# Central Bank Swap Lines: Evidence on the effects of the lender of last resort

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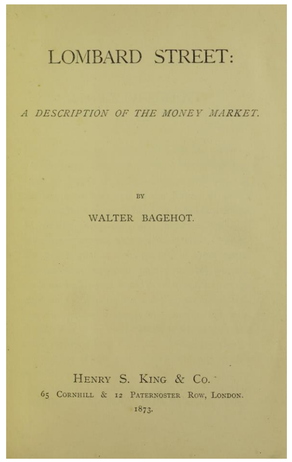
*The views expressed are those of the presenters and not necessarily those of the Bank of England, the MPC, the FPC or the PRC.*

# What are the effects of lending facilities?

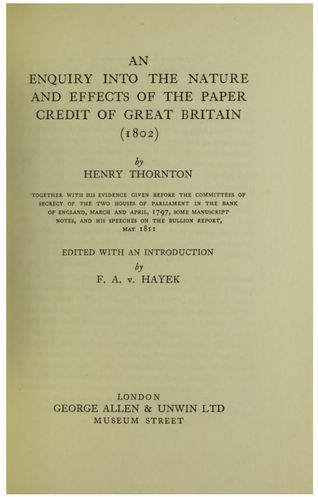


LOMBARD STREET:

*A DESCRIPTION OF THE MONEY MARKET.*

BY

WALTER BAGEHOT.

HENRY S. KING & CO.
65 CORNHILL & 12 PATERNOSTER ROW, LONDON.
1873.


AN
ENQUIRY INTO THE NATURE
AND EFFECTS OF THE PAPER
CREDIT OF GREAT BRITAIN
(1802)

*by*
HENRY THORNTON

TOGETHER WITH HIS EVIDENCE GIVEN BEFORE THE COMMITTEES OF SECRECY OF THE TWO HOUSES OF PARLIAMENT IN THE BANK OF ENGLAND, MARCH AND APRIL, 1797, SOME MANUSCRIPT NOTES, AND HIS SPEECHES ON THE BULLION REPORT, MAY 1811

EDITED WITH AN INTRODUCTION
*by*
F. A. v. HAYEK

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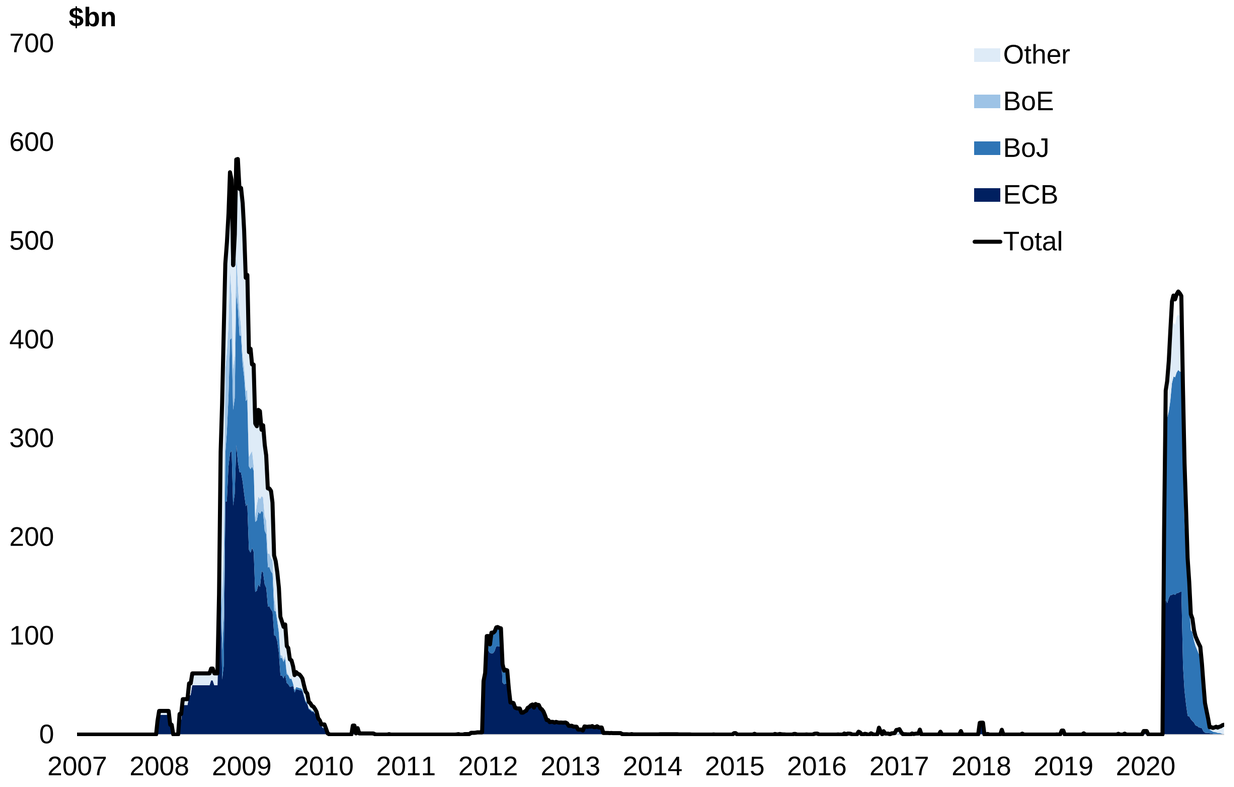
**Lending facilities are supposed to:**

