

Covered interest rate parity, relative funding liquidity risk and cross-currency repos

ECB workshop on money markets, monetary policy implementation, and central bank balance sheets

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The covered interest rate parity (CIP)

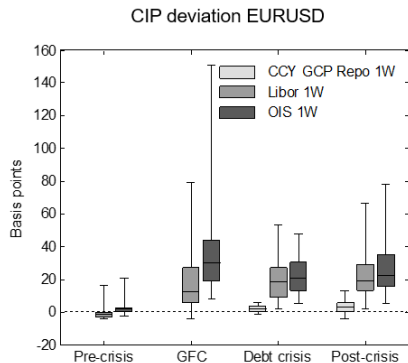
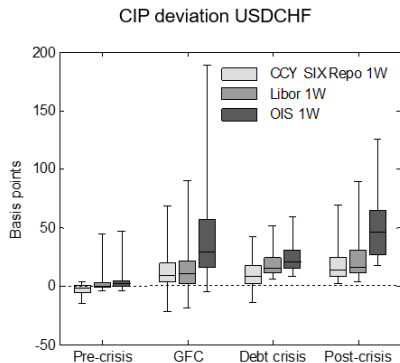
$$\frac{F_{t,t+1}}{S_t} = \frac{1 + i_{t,t+1}^p}{1 + i_{t,t+1}^b} \quad (1)$$

where $i_{t,t+1}^{p(b)}$ = price (base) currency money market interest rate

in logs:

$$f_{t,t+1} - s_t = i_{t,t+1}^p - i_{t,t+1}^b \quad (2)$$

The CIP across time and calculated using different money market interest rates



CIP deviation (in basis points): $\epsilon = f_{t,t+1} - s_t - i_{t,t+1}^p + i_{t,t+1}^b$

Pre GFC: CIP holds tightly

During GFC: CIP fails due to counterparty risk and USD funding shortages

Since 2014: CIP puzzle

- Regulation inhibits arbitrage
 - ▶ See Du et al. (2018) and Sushko et al. (2016)
- CIP holds better if risk factors are accurately taken into account
 - ▶ See Wong et al. (2016) and Rime et al. (2017)

Main findings of this paper

Empirical finding:

- Significantly smaller but non-zero CIP deviations when tested using cross-currency (CCY) repo rates compared to using standard money market interest rates

Theoretical findings:

- CCY repo rates accurately reflect risk-premia incorporated in FX swap pricing
- CCY repos allow for CIP arbitrage

Agenda

- 1 Theoretical considerations
- 2 Empirical analysis
- 3 Explaining CIP deviations
- 4 Conclusion and policy implications

Theoretical considerations

Risk premia considerations

Counterparty risk:

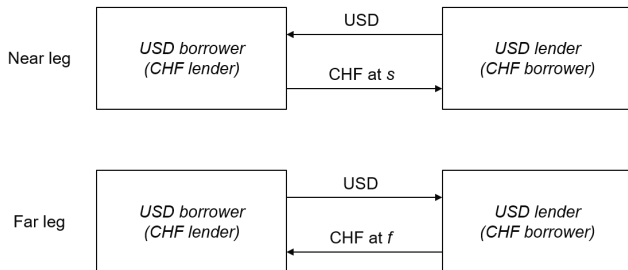
- Risk of a debtor defaulting on its contractual obligations

Funding liquidity risk:

- Ease at which funding can be obtained (see Brunnermeier and Pedersen (2009) and Rime et al. (2017))

Risk premia reflected in the pricing of FX swaps

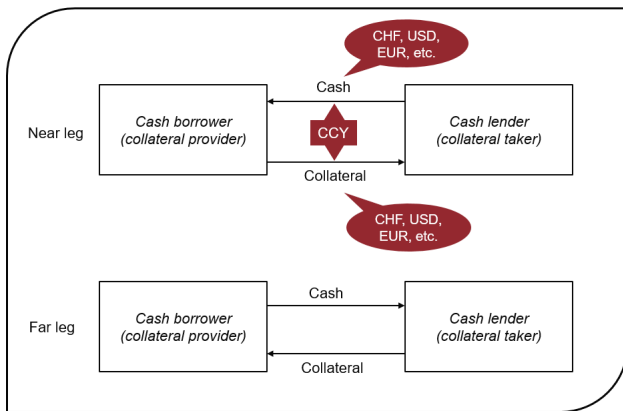
$$\text{CIP: } f_{t,t+1} - s_t = i_{t,t+1}^p - i_{t,t+1}^b$$



- Close to zero counterparty risk
- (Relative) funding liquidity risk

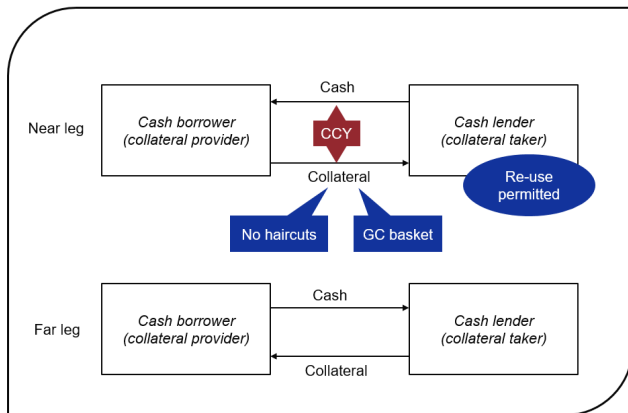
CCY repos correctly reflect FX swap risk premia

$$\text{CIP: } f_{t,t+1} - s_t = i_{t,t+1}^P - i_{t,t+1}^b$$



- Close to zero counterparty risk
- (Relative) funding liquidity risk (cash vs. collateral!)

CCY repos allow to conduct CIP arbitrage



- Conventional repos do not allow to conduct CIP arbitrage (see Du et al. (2018))

Risk premia and arbitrage overview

$$\text{CIP: } f_{t,t+1} - s_t = i_{t,t+1}^p - i_{t,t+1}^b$$

Instrument	Rel. CP risk	Rel. funding risk	Arbitrage
FX swap pricing	-	✓	
OIS rate diff.	-	-	✗
LIBOR rate diff.	✓	✓	✗
Repo rate diff.	-	-	✗
CCY repo rate diff.	-	✓	✓

Empirical analysis

Data overview and sequence of transactions

Instrument	Currencies	Source	Remarks
Spot/forward ex. rates	USDCHF, EURUSD	Bloomberg	Mid-prices, NY close prices
LIBOR rates	USD, CHF, EUR	Bloomberg	11 a.m. London time
OIS rates	USD, CHF, EUR	Bloomberg	Mid-prices, close prices
CCY SIX Repo rates	USD, CHF	SIX Repo Ltd	Vol. w. average, SNB GC
CCY GCP Repo rates	USD, EUR	Eurex Repo Ltd	Vol. w. average, ECB GC

Setup of regression – USDCHF

$$y_t = \beta_1 \cdot \text{Pre-crisis ex. Q-end}_t + \beta_2 \cdot \text{GFC ex. Q-end}_t + \\ + \beta_3 \cdot \text{Debt crisis ex. Q-end}_t + \beta_4 \cdot \text{Post-crisis ex. Q-end}_t + \\ + \beta_5 \cdot \text{Pre-crisis Q-end}_t + \beta_6 \cdot \text{GFC Q-end}_t + \\ + \beta_7 \cdot \text{Debt crisis Q-end}_t + \beta_8 \cdot \text{Post-crisis Q-end}_t + \epsilon_t$$

y_t	CIP deviation (ϵ) based on CCY SIX repo (col. 1), LIBOR (col. 2) and OIS (col. 3)
β_1 to β_8	Sensitivity to respective dummy variable
Pre-crisis_t	Pre crisis dummy (Jan 06 - Jun 07)
GFC_t	Global financial crisis dummy (Jul 07 - Dec 09)
Debt crisis_t	Debt crisis dummy (Jan 10 - Dec 13)
Post-crisis_t	Post crisis dummy (Jan 14 - Jul 17)
ex.Q-end_t	Non-quarter-end dummy
Q-end_t	Quarter-end dummy
ϵ_t	Error term

Regression results – USDCHF

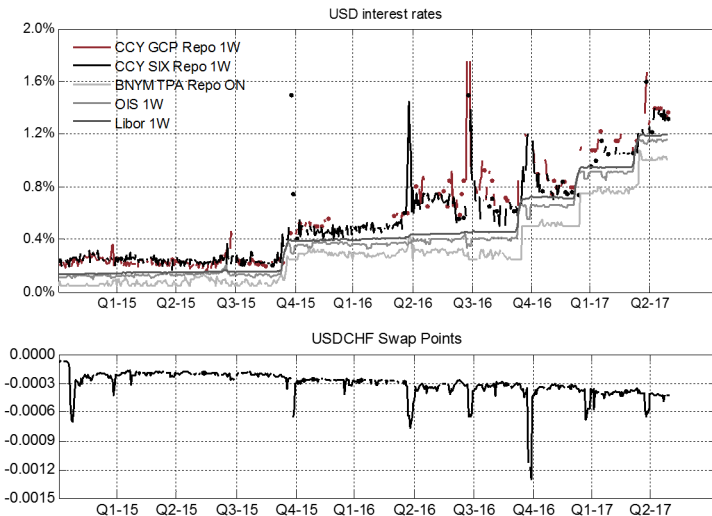
Period	(1) CCY SIX Repo	(2) LIBOR	(3) OIS
Pre-crisis ex. Q-end (β_1)	-2.80*** (-2.75)	1.40 (1.64)	3.10*** (3.22)
GFC ex. Q-end (β_2)	14.20*** (3.43)	14.70*** (3.74)	45.10*** (5.33)
Debt crisis ex. Q-end (β_3)	10.50*** (5.32)	20.20*** (11.08)	26.00*** (12.67)
Post-crisis ex. Q-end (β_4)	18.80*** (7.25)	21.60*** (6.92)	49.20*** (12.03)
Pre-crisis Q-end (β_5)	1.40 (1.30)	3.00*** (7.93)	6.00*** (6.81)
GFC Q-end (β_6)	62.20 (1.54)	50.10* (1.87)	92.80** (1.99)
Debt crisis Q-end (β_7)	19.80*** (3.67)	33.00*** (4.76)	39.50*** (5.27)
Post-crisis Q-end (β_8)	74.10*** (4.36)	94.40*** (4.08)	123.70*** (4.91)
Observations	1358	1358	1358
Adjusted R^2	0.12	0.14	0.16

Regression results – EURUSD

Period	(1) CCY GCP Repo	(2) LIBOR	(3) OIS
Debt crisis ex. Q-end (β_1)	1.70*** (5.52)	5.70*** (9.75)	9.80*** (16.40)
Post-crisis ex. Q-end (β_2)	3.50*** (7.06)	16.10*** (9.34)	19.60*** (10.17)
Q-end (β_3)	17.40* (1.76)	45.60** (2.12)	50.50** (2.21)
Observations	502	502	502
Adjusted R^2	0.08	0.10	0.09

Explaining CIP deviations

An attempt to explain CIP deviations



Conclusion and policy implications

Policy implications and open questions

- What drives the funding liquidity premium and (how) is it related to market segmentation and/or regulation?
- How are collateral markets influenced by the funding liquidity premium?
 - ▶ Do investors exhibit a preference for USD collateral?
 - ▶ Is the collateral delivered in a CCY repo transaction a function of the basis?
 - ▶ Are securities borrowing and lending schemes affected by the basis?
- Were central bank swap lines effective in alleviating USD funding stress because they were designed as CCY repos?
- Should regulators treat CCY repos and FX swaps similarly because both exhibit similar risk exposure?

