	2.9	65%	33%	8%	725
JPY	(i)	**-2.0**	4.7	23%	8%	1%	1417	**-2.5**	3.1	10%	0%	0%	694
	(ii)	**1.4**	4.9	68%	43%	22%	1417	**2.3**	3.0	87%	65%	38%	694

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LOOP for CP rates (A-2/P-2)

$$(i) \quad \underbrace{y^\$}_{\text{Direct \$-rate}} - \underbrace{y^{FCU\to\$}}_{\text{Swap-implied \$-rate}}$$

$$(ii) \quad \underbrace{y^{FCU}}_{\text{Direct FCU -rate}} - \underbrace{y^{\$\to FCU}}_{\text{Swap-implied FCU-rate}}$$

| | | | | Deviation | | | |
		Median	Std.	(%D)	(%W)	(%M)	Obs.
EUR	(i)	**-4.2**	8.6	3%	0%	0%	716
	(ii)	**3.4**	8.4	93%	79%	54%	716
GBP	(i)	**-0.3**	4.2	44%	22%	8%	716
	(ii)	**-0.4**	4.1	43%	21%	7%	716
JPY	(i)	**-1.6**	6.4	25%	4%	0%	714
	(ii)	**0.3**	6.1	55%	28%	8%	714

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Part VI

Funding Liquidity Premia

Funding liquidity premia and the basis

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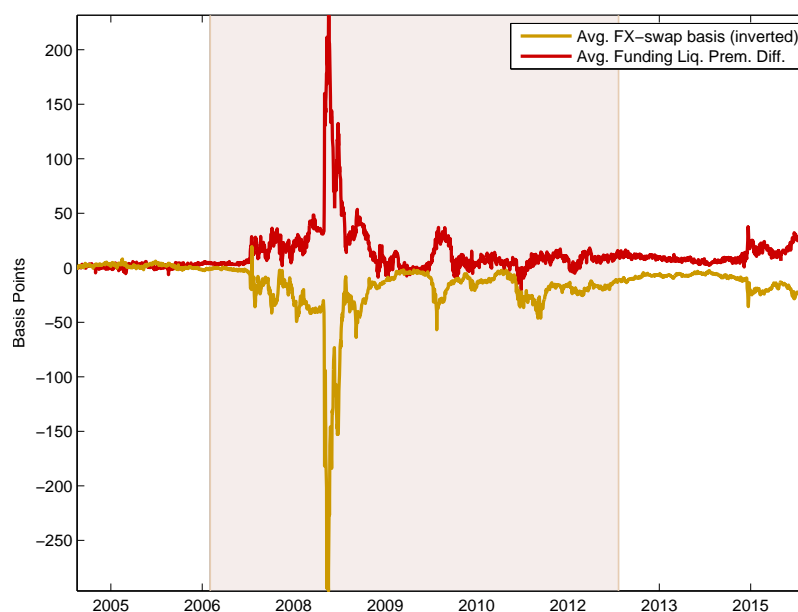
Funding liquidity premia and the basis
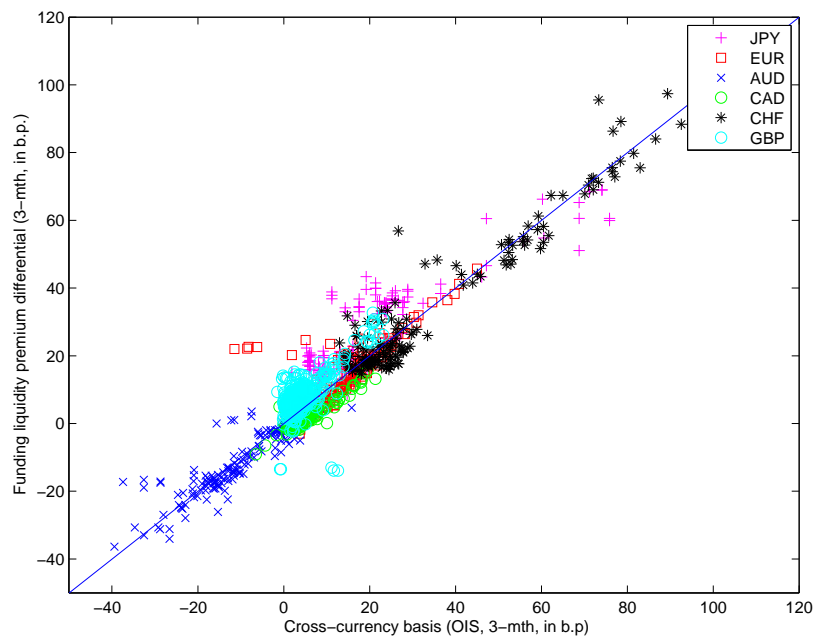
Funding liquidity premia and the basis

Commercial paper
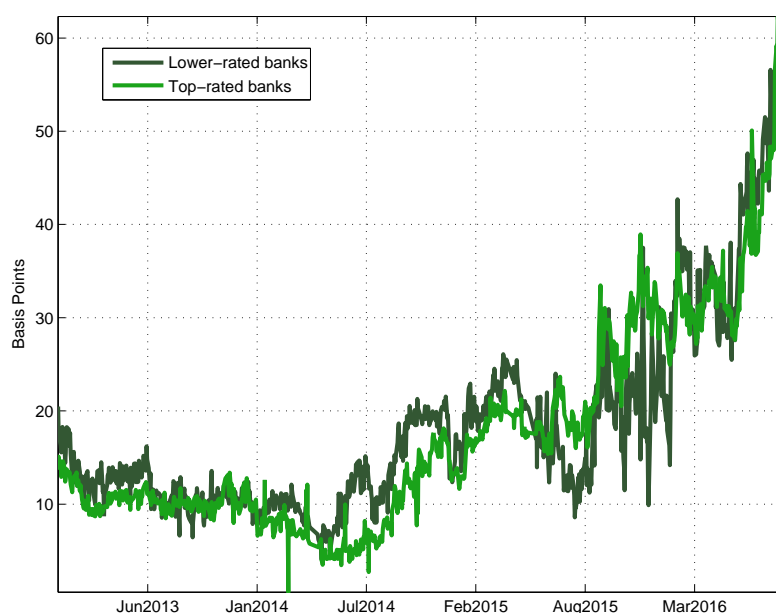
Part VII

True CIP Arbitrage

True CIP Arb (Post-crisis)

Funded via USD CP and investing in T-Bills

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

	Median	Std.	(%D)	(%W)	(%M)	Obs.
AUD	**-38.9**	10.4	0%	0%	0%	167
CAD	**-28.6**	6.9	0%	0%	0%	691
CHF	**-13.6**	10.7	9%	6%	3%	679
EUR	**-23.2**	6.1	1%	0%	0%	713
GBP	**-25.3**	7.1	0%	0%	0%	688
JPY	**-4.8**	10.8	30%	18%	9%	497

True CIP Arb   (Post-crisis)

Funded via USD CP and investing in T-Bills

Top-rated banks (A-1/P-1)

	Median	Std.	(%D)	(%W)	(%M)	Obs.
AUD	**-25.9**	13.2	0%	0%	0%	167
CAD	**-15.5**	5.5	1%	0%	0%	691
CHF	**-0.2**	10.7	49%	28%	9%	679
EUR	**-9.3**	7.4	6%	3%	0%	713
GBP	**-12.5**	6.7	7%	6%	3%	688
JPY	**6.3**	10.6	95%	88%	80%	497

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True CIP Arb   (Post-crisis)

Funded via USD CP and investing in T-Bills

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

	Median	Std.	(%D)	(%W)	(%M)	Obs.
AUD	**-21.0**	13.4	18%	11%	0%	161
CAD	**-9.3**	5	5%	2%	0%	683
CHF	**6.0**	10.6	78%	65%	45%	671
EUR	**-3.4**	7.4	32%	23%	14%	705
GBP	**-6.5**	6.7	21%	13%	5%	680
JPY	**12.5**	10.7	100%	100%	100%	492

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True CIP Arb   (Post-crisis)

Funded via USD CP and placing funds with foreign CB

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

	Median	Std.	(%D)	(%W)	(%M)	Obs.
AUD	**-53.5**	11	0%	0%	0%	639
CAD	**-20.1**	6.9	0%	0%	0%	696
CHF	**0.5**	16.9	53%	41%	31%	699
EUR	**-22.9**	11.5	7%	4%	1%	696
GBP	**-12.9**	5.2	1%	0%	0%	698
JPY	**4.0**	14.8	65%	60%	49%	699

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True CIP Arb   (Post-crisis)

Funded via USD CP and placing funds with foreign CB

Top-rated banks (A-1/P-1)

	Median	Std.	(%D)	(%W)	(%M)	Obs.
AUD	**-42.6**	11.4	0%	0%	0%	639
CAD	**-7.5**	5.6	14%	9%	2%	696
CHF	**13.1**	17.9	100%	99%	97%	699
EUR	**-9.7**	13.1	29%	25%	19%	696
GBP	**0.6**	3.5	59%	46%	28%	698
JPY	**13.3**	14.6	100%	100%	100%	699

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True CIP Arb   (Post-crisis)

Funded via USD CP and placing funds with foreign CB

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

	Median	Std.	(%D)	(%W)	(%M)	Obs.
AUD	**-35.9**	11.3	0%	0%	0%	631
CAD	**-1.5**	5.6	35%	24%	12%	688
CHF	**18.7**	18.1	100%	99%	97%	691
EUR	**-3.6**	12.9	44%	42%	37%	688
GBP	**7.4**	3.7	98%	96%	92%	690
JPY	**18.8**	14.8	100%	100%	100%	691

Cash deposits of foreign banks with Bank of Japan

Panel regression: $(BoJCash - Funding)/TotAssets$

	(1)	(2)	(3)	(4)
Rating	-0.019	-0.019	-0.018	-0.019
	(-2.44)	(-2.41)	(-2.32)	(-2.33)
CIP, top rating		0.295		0.150
		(1.83)		(1.00)
CIP, low rating			0.109	0.089
			(3.81)	(4.47)

CD issuance in US Dollars

Dispersion in USD funding costs - low-rated banks

Legend:
- ○ 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

Y-axis: Basis points
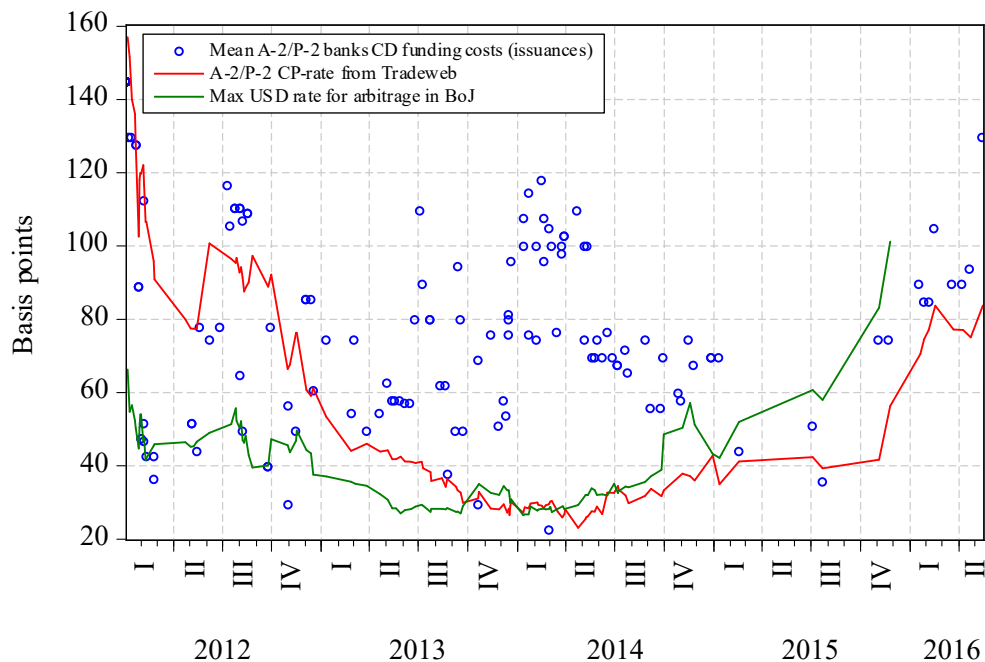
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Activity in US interbank markets

Y-axis: USD billions

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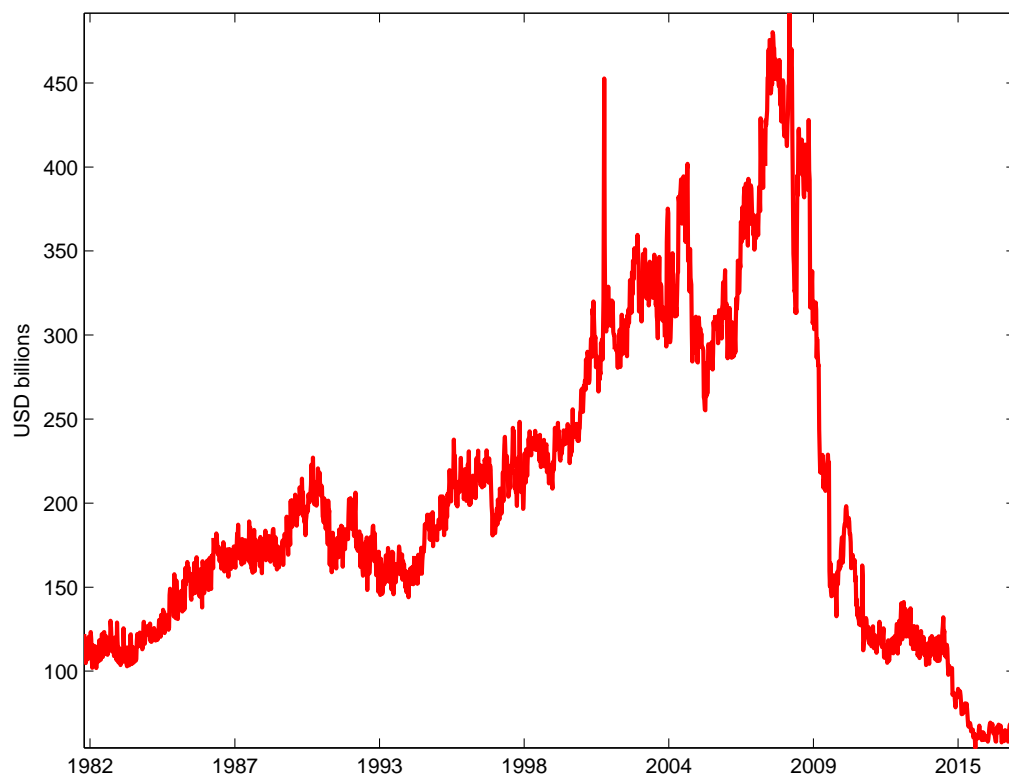
Global banks and their ratings

	Rating category			
	A-1+/P-1	A-1/P-1	A-2/P-2	Lower/No

A: Non-Asian banks, including Japanese banks

	A-1+/P-1	A-1/P-1	A-2/P-2	Lower/No
Average size	749	861	877	310
Total size	8,990	35,301	14,907	19,519
# banks	12	41	17	63

B: Asian banks, excluding Japanese banks

	A-1+/P-1	A-1/P-1	A-2/P-2	Lower/No
Average size	301	1,026	473	342
Total size	1,803	11,282	3,311	6,155
# banks	6	11	7	18

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)
  $\rightarrow$ 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.)

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

OF: Robustness

	A-2/P-2		A-1/P-1	
	(1)	(2)	(3)	(4)
Swap OF, dev	1.54	1.81	0.58	0.69
	(2.37)	(2.49)	(2.38)	(9.14)
Swap OF, no dev	0.17	0.16	0.21	0.25
	(3.87)	(3.62)	(2.20)	(1.91)
Spot index, dev	1.44		0.64	
	(1.68)		(1.32)	
Spot index, no dev	0.03		-1.66	
	(0.11)		(-2.92)	
Spot, dev		1.05		0.28
		(0.92)		(2.06)
Spot, no dev		-0.64		-0.78
		(-1.56)		(-3.77)
LP diff, dev	0.13		0.16	
	(5.28)		(5.82)	
LP diff, no dev	0.06		0.01	
	(2.58)		(0.35)	

References I

Q. Farooq Akram, Dagfinn Rime, and Lucio Sarno. Arbitrage in the foreign exchange market: Turning on the microscope. *Journal of International Economics*, 76:237–253, 2008.

Stefan Avdjiev, Wenxin Du, Catherine Koch, and Hyun Song Shin. The dollar, bank leverage and the deviation from covered interest parity. Working Paper 592, BIS, November 2016. URL http://www.bis.org/publ/work592.htm.

Naohiko Baba and Frank Packer. Interpreting deviations from covered interest parity during the financial market turmoil of 2007-08. *Journal of Banking and Finance*, 33(11): 1953–1962, 2009. ISSN 0378-4266.

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References II

Naohiko Baba, Frank Packer, and Teppei Nagano. The spillover of money market turbulence to fx swap and cross-currency swap markets. *BIS Quarterly Review*, (1):27–42, March 2008. URL
http://ideas.repec.org/a/bis/bisqtr/1012e.html.

Jean-Marc Bottazzi, Jaime Luque, Mario Pascoa, and Suresh M. Sundaresan. Dollar shortage, central bank actions, and the cross currency basis. typescript, Columbia Business School, October 2012. URL
http://ssrn.com/abstract=2167716.

William H. Branson. The minimum covered interest differential needed for international arbitrage activity. *Journal of Political Economy*, 77(6):1028–1035, 1969.

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BUSINESS SCHOOL

References III

Niall Coffey, Warren Hrung, Hoai-Luu Nguyen, and Asani Sarkar. Credit risk, liquidity risk and deviations from covered interest rate parity. Staff Report 393, Federal Reserve Bank of New York, 2009. URL https://www.newyorkfed.org/medialibrary/media/research/staff_reports/sr393.pdf.

Wenxin Du, Alexander Tepper, and Adrien Verdelhan. Deviations from covered interest rate parity. Working paper, MIT, August 2016. URL http://ssrn.com/abstract=2768207.

Jacob A. Frenkel and Richard M. Levich. Covered interest arbitrage: Unexploited profits. *Journal of Political Economy*, 83(2):325–338, 1975.

Jacob A. Frenkel and Richard M. Levich. Transaction costs and interest arbitrage: Tranquil versus turbulent periods. *Journal of Political Economy*, 85(6):1209–1226, 1977.

References IV

Linda S. Goldberg, Craig Kennedy, and Jason Miu. Central bank dollar swap lines and overseas dollar funding costs. *FRBNY Economic Policy Review*, pages 3–20, May 2011. URL http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.422.11&rep=rep1&type=pdf.

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.

Tomoyuki Iida, Takeshi Kimura, and Nao Sudo. Regulatory reforms and the dollar funding of global banks: Evidence from the impact of monetary policy divergence. Working Paper No.16-E-14, Bank of Japan, August 2016. URL https://www.boj.or.jp/en/research/wps_rev/wps_2016/data/wp16e14.pdf.

References V

Patrick McGuire and Goetz von Peter. The dollar shortage in global banking and the international policy response. *International Finance*, 15(2):155–178, jun 2012.

Vladyslav Sushko, Claudio Borio, Robert McCauley, and Patrick McGuire. The failure of covered interest parity: FX hedging demand and costly balance sheets. Working Paper 590, BIS, 2016. URL http://www.bis.org/publ/work590.htm.

Olav Syrstad. The impact of the Term Auction Facility on the liquidity risk premium and unsecured interbank spreads. Working Paper 7/2014, Norges Bank, 2014. URL http://www.norges-bank.no/en/Published/Papers/Working-Papers/2014/201407/.

Mark P. Taylor. Covered interest parity: A high-frequency, high-quality data study. *Economica*, 54(216):429–438, November 1987.