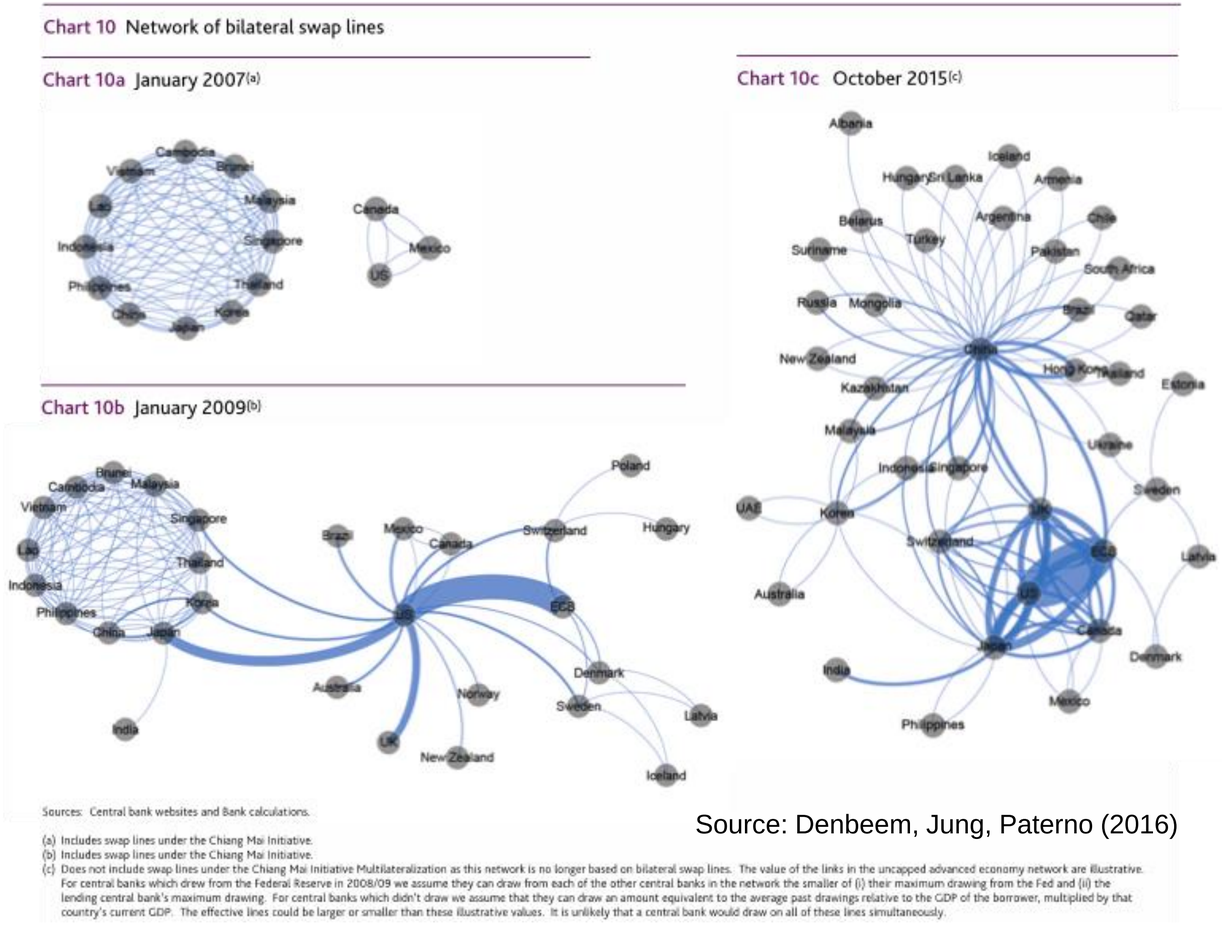
- Put a ceiling on private market interbank rates
- Provide insurance against funding crises
- Prevent possible fire sales

**Federal Reserve Lending Facilities in 2007-09:**

- DW: Discount window facility
- TAF: Term Auction Facility
- TALF: Term Asset-Backed Securities Loan Facility
- CPFF: Commercial Paper Funding Facility
- AMLF: Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility
- MMIFF: Money Market Investor Facility
- CBSL: Central Bank Swap Lines

# CB swap lines post 2007




Source: Denbeem, Jung, Paterno (2016)

*The governor of the Reserve Bank of India on Sunday called on major central banks to extend their network of currency swap lines deep into emerging markets, saying a type of "virtual apartheid" in the provision of foreign currencies hampers efforts to fight financial instability."* Wall Street Journal, October 15, 2017.

# This paper

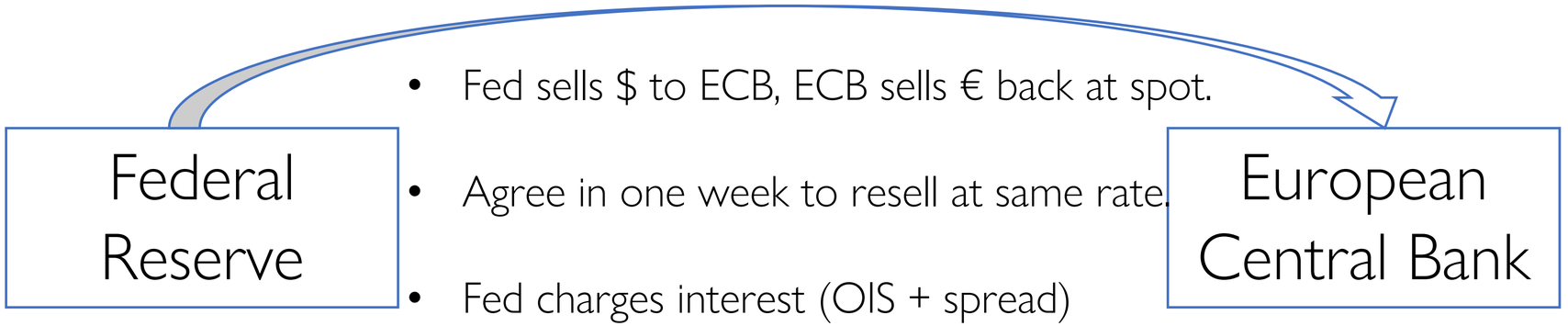
1. How do swap lines work and what is their role in monetary policy?
   - Source country CB lending to recipient country banks. Recipient CB bears credit risk and does the monitoring of the bank.
2. How does this monetary policy transmit through financial markets?
   - Ceiling on CIP deviations => lower funding costs
3. What economic consequences does this have?
   - Encourage investment from recipient- country banks into assets denominated in the source-country's currency.
   - Increases prices of affected bonds, and of affected banks' equity.

**Model:** From simple arbitrage trade through to GE model of international bank investment.

**Empirics**: Exploit variation in timing of swap line operations and in the Swap Line Rate in 11/2011.

# 2. Role in central banking: how the swap lines work

# ECB borrowing USD from Fed




EZ Bank

# ECB borrowing USD from Fed

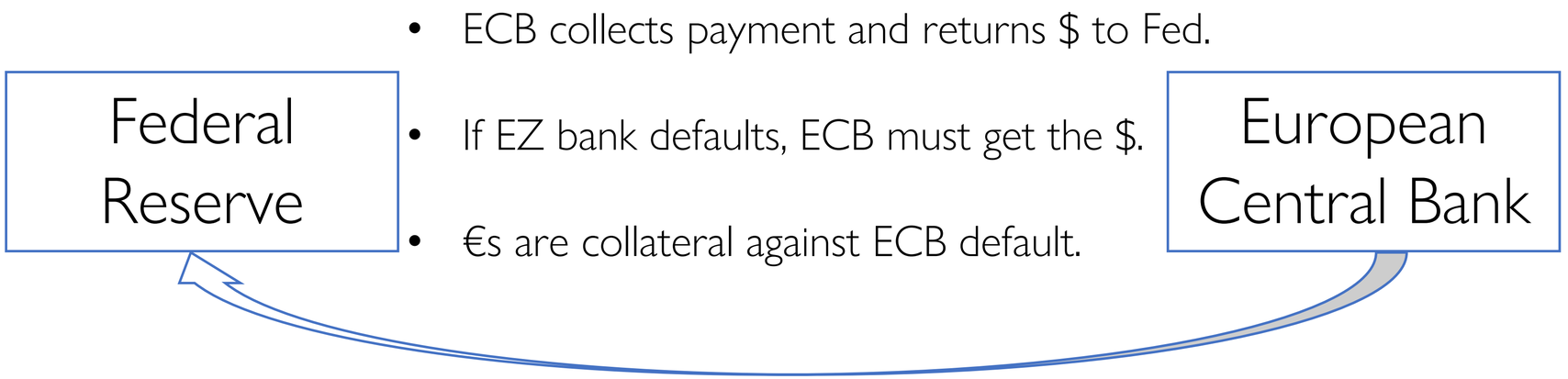
Federal Reserve

European Central Bank

- ECB lends to EZ bank.
- Charges same rate.
- Determines eligibility and collateral

EZ Bank

# ECB borrowing USD from Fed




- ECB collects payment and returns $ to Fed.
- If EZ bank defaults, ECB must get the $.
- €s are collateral against ECB default.

*Liquidity assistance to foreign bank using foreign central bank to do the monitoring of the collateral and of the bank.*

EZ Bank

# Functions and alternatives

## Properties

- US monetary policy on monetary base and rate, not EA monetary policy
- No exchange-rate or interest-rate risk, ECB has credit risk as in any lending facility

## Basic function of central banks:

- Fed: provide liquidity when there is a funding crisis
- ECB: judge banks eligible for liquidity assistance

## Alternatives (beyond FX reserves):

1. Fed lends directly to EZ banks through discount window/TAF? *But (i) less efficient monitoring, Fed refuse, (ii) branches/subsidiaries did not have collateral; (iii) stigma.*
2. EZ banks borrow euros from ECB, then buy dollars, and swap out the currency risk? *Spot and forward markets never closed, but cost…*

# 3. Theoretical predictions: The economic consequences of the swap lines

# Alternative

- Trade involving only a bank and the central bank (all in logs)
  - EZ bank borrows dollars for one week from ECB swap line, pay $i_t^s$
  - Buys euros at spot rate $s_t$, and sell forward at rate $f_t$ in one week
  - Deposit euros at ECB at at rate $i_t^{v*}$
  - Swap overnight for one-week rate at cost $i_t^* - i_t^{p*}$

- Borrow and deposit at the ECB. No risk beyond (i) counterparty in currency swap, (ii) movements in EZ policy spread. Principle of no arbitrage:

$$i_t^s \geq s_t - f_t + (i_t^{v*} + i_t^* - i_t^{p*})$$

# Arbitrage relation

- Deviations from CIP (in OIS terms):

$$x_t = s_t - f_t + i_t^* - i_t$$

- Two options: borrow from swap line at $i^s$, or borrow dollars synthetically: $i + x$

- **Proposition:** *Deviations from covered interest parity have a ceiling given by the spread between the source swap and interbank rates plus the difference between the recipient central bank policy and deposit rates:*

$$x_t \leq (i_t^s - i_t) + (i_t^{p*} - i_t^{v*})$$

Spread on the swap line

Spread IOR vs policy rate

# A supply curve for FX swaps

- Two extra ingredients:
  1. The market for forwards works over the counter so at any date there is a distribution of transaction prices for a distribution of lenders and borrowers.
  2. Two leading theories for why CIP stopped holding after 2007.

- Representative intermediary in FX swaps, atomistic risk-neutral traders, matched with bank OTC. Two frictions:
  1. Capital requirement of fraction $m$ that costs $i_t + \Delta_t^e$
  2. Haircut cash ratio $\xi$ and unsecured funding costs $i_t + \Delta_t^u$
  - So profit per unit of trade:

$$x_t - (i_t^{p*} - i_t^{v*}) - \underbrace{[m\Delta_t^e + (1-m)(1-\xi)\Delta_t^u]}_{\equiv h(.)}$$

# Equilibrium in financial markets

- Arguments for *h(.)* to increase in total volume of trade ($V_t$):
  (i) opportunity cost of capital,
  (ii) default and debt overhang.

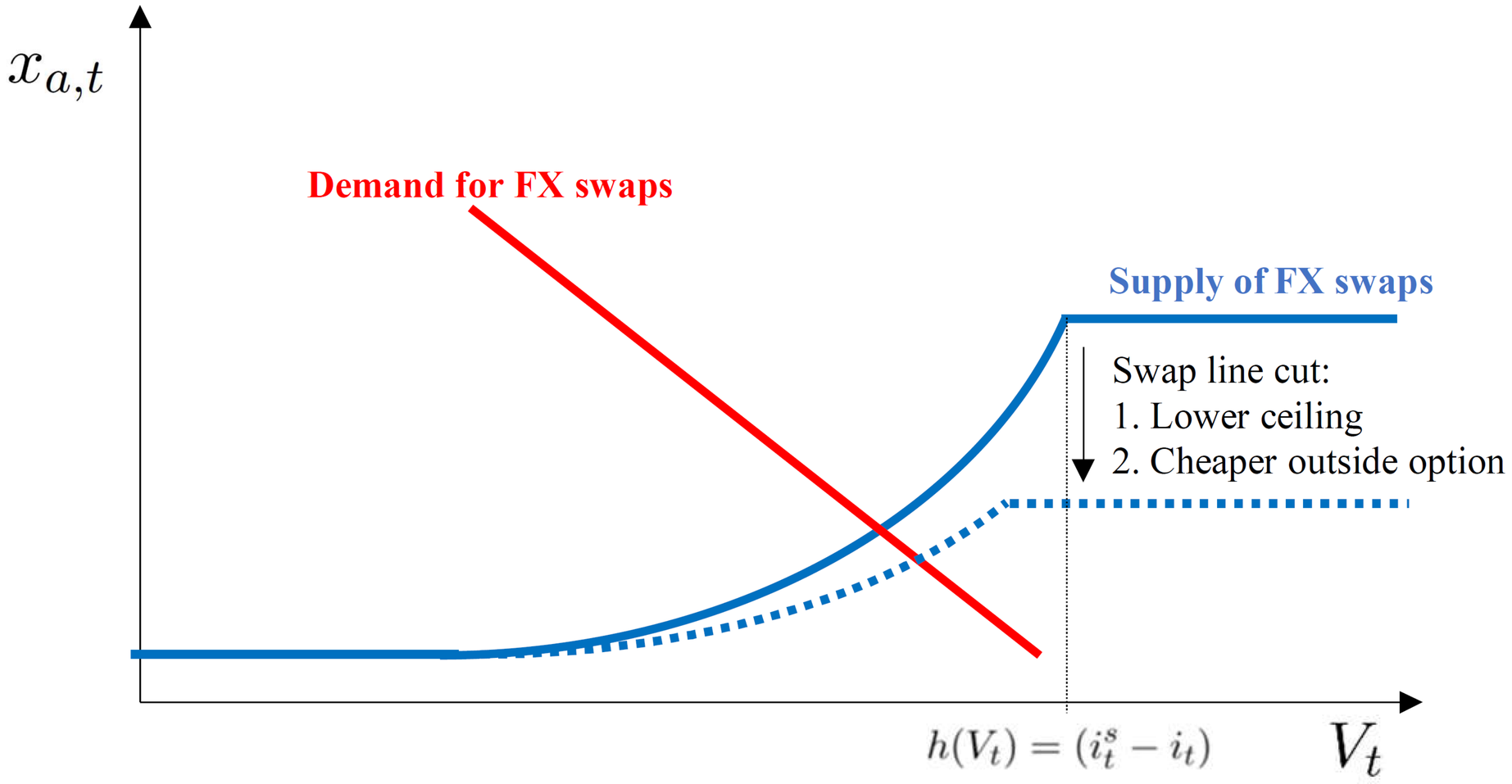
- Banks, indexed by a, heterogenous in bargaining power $\delta_a$

- Nash bargaining with F($\delta_a$) in OTC market (swap line outside option)

$$x_{a,t} = (i_t^{p*} - i_t^{v*}) + \delta_a h_t + (1 - \delta_a)(i_t^s - i_t)$$

- If $h_t > (i_t^s - i_t)$ swap line "in the money" and replaces private funding.

# Equilibrium result



# Further discussion: haircuts and regulation

- Alternative source of funding for European banks was central bank, and these have same cash rate no matter which currency is borrowed.

**Proposition:** *Bank-specific deviations from covered interest parity have a ceiling given by the spread between the source swap and interbank rates, plus the difference between the recipient central bank policy and deposit rates, plus the shadow value of collateral, plus the shadow cost of regulation on banks that is triggered by borrowing and lending from their central bank:*

Shadow value of reg. constraint

$$x_{a,t} \leq (i_t^s - i_t) + (i_t^{p*} - i_t^{v*}) + (1 - \xi^c)(i_{a,t}^u - i_t^s) + \psi_{a,t}.$$

Shadow value of collateral

# Model of cross border investment (in brief)

Put into three period (0,1,2), two country, Holmstrom-Tirole model of investment and funding shocks. Recipient country banks investing in source country assets.

Initial period-0 investment and complementary period-1 investment. Payoff in period-2.

Funding risk in source currency in period-1 (recipient currency unconstrained) → switch to FX swaps subject to same frictions as before.

Swap line provides ceiling, mitigates funding shock in period 1, reduces risk from period-0 perspective.

Implications…

# Model of cross border investment

Put into three period (0,1,2), two country, Holmstrom-Tirole model of investment and funding shocks. Recipient country banks investing in source country assets.

Representative source-country firm, aside from local inputs, uses recipient country capital: $k_0$ $k_1$ $F(k_0, k_1)$ $\partial F(.)/\partial k_0 \partial k_1 > 0$

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Representative source-country firm, aside from local inputs, uses recipient country capital:

$k_0$

Initial period-0 investment

$k_1$

Follow-up period-1 investment

$F(k_0, k_1)$

Period-2 gross return

$\partial F(.)/\partial k_0 \partial k_1 > 0$

Complementarity in investment

# Model of cross border investment

Put into three period (0,1,2), two country, Holmstrom-Tirole model of investment and funding shocks. Recipient country banