BANK FOR INTERNATIONAL SETTLEMENTS

The dollar, bank leverage and the deviation from covered interest parity

Stefan Avdjiev*, Wenxin Du**, Catherine Koch* and Hyun Shin*

**Bank for International Settlements; **Federal Reserve Board of Governors*

CEBRA/Boston Fed

Boston Policy Workshop

Boston, July 9, 2017

Outline

I. **Motivation**

II. **The spot-basis relationship**

III. **The spot-flow relationship**

IV. **Theoretical Model**

V. **Bank Equities and the Broad Dollar**

VI. **Summary**

Motivation

- Covered interest parity (CIP): interest rates implicit in FX swap markets should equal interest rates in cash markets.
- Breakdowns of CIP:
  - At the height of the GFC (2008-2009)
  - Mid-2014 to present.
- Why is the basis not arbitraged away?
  - Banks' **balance sheet constraints** limit ability to exploit arbitrage opportunities:
    - for banks
    - for non-banks (which rely on banks for leverage)
  - The value of the dollar plays the role of a barometer of *risk-taking capacity* in capital markets.

US dollar broad index and the cross-currency basis

Figure 1

The cross-currency basis is the mirror image of dollar strength.

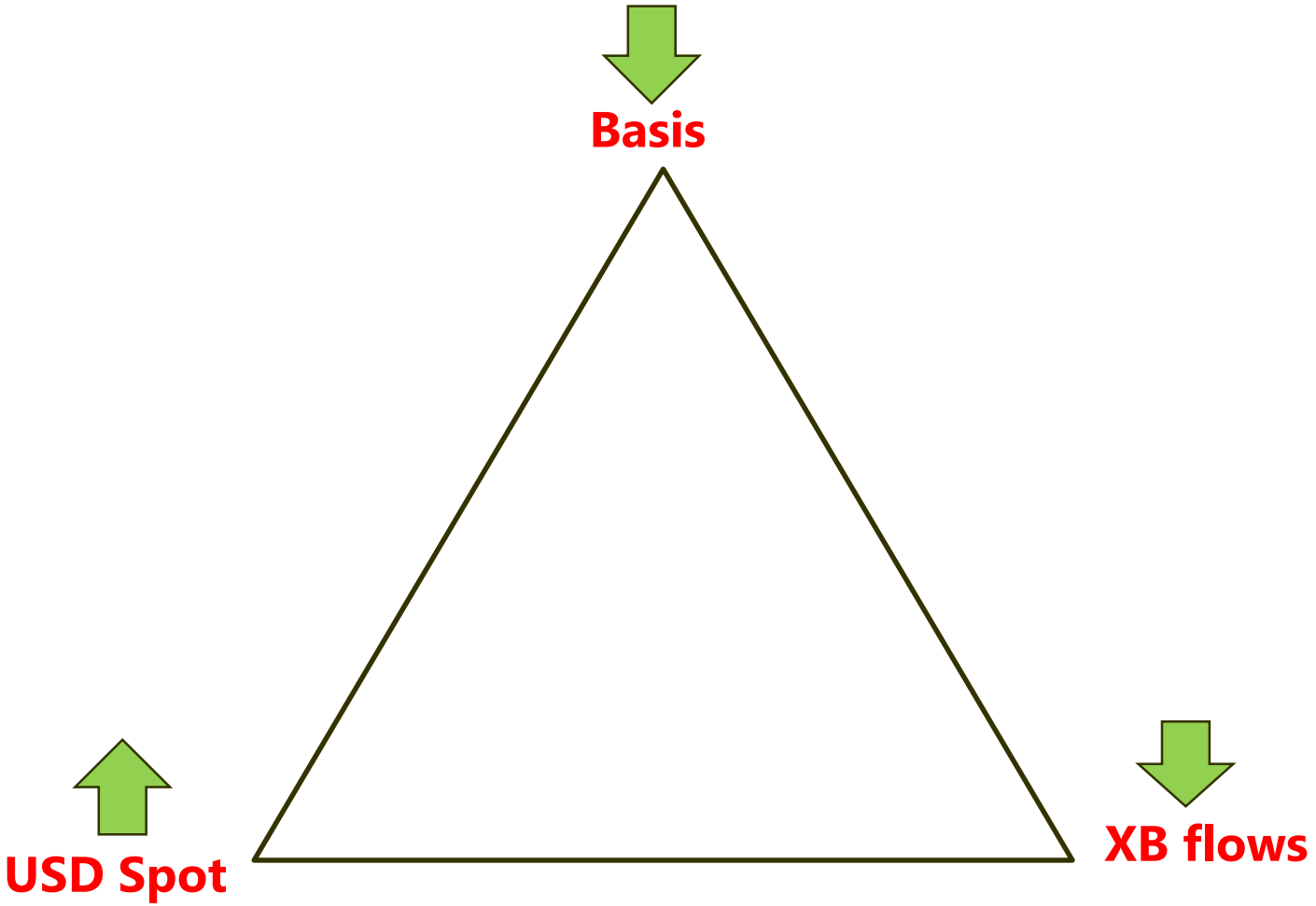
US dollar broad index and the cross-currency basis

Figure 1

US dollar broad index and the cross-currency basis

Figure 1

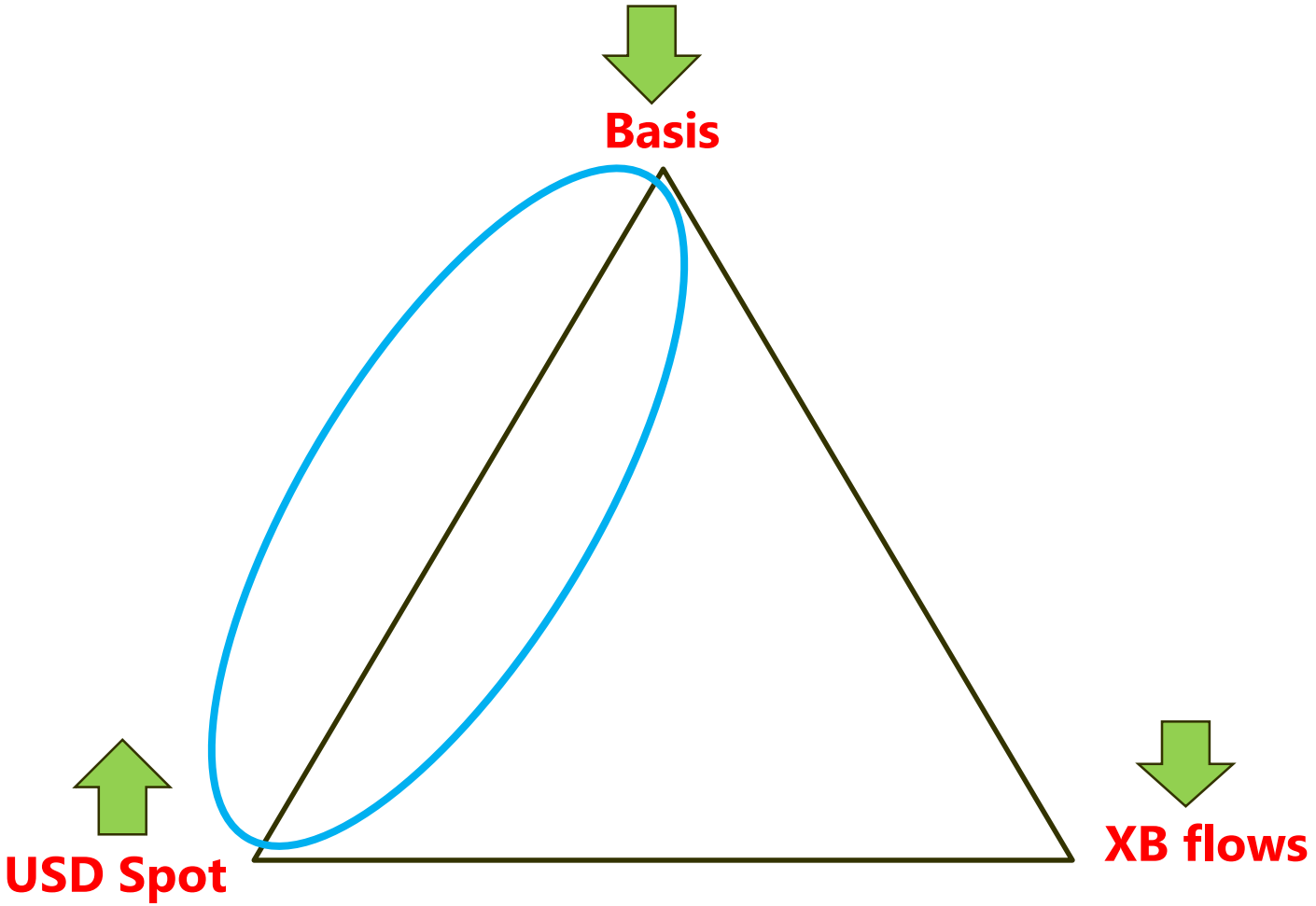
The Spot-Basis-XB Lending "Triangle"