Conclusion

- CIP holds comparatively well when calculated on the basis of CCY repos
- Commonly reported CIP deviations considerably overstated due to neglect of funding liquidity risk and the inability to conduct arbitrage
- USD CCY repos are significantly influenced by funding liquidity risk

Literature

- Brunnermeier, M. K. and Pedersen, L. H. (2009). Market liquidity and funding liquidity. *The Review of Financial Studies*, 22(6):2201–2238.
- Du, W., Tepper, A., and Verdelhan, A. (2018). Deviations from covered interest rate parity. *Journal of Finance*, 73(3):915–957.
- Rime, D., Schrimpf, A., and Syrstad, O. (2017). Segmented money markets and covered interest parity arbitrage. *BIS Working Paper*, (651).
- Sushko, V., Borio, C., McCauley, R., and McGuire, P. (2016). The failure of covered interest parity: FX hedging demand and costly balance sheets. *BIS Working Papers*, (590).
- Wong, A., Leung, D., and Ng, C. (2016). Risk-adjusted covered interest parity: Theory and evidence. *HKIMR Working Paper*, (16).

USDCHF – Number of observations

Period	CCY SIX Repo	LIBOR	OIS	Dataset
Overall sample	1358	2689	2689	1358
Pre-crisis ex. Q-end	43	338	338	43
GFC ex. Q-end	243	536	536	243
Debt crisis ex. Q-end	579	844	844	579
Post-crisis ex. Q-end	376	731	731	376
Pre-crisis x Q-end	3	35	35	3
GFC x Q-end	18	50	50	18
Debt crisis x Q-end	62	86	86	62
Post-crisis x Q-end	34	69	69	34

Displays the number of observations used to calculate arbitrage profits based on 1W CCY SIX Repo, LIBOR, and OIS rates. The pre-crisis period covers data from January 2006 to June 2007, the GFC from July 2007 to December 2009, the sovereign debt crisis from January 2010 to December 2013, and the post-crisis period from January 2014 to July 31, 2017. The interaction between the various periods and quarter-ends denotes the number of observations where the contract runs over a quarter-end. In order to avoid a sample selection bias affecting our regression analysis, only days where interest rate information for every interest rate type is available are considered (see column five, dataset).

EURUSD – Number of observations

Period	CCY GCP Repo	LIBOR	OIS	Dataset
Overall sample	502	940	940	502
Debt crisis ex. Q-end	75	86	86	75
Post-crisis ex. Q-end	395	770	770	395
Q-end	32	84	84	32

Displays the number of observations used to calculate deviations from CIP based on 1W CCY GCP Repo, LIBOR, and OIS rates, respectively. The analysis runs from July 31, 2013 to July 31, 2017. The quarter-end dummy denotes the number of observations where the contract runs over a quarter-end. In order to avoid a sample selection bias affecting our regression analysis, only days where interest rate information for every interest rate type is available are considered (see column five, dataset).

USDCHF – P -values of a paired t -test for β -estimates across regressions

Period	(1) CCY Repo vs. LIBOR	(2) CCY Repo vs. OIS	(3) LIBOR vs. OIS
Pre-crisis ex. Q-end (β_1)	0.00***	0.00***	0.00***
GFC ex. Q-end (β_2)	67.14	0.00***	0.00***
Debt crisis ex. Q-end (β_3)	0.00***	0.00***	0.00***
Post-crisis ex. Q-end (β_4)	0.00***	0.00***	0.00***
Pre-crisis Q-end (β_5)	47.68	18.09	5.21*
GFC Q-end (β_6)	19.77	0.01***	0.43***
Debt crisis Q-end (β_7)	0.00***	0.00***	0.00***
Post-crisis Q-end (β_8)	0.44***	0.00***	0.00***

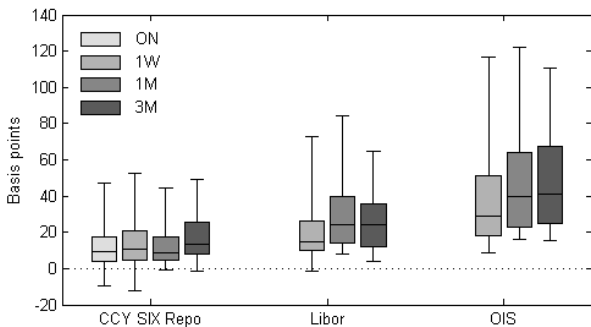
Shows p -values from a paired t -test with unknown variance. According to the null hypothesis, the β -estimates are equal in size for the regressions shown in the respective columns of the table. The pre-crisis period covers data from January 2006 to June 2007, the GFC from July 2007 to December 2009, the sovereign debt crisis from January 2010 to December 2013, and the post-crisis period from January 2014 to July 31, 2017. The q -end-dummies take on a value of one in the period from nine days to one day before the turn of a quarter. (***), (**), and (*) denote statistical significance (one-tailed) at the 1%, 5%, and 10% significance level.

EURUSD – P -values of a paired t -test for β -estimates across regressions

Period	(1) CCY Repo vs. LIBOR	(2) CCY Repo vs. OIS	(3) LIBOR vs. OIS
Debt crisis ex. Q-end (β_1)	0.00***	0.00***	0.00***
Post-crisis ex. Q-end (β_2)	0.00***	0.00***	0.00***
Q-end (β_3)	0.00***	0.00***	0.00***

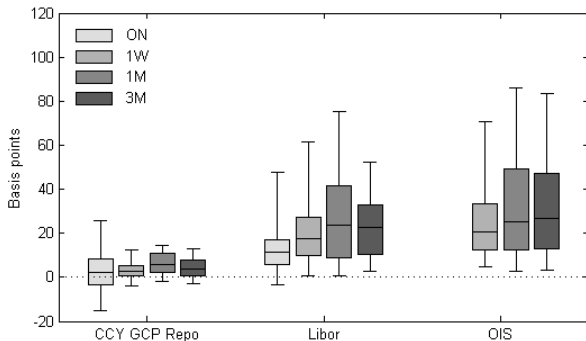
Shows p -values from a paired t -test with unknown variance. According to the null hypothesis, the β -estimates are equal in size for the regressions shown in the respective columns of the table. The regression runs from July 31, 2013 to July 31, 2017. Due to lack of historical data, the sovereign debt crisis covers data from July 31, 2013 (instead of January 2010 as in the previous analysis) to December 2013, and the post-crisis period from January 2014 to July 31, 2017. The Q -end-dummy takes on a value of one in the period from nine days to one day before the turn of a quarter.

USDCHF – Regression results across maturities



The boxplot depicts the distribution of CIP deviations, calculated on the basis of CCY SIX Repo, LIBOR, and OIS rates, each for ON (where available), 1W, 1M and 3M maturities. The analysis covers the post-crisis period, which we define to run from July 31 2007 to July 31 2017. The bottom and the top of the box indicate the first and the third quartile, while the band inside the box corresponds to the median. 90% of all values are located between the lower and the upper boxplot whisker.

EURUSD – Regression results across maturities



The boxplot depicts the distribution of CIP deviations, calculated on the basis of CCY GCP Repo, LIBOR, and OIS rates, each for ON (where available), 1W, 1M and 3M maturities. The analysis covers the period from July 31 2013 to July 31 2017. The bottom and the top of the box indicate the first and the third quartile, while the band inside the box corresponds to the median. 90% of all values are located between the lower and the upper boxplot whisker.