Related literature

- **CIP deviations**
  - *Baba et al (2008); Baba et al (2009); Baba and Packer (2009); Coffey et al (2009); Goldberg et al (2011); Griffolli and Ranaldo (2011); McGuire and von Peter (2012); Bottazzi et al (2012); and Ivashina et al (2015).*
  - *Borio et al (2016) and Sushko et al (2016); Du, Tepper and Verdelhan (2016); Liao (2016); Iida et al (2016); Rime et al (2016).*
- **Intermediary- and margin-based asset pricing**
  - *Bernanke and Gertler (1989), Holmstrom and Tirole (1997), Brunnermeier and Pedersen (2009), Garleanu and Pedersen (2011), He and Krishnamurthy (2012, 2013), Brunnermeier and Sannikov (2014), Adrian and Shin (2014) and Adrian et al (2014).*
- **FX determination in the presence of financial frictions**
  - *Gabaix and Maggiori (2015)*
- **The role of the dollar in bilateral FX rates**
  - *Verdelhan (2017).*

The Spot-Basis-XB Lending "Triangle"



$$\Delta x_{it} = \alpha_i + \beta \Delta Dollar_t + \gamma \Delta BER_{it} + \delta \prime \mathbf{CONTR}_{it} + \varepsilon_{it}$$

Regression results of the 3-month cross-currency basis (daily frequency) Table 2

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta Dollar_t$	-2.641***		-2.915***	-2.908***	-2.307***	-2.080***
	(0.682)		(0.786)	(0.793)	(0.731)	(0.634)
ΔBER_{it}		-0.440*	0.228	0.284	0.238	0.239
		(0.236)	(0.233)	(0.238)	(0.222)	(0.194)
$\ln VIX_t$				0.000596	0.00135	0.00130
				(0.00489)	(0.00477)	(0.00417)
$\Delta \ln VIX_t$				-0.0183	0.00465	-0.0158
				(0.0231)	(0.0237)	(0.0191)
$\Delta \ln Vol_{it}$					-0.263***	-0.221***
					(0.0613)	(0.0519)
ΔRR_{it}					0.0112*	0.0110
					(0.00587)	(0.00748)
$\Delta(y_{it} - y_t^{US})$						0.106***
						(0.0367)
$\Delta(ts_{it} - ts_t^{US})$						-0.140***
						(0.0492)
Observations	21,555	21,949	21,555	20,896	20,495	18,092
R-squared	0.016	0.002	0.016	0.016	0.026	0.038

$$\Delta x_{it} = \alpha_i + \beta \Delta Dollar_t + \gamma \Delta BER_{it} + \delta' \mathbf{CONTR}_{it} + \varepsilon_{it}$$

Regression results of the 5-year cross-currency basis (quarterly frequency) Table 3

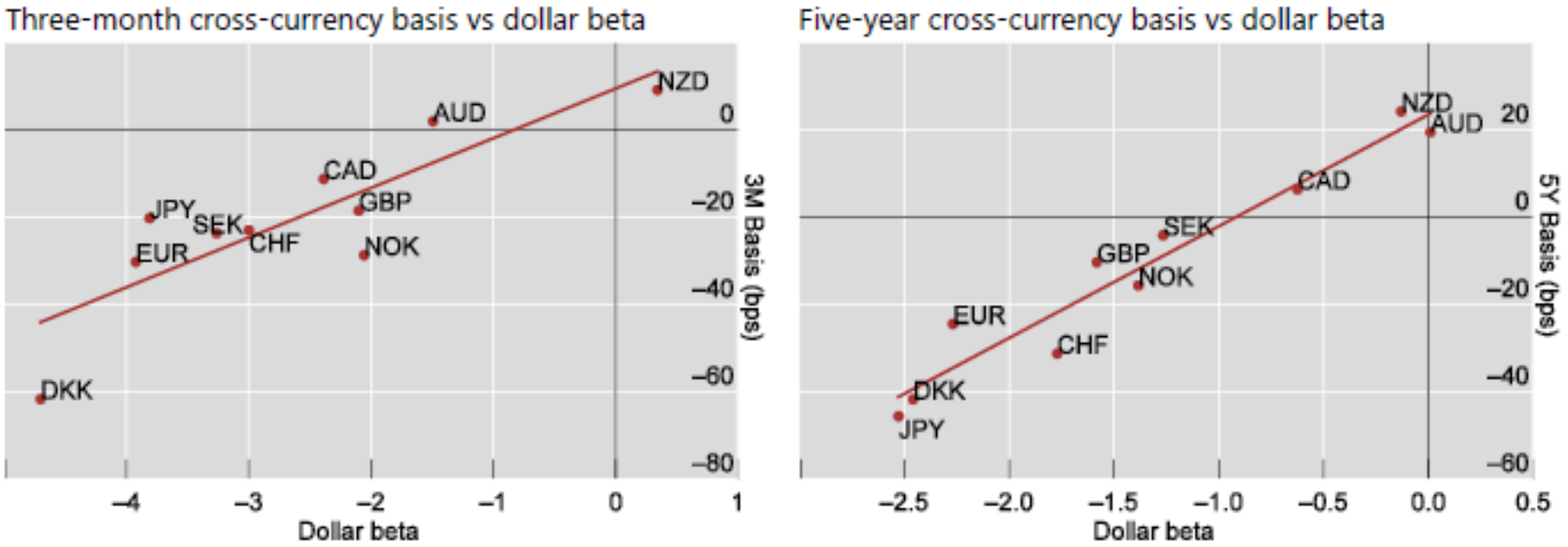
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta Dollar_t$	-1.399***		-1.293***	-1.071***	-1.078***	-0.965**
	(0.303)		(0.437)	(0.370)	(0.404)	(0.404)
ΔBER_{it}		-0.562***	-0.0738	-0.0885	-0.0398	-0.409**
		(0.126)	(0.137)	(0.126)	(0.148)	(0.202)
$\ln VIX_t$				-0.0338	-0.0326	-0.0383*
				(0.0250)	(0.0248)	(0.0223)
$\Delta \ln VIX_t$				-0.0472**	-0.0398	-0.0108
				(0.0238)	(0.0279)	(0.0342)
$\Delta \ln Vol_{it}$					-0.0188	0.0144
					(0.0436)	(0.0333)
ΔRR_{it}					-0.00327	-0.00450
					(0.00987)	(0.00937)
$\Delta(y_{it} - y_t^{US})$						-0.0929***
						(0.0236)
$\Delta(ts_{it} - ts_t^{US})$						0.0152
						(0.0151)
Observations	360	360	360	360	358	316
R-squared	0.191	0.117	0.191	0.208	0.209	0.278

Cross-country relationship between the USD and the basis

- Asset-pricing relationship underpinning above empirical observations.
  - The **exposure to USD** FX rate is **priced** in cross-section of CIP deviations
  - **Variations** in CIP deviations **across currencies** - explained by **sensitivity** of the basis to fluctuations in the **broad dollar** index.
    - Currencies with higher **sensitivities to the USD** exhibit larger CIP deviations and offer greater potential arbitrage **profits** for banks.
- The **USD** is a potential **risk factor** pricing the cross-section of CIP arbitrage returns

Cross-currency basis vs. dollar beta (2007–16)

Figure 5



The vertical axis of the LHP shows the average three-month cross-currency basis expressed in basis points, while the horizontal axis indicates the regression beta of running daily regression for changes in the three-month cross-currency basis on changes in the broad US dollar index. The vertical axis of the RHP shows the average five-year cross-currency basis expressed in basis points, while the horizontal axis indicates the regression beta of running quarterly regression for changes in the five-year cross-currency basis on changes in the broad US dollar index.

Strong positive relationship between the (average) basis and

- the daily dollar beta (for 3M basis); correlation: 85% (LHP)
- the quarterly dollar beta (for 5Y basis); correlation: 97% (RHP)

$$\Delta x_{it} = \alpha_i + \beta_i \Delta Dollar_t + \epsilon_{it}$$

Table 4: Dollar beta by country

	(1) AUD	(2) CAD	(3) CHF	(4) DKK	(5) EUR	(6) GBP	(7) JPY	(8) NOK	(9) NZD	(10) SEK
Panel (A): 3-month basis, daily frequency										
$\Delta Broad_{it}$	-1.494***	-2.388***	-3.000***	-4.702***	-3.924***	-2.101***	-3.811***	-2.057***	0.342	-3.262***
	(0.473)	(0.385)	(0.561)	(0.556)	(0.409)	(0.383)	(0.505)	(0.423)	(0.389)	(0.385)
Panel (B): 5-year basis, quarterly frequency										
$\Delta Broad_{it}$	0.0103	-0.623	-1.770***	-2.458***	-2.268***	-1.581***	-2.526***	-1.384***	-0.129	-1.265***
	(0.457)	(0.560)	(0.409)	(0.670)	(0.526)	(0.324)	(0.550)	(0.311)	(0.485)	(0.267)

$$\overline{bs}_i = \lambda_0 + \lambda_1 \beta_i$$

Table 5: Dollar beta and the cross-currency basis

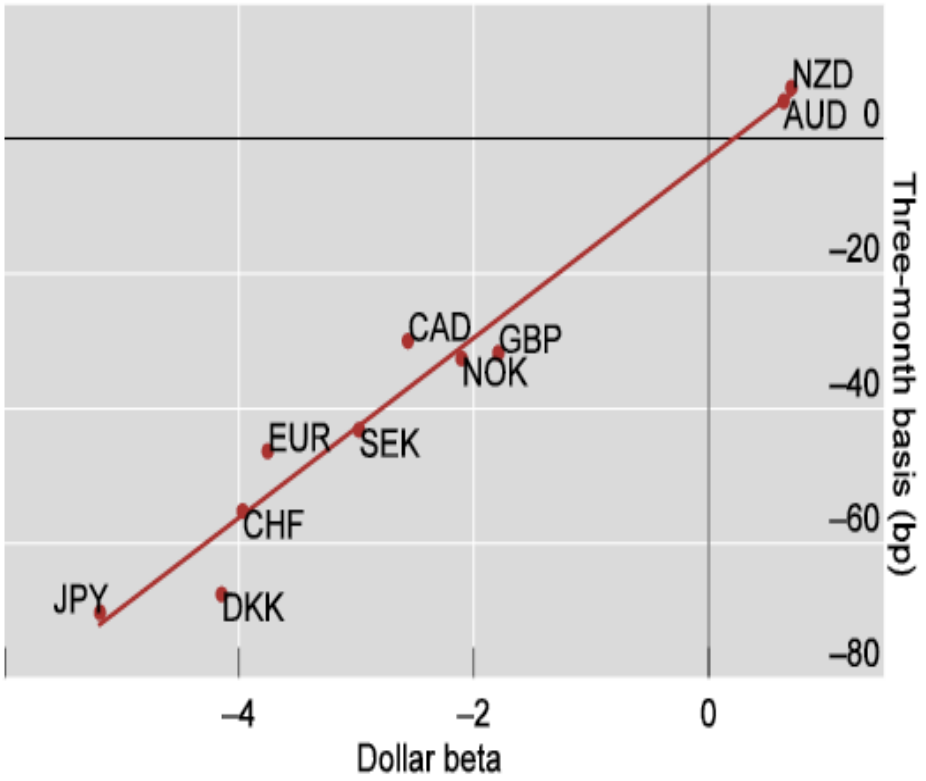
	(1) Mean 3M Basis	(2) Mean 5Y Basis
β_i	11.38***	25.55***
	(1.900)	(3.633)
Constant	9.450	23.47***
	(5.430)	(5.582)
Observations	10	10
R-squared	0.723	0.937

Addendum: The USD and the basis since the US election

Changes in the broad dollar index and three-month cross-currency basis since the US election

Currency	8/11/ 2016	29/11/ 2016	change	dollar beta[1]
Broad dollar	122.8	127.6	4.8 (3.9%)	
AUD	5.5	8.0	2.5 bps	0.64
CAD	–30.0	–40.0	–10.0 bps	–2.56
CHF	–55.3	–70.8	–15.5 bps	–3.97
DKK	–67.5	–83.7	–16.2 bps	–4.14
EUR	–46.4	–61.0	–14.7 bps	–3.75
GBP	–31.8	–38.8	–7.0 bps	–1.79
JPY	–70.3	–90.5	–20.3 bps	–5.18
NZD	7.5	10.3	2.8 bps	0.70
NOK	–32.6	–40.8	–8.2 bps	–2.10
SEK	–43.2	–54.9	–11.6 bps	–2.98

Cross-currency basis vs dollar beta[2]



[1] The dollar beta is calculated as the ratio of changes in the three-month cross-currency basis over changes in the broad US dollar index between 8 and 29 November 2016.

[2] The vertical axis shows the three-month cross-currency basis expressed in basis points on 8 November 2016, while the horizontal axis indicates the dollar beta.

Cross-currency basis and aggregate exchange rates, using alternative base currencies

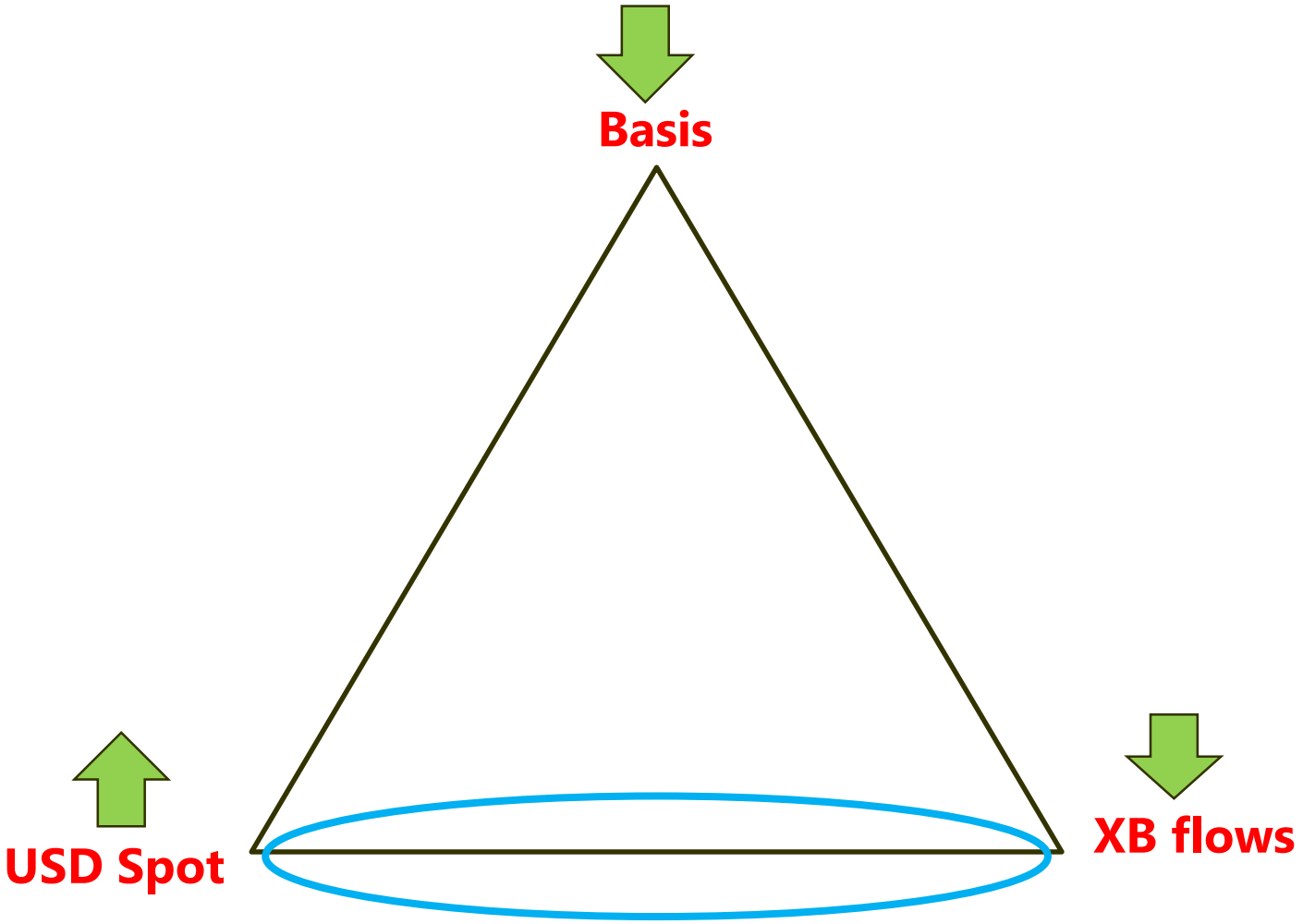
Table 5

	(1) AUD	(2) CAD	(3) CHF	(4) DKK	(5) EUR	(6) GBP	(7) JPY	(8) NOK	(9) NZD	(10) SEK
Panel (A): 3-month basis, daily frequency										
$\Delta\overline{NEER}_t^{(J)}$	-0.0963	-0.179	-0.0476	-0.633***	-0.378**	-0.165	-0.231	0.114	0.0677	-0.598***
	(0.209)	(0.209)	(0.274)	(0.239)	(0.174)	(0.194)	(0.232)	(0.206)	(0.270)	(0.159)
Panel (B): 5-year basis, quarterly frequency										
$\Delta\overline{NEER}_t^{(J)}$	0.156	0.093	-0.143	-0.418*	-0.589**	-0.0722	-0.119	-0.142	0.241	-0.14
	-0.32	-0.293	-0.162	-0.233	-0.232	-0.206	-0.283	-0.172	-0.302	-0.183

This table reports regression coefficients of changes in the cross-currency basis of currency i against the base currency j on changes in the aggregate exchange rate against the base currency j, $\Delta\overline{NEER}_t^{(J)}$, controlling for changes in the bilateral exchange rate of i against j, and the log level and changes in VIX. The variable $\Delta\overline{NEER}_t^{(J)}$ is the change in the BIS nominal effective exchange rate for currency j. Each column corresponds to a different base currency. Panel A is performed on daily changes for the 3-month basis and Panel B is performed on quarter changes for the 5-year basis.

- The spot-basis relationship is ***not*** mechanical
  - It does not hold when most other currencies are used as the base currency.
- The ***euro*** is a notable exception:
  - stronger euro => larger CIP deviations of other currencies vis-à-vis the euro.

The Spot-Basis-XB Lending "Triangle"



$$\Delta xbl_{it} = \alpha_i + \beta \Delta Dollar_t + \gamma \Delta BER_{it} + \varepsilon_{it}$$

Table 8: Bilateral Panel Regressions: US dollar-denominated cross-border lending, by borrowing sector

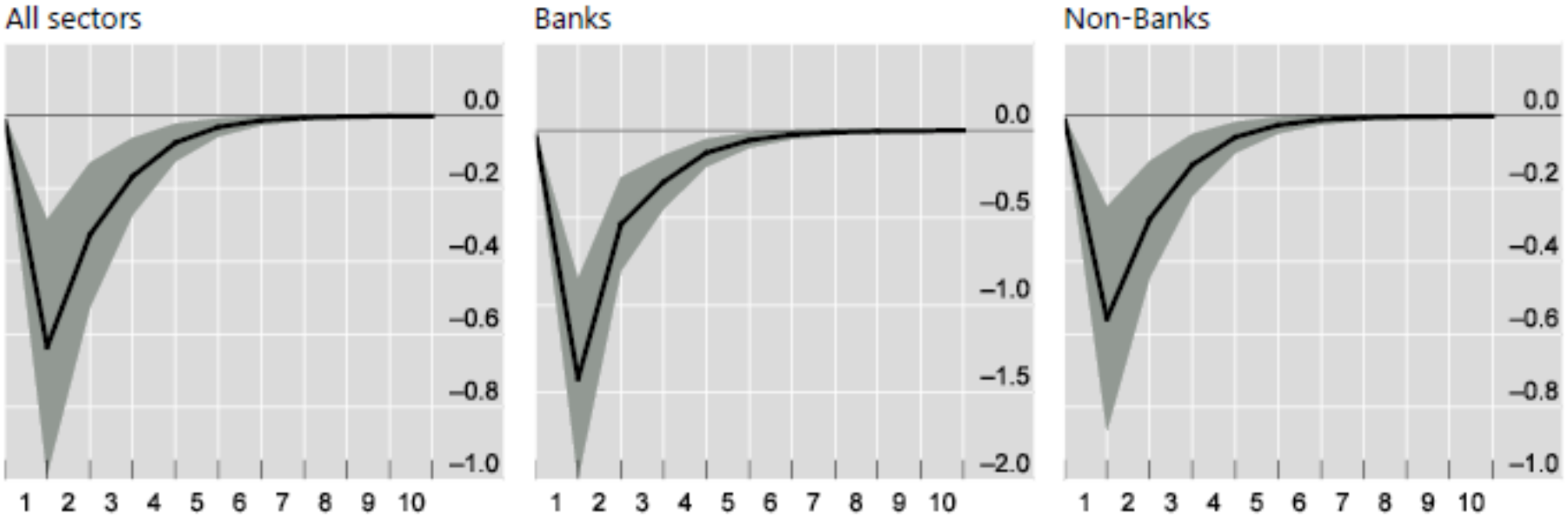
	All Sector			Banks			Non-Banks		
Panel A: Q1/2002 - Q3/2015	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\Delta Dollar_t$	-0.591***		-0.490***	-0.752***		-0.614***	-0.401***		-0.338***
	(0.055)		(0.066)	(0.103)		(0.119)	(0.058)		(0.068)
ΔBER_t		-0.209***	-0.107***		-0.275***	-0.146**		-0.137***	-0.066*
		(0.043)	(0.041)		(0.062)	(0.062)		(0.039)	(0.040)
Constant	5.068	5.286	5.237	-4.308	-4.866*	-4.411	3.338	3.477	3.443
	(3.272)	(3.252)	(3.256)	(2.741)	(2.538)	(2.701)	(3.131)	(3.125)	(3.129)
Observations	6,215	6,215	6,215	6,207	6,207	6,207	6,211	6,211	6,211
R-Squared	0.048	0.040	0.050	0.030	0.026	0.031	0.035	0.031	0.035
Panel B: Q1/2007 - Q3/2015									
$\Delta Dollar_t$	-0.636***		-0.486***	-0.821***		-0.603***	-0.481***		-0.384***
	(0.062)		(0.073)	(0.114)		(0.136)	(0.065)		(0.076)
ΔBER_t		-0.295***	-0.155***		-0.398***	-0.224***		-0.210***	-0.099**
		(0.043)	(0.041)		(0.064)	(0.070)		(0.040)	(0.041)
Constant	-4.178*	-4.649**	-4.289*	-4.257	-4.866*	-4.418	-3.883	-4.239	-3.954
	(2.264)	(2.163)	(2.237)	(2.776)	(2.552)	(2.714)	(2.870)	(2.807)	(2.856)
Observations	3,975	3,975	3,975	3,974	3,974	3,974	3,975	3,975	3,975
R-Squared	0.076	0.068	0.080	0.049	0.046	0.051	0.053	0.048	0.055

The dollar index has explanatory power over and above the bilateral USD exchange rate for cross-border bank lending.

Structural Panel VAR: $\mathbf{B}\mathbf{y}_{it} = \mathbf{f}_i + \mathbf{A}(\mathbf{L})\mathbf{y}_{i,t-1} + \mathbf{u}_{it}$

Impulse response functions of US dollar denominated cross-border bank lending to a US dollar exchange rate shock

Figure 6

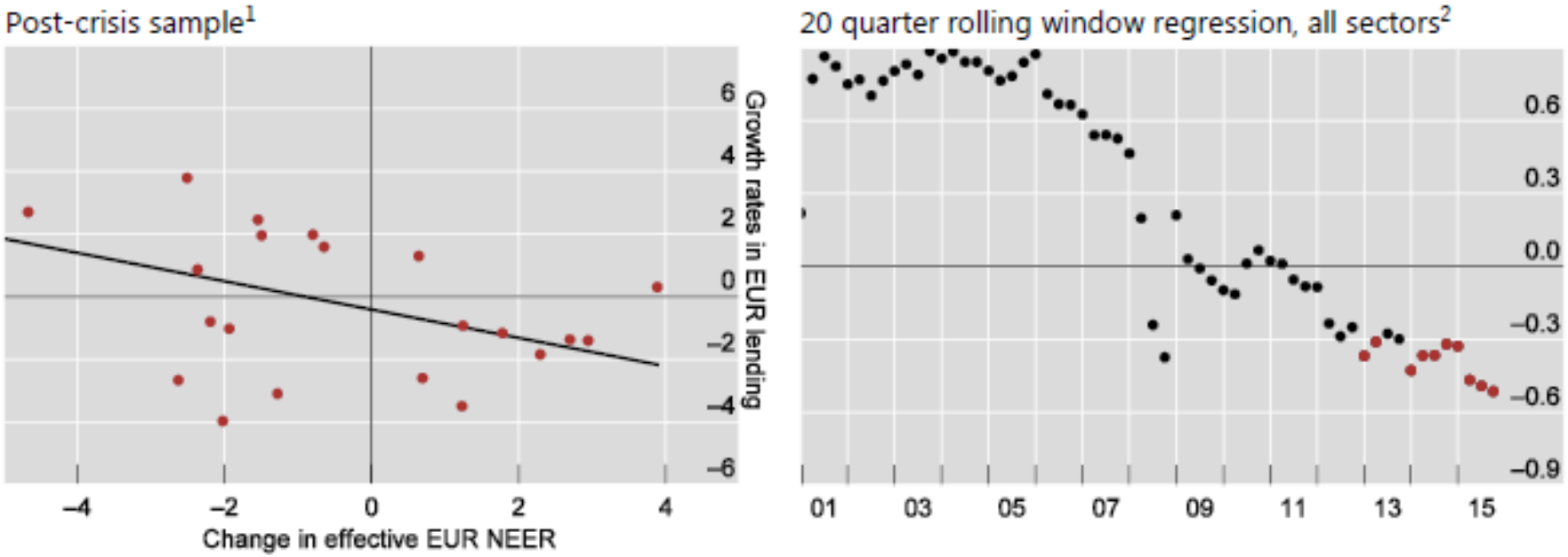


All panels display the response of changes in cross-border lending to a one standard deviation shock to the local foreign exchange rate vis-à-vis the US dollar. The estimates of our orthogonalized impulse response functions are based on a Cholesky decomposition with four endogenous variables ordered as $y_{i,t} = \left[\Delta ir_t^c, \Delta xbl_{i,t}^c, \ln VIX_{i,t}, \Delta fx_{i,t}^c\right]'$. The shaded areas represent 95 percent confidence intervals, obtained using a Gaussian approximation based on 1000 Monte Carlos draws from the estimated structural panel VAR. Period covered: Q1/2002-Q3/2015.

- USD FX rate has a negative and strongly significant impact on XB lending
- Impact stronger for lending to banks to non-banks (in line with Bruno and Shin (2015)).

Euro-denominated cross-border bank lending vs. the euro index

Figure 7



[1] Covers the Q1 2010–Q3 2015 period. Lending refers to the extension of loans and holdings of debt securities by BIS reporting banks, while all borrowers (the total of banks and non-banks) reside outside of the euro areas The black line is a fitted regression line. Positive changes in the foreign exchange rate indicate an appreciation of the EUR. For presentational purposes, outliers with FX rate changes exceeding 5% in absolute value have been dropped from the panel, but not from the regressions. [2] Extension of the LHP static regression to a rolling window framework of 20 quarters per estimation for cross-border lending (loans and debt securities) denominated in euros. The position of dots with respect to the vertical axis gives the coefficient estimate, while the horizontal timeline refers to the last period of the rolling window. Red dots indicate a negative coefficient estimate that is statistically significant at the 10% level.

- Pre-crisis: impact of euro FX rate on XB bank lending in EUR was *not* significant.
- Post-crisis: estimated impact coefficient dived deep into negative territory.

Theoretical model

- A bank located outside the US, with a two-line USD business:
  - Lends USD to FX-mismatched borrowers (eg EME corporates)
  - Provides USD funding in the FX swap market.

- The bank is a (risk-neutral) price-taker in both markets.

$$a_1 + a_2 = e + d \qquad r = a_1 r_1 + a_2 r_2 \qquad \mu_1 = E(r_1), \qquad \mu_2 = E(r_2),$$

$$\max_{a_1, a_2} E(r) \quad \text{subject to} \quad \text{VaR} \leq e \qquad \text{VaR} = \alpha \sigma_r.$$

$$\begin{bmatrix} a_1 \\ a_2 \end{bmatrix} = \frac{1}{2\lambda} \Sigma^{-1} \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}.$$

Theoretical model (cont'd)

- Lagrange multiplier is the shadow value of bank's balance sheet capacity
  - λ acts like a time-varying risk-aversion parameter

$$\lambda = \frac{\alpha}{2e}\sqrt{\mu'\Sigma^{-1}\mu}$$

  - USD ↑ ► equity ↓ ► shadow value of bank's balance sheet capacity ↑
- The bank's optimal portfolio:

$$\begin{bmatrix} a_1 \\ a_2 \end{bmatrix} = \frac{e}{\alpha} \cdot \frac{1}{\sqrt{\mu'\Sigma^{-1}\mu}} \Sigma^{-1} \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}$$

- The market clearing condition :

$$\begin{bmatrix} X_1(\mu_1) \\ X_2(\mu_2) \end{bmatrix} = \frac{E}{\alpha} \cdot \frac{1}{\sqrt{\mu'\Sigma^{-1}\mu}} \Sigma^{-1} \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}$$

  - USD ↑ ► equity ↓ ► μ_1 ↑ and μ_2 (basis)↑ [to restore market equilibrium]

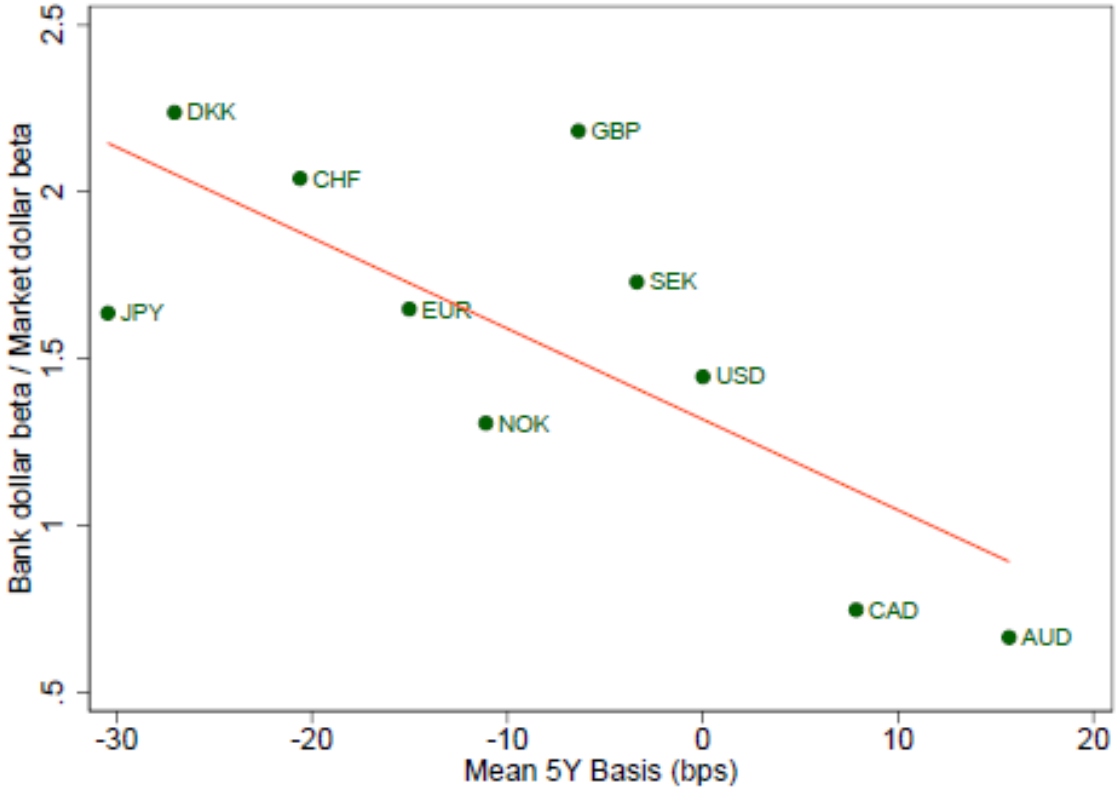
Bank Equities and the Broad Dollar

Table 9: Regressions of bank equity returns on the broad dollar movements

	(1) Bank Equity Return	(2) Bank Equity Return	(3) Bank Equity Return
$\Delta Broad_t$	-2.016***	-0.268**	-0.0303
	(0.127)	(0.103)	(0.0838)
$\Delta Broad_t \times bs_t$			2.875***
			(0.808)
$\Delta Market_t$		1.246***	1.236***
		(0.0527)	(0.0524)
Constant	-0.00444***	-0.00762***	-0.00728***
	(3.25e-05)	(0.000122)	(0.000166)
Observations	3,755	3,755	3,755
R-squared	0.102	0.452	0.459

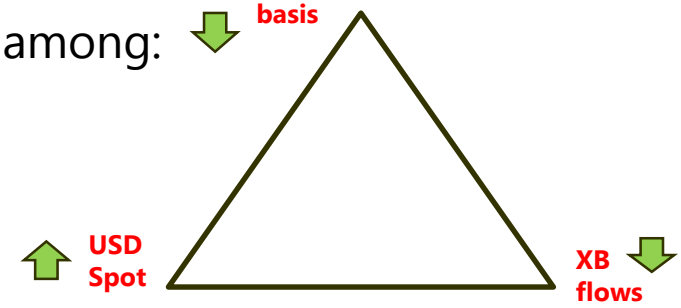
Bank Equities and the Broad Dollar

Figure 7: Sensitivity of bank equity returns to the dollar vs. cross-currency basis



Summary

- Document the existence of a triangular relationship among:
  - Value of USD
  - CIP deviations
  - XB bank lending denominated in USD



- The US dollar is a barometer of risk-bearing capacity in global capital markets
  - USD impacts the *shadow price of bank leverage*.
    - magnitude of **CIP deviations:** price of bank **balance sheet capacity**
    - **dollar**-denominated **credit:** a proxy of bank **leverage**.
  - A USD appreciation => higher price of bank leverage =>
    - wider CIP deviations
    - lower USD-denominated XB bank lending.

Supplementary Slides

Overview

- The cross-currency basis:

$$(1 + y^{\$}_{t,t+n})^n = (1 + y^{i}_{t,t+n} + x_{it,t+n})^n \frac{S_{it}}{F_{it,t+n}},$$

$$x_{it,t+n} = y^{\$}_{t,t+n} - (y^{i}_{t,t+n} - \rho_{it,t+n}),$$

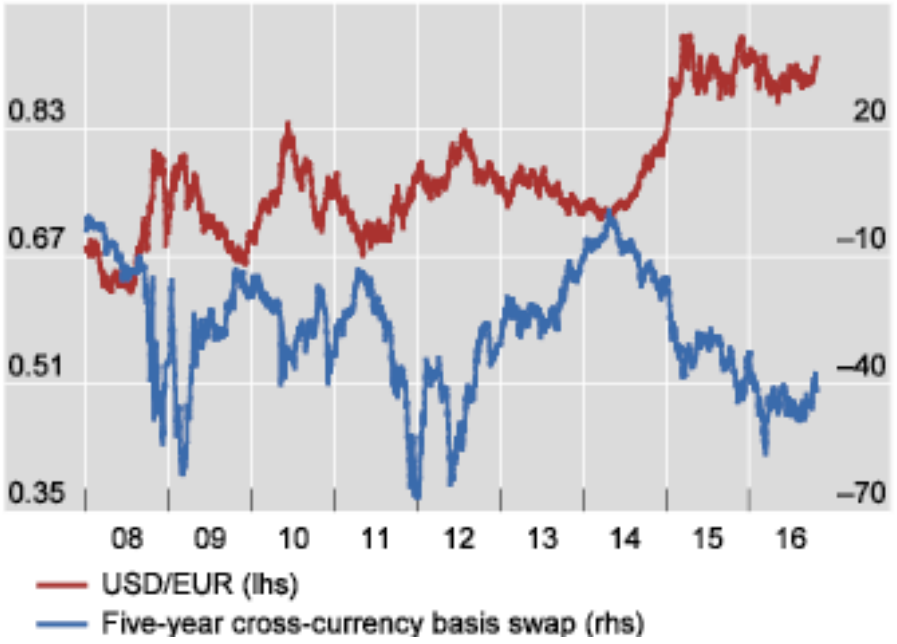
$$\rho_{it,t+n} \equiv \frac{1}{n}[\log(F_{it,t+n}) - \log(S_{it,t+n})]$$

- We focus on the cross-currency basis derived from benchmark *interbank rates* in the respective currency.
- Arbitrage profits associated with the CIP trades *cannot* be explained away by transaction costs or credit risk (Du, Tepper and Verdelhan (2016)).
- Constraints on banks' balance sheet capacity.
- Non-regulated entities (e.g. hedge funds) obtain leverage from dealer banks => banks' balance sheet constraints remain the key constraint => CIP deviations give the shadow price of banks' balance sheet capacities.

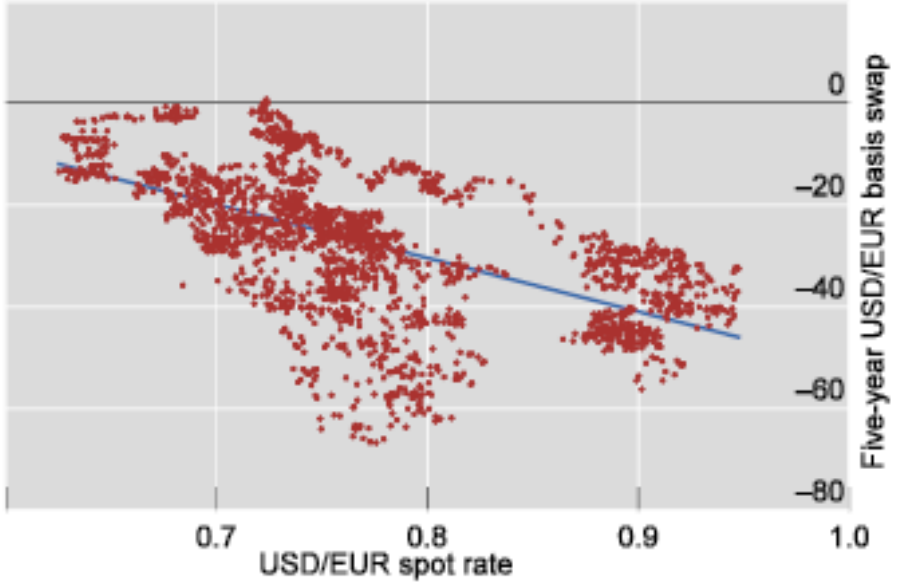
Cross-currency basis of euro against the dollar

Figure 2

Time plot of USDEUR cross-currency basis



Scatter chart of USDEUR cross-currency basis

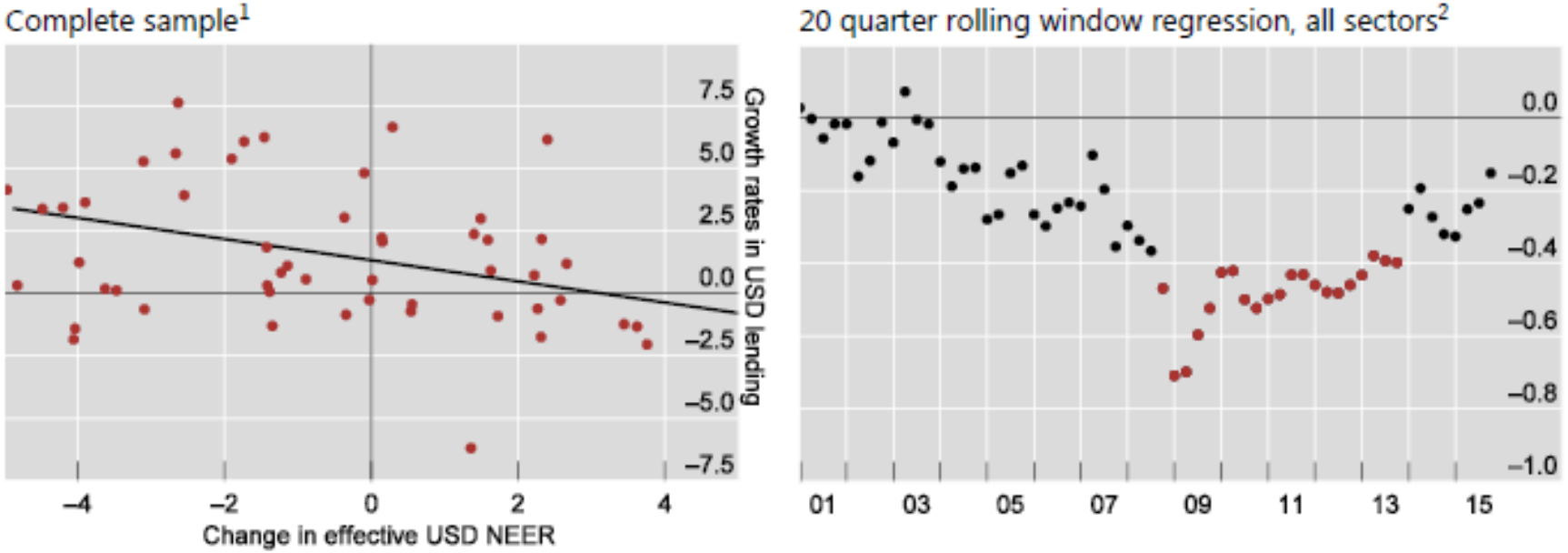


The basis co-moves very closely with the exchange rate...

...even at a daily frequency.

US dollar-denominated cross-border bank lending vs. the US dollar index

Figure 3



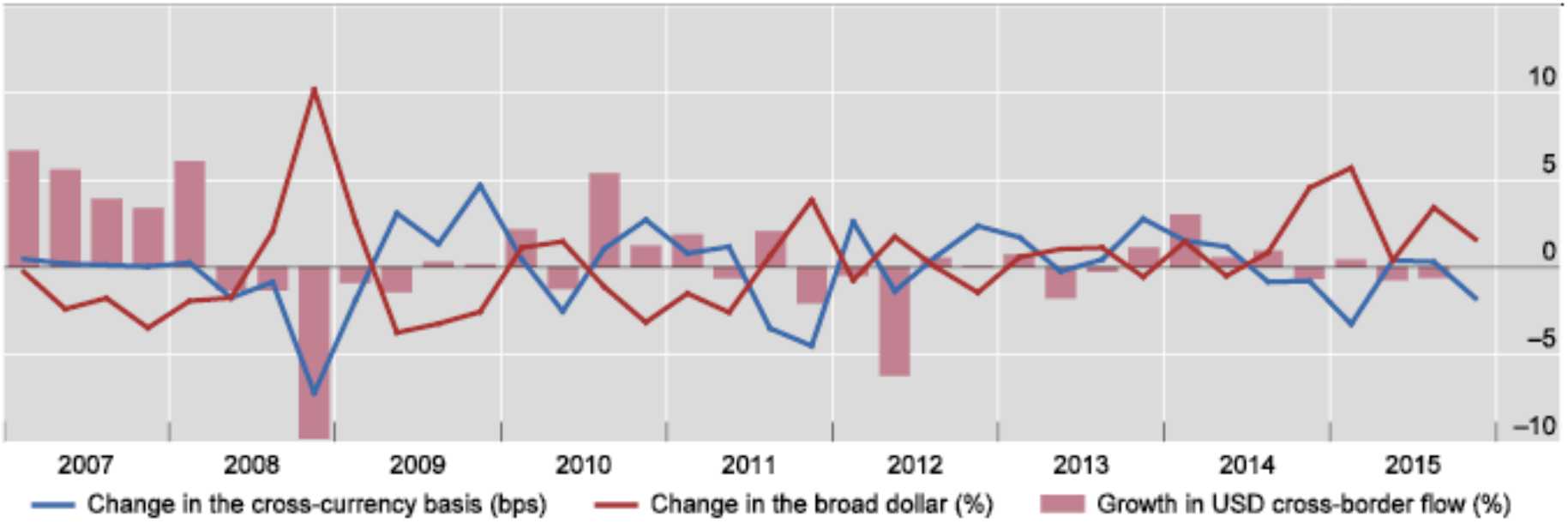
[1] Covers the Q1 2010–Q3 2015 period. Lending refers to the extension of loans and holdings of debt securities by BIS reporting banks, while all borrowers (the total of banks and non-banks) reside outside of the United States. The black line is a fitted regression line. Positive changes in the foreign exchange rate indicate an appreciation of the USD. For presentational purposes, outliers with FX rate changes exceeding 5% in absolute value have been dropped from the panel, but not from the regressions. [2] Extension of the LHP static regression to a rolling window framework of 20 quarters per estimation for cross-border lending (loans and debt securities) denominated in US dollars. The position of dots with respect to the vertical axis gives the coefficient estimate, while the horizontal timeline refers to the last period of the rolling window. Red dots indicate a negative coefficient estimate that is statistically significant at the 10% level.

Negative and strongly statistically significant relationship, which...

...gradually strengthened during the lead-up to the GFC and peaked in 2008.

Cross-currency basis, US dollar index and cross-border lending

Figure 4



The bars show percentage growth rates of total cross-border lending denominated in US dollars. The red line plots quarterly changes in the broad US dollar index in percentage points, while the blue line plots the first principal component of quarterly changes in the 5-year cross-currency basis for G10 currencies expressed in basis points.

- A stronger USD is associated with
  - greater CIP deviations
  - lower growth rates in USD-denominated XB bank lending.

Summary statistics for the cross-currency basis — Table 1

	3-month basis		5-year basis	
Currency	mean	sd	mean	sd
AUD	0.02	(0.15)	0.20	(0.11)
CAD	-0.11	(0.13)	0.07	(0.08)
CHF	-0.23	(0.23)	-0.30	(0.17)
DKK	-0.62	(0.37)	-0.39	(0.22)
EUR	-0.30	(0.29)	-0.23	(0.15)
GBP	-0.19	(0.25)	-0.10	(0.13)
JPY	-0.20	(0.18)	-0.44	(0.28)
NOK	-0.29	(0.27)	-0.15	(0.1)
NZD	0.09	(0.12)	0.24	(0.14)
SEK	-0.24	(0.22)	-0.04	(0.08)
Total	-0.21	(0.3)	-0.11	(0.27)

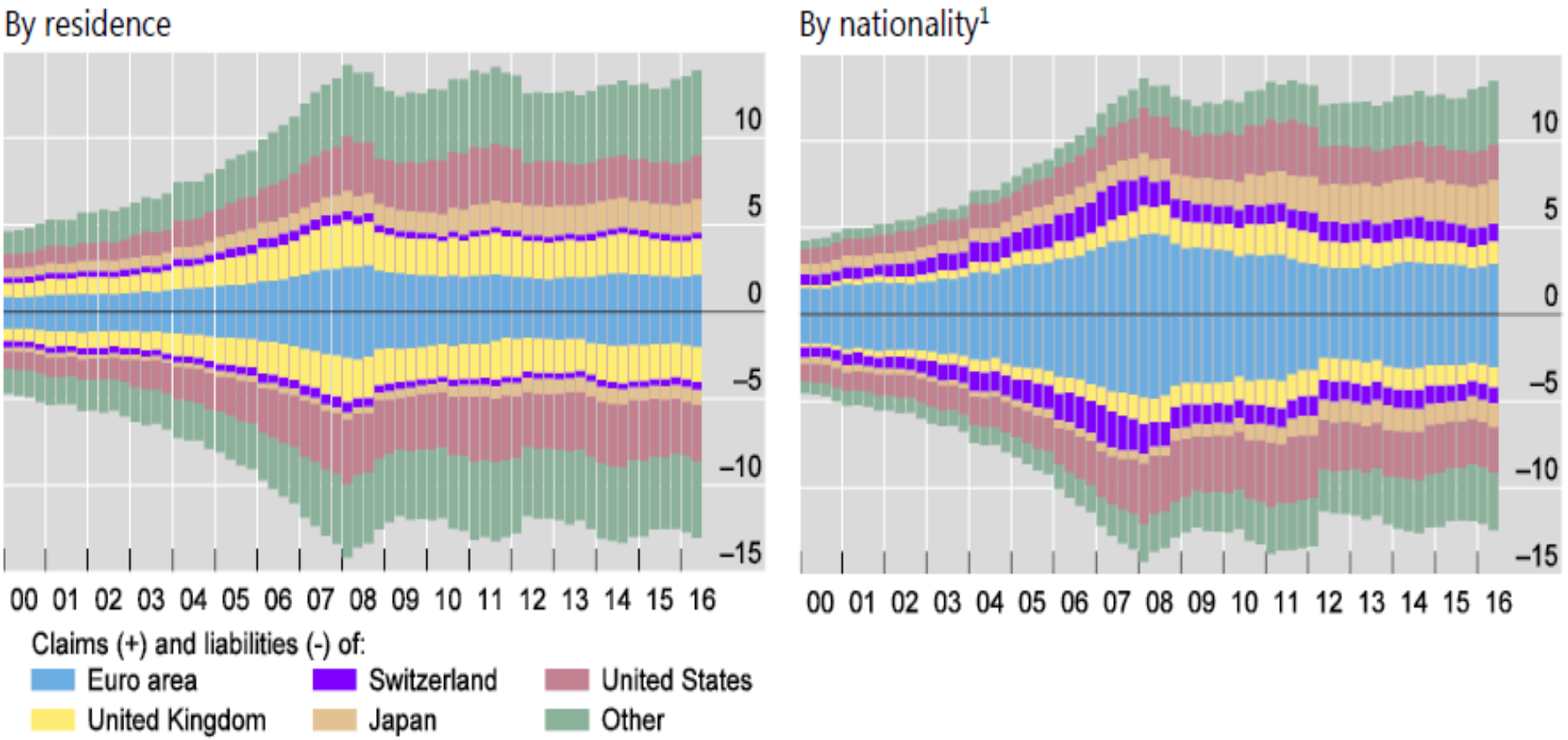
This table provides summary statistics for the 3-month and the 5-year cross-currency bases for the period between 1 January 2007 and 2 February 2016. Means and standard deviations are expressed in percentage points.

- Average basis tends to be negative,
  - exceptions: AUD, NZD, and CAD (5Y basis).

Cross-border US dollar-denominated credit, all sectors

In trillions of US dollars

Graph 6



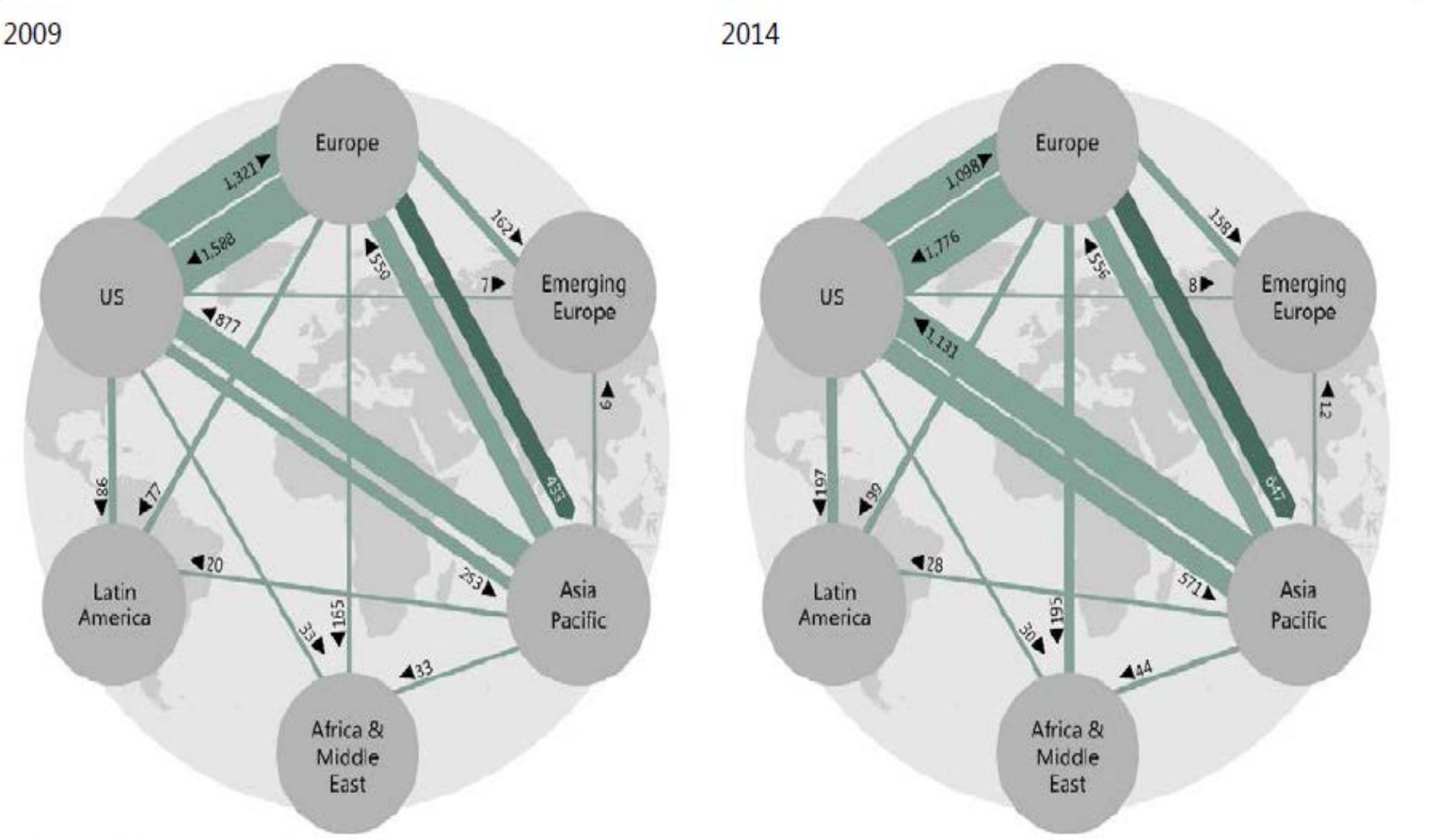
[1] The break in series between Q1 2012 and Q2 2012 is due to the Q2 2012 introduction of a more comprehensive reporting of cross-border positions. For more details, see www.bis.org/publ/qtrpdf/r_qt1212v.htm.

Source: BIS locational banking statistics, Tables A5 (by residence) and A7 (by nationality).

US dollar-denominated cross-border claims

In billions of US dollars

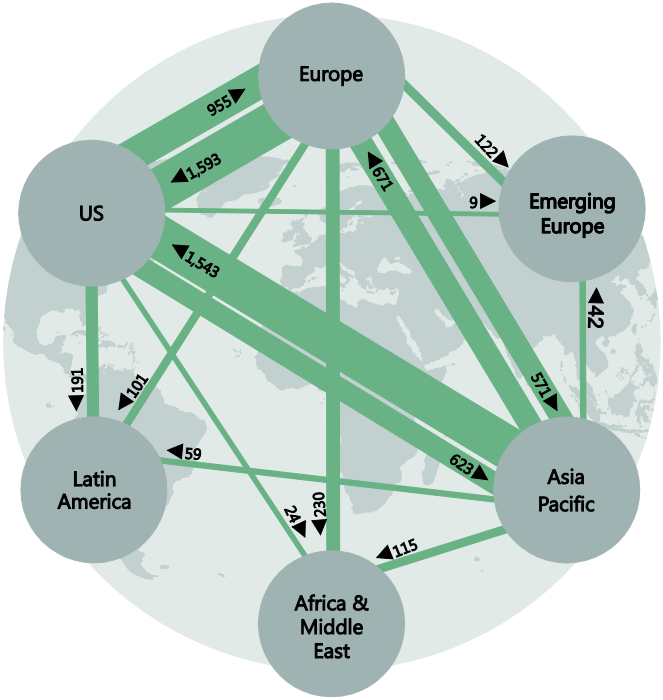
Graph 8



Source: BIS locational banking statistics.

US dollar-denominated cross-border claims[1]

In billions of US dollars, end-Q2 2016



[1] The thickness of the arrows indicates the size of the outstanding stock of claims. The direction of the arrows indicates the direction of claims: arrows directed from region A to region B indicate lending from banks located in region A to borrowers located in region B.

Source: Avdjiev, S, R. McCauley and H. S. Shin (2016): "Breaking free of the triple coincidence", Economic Policy 31: 409-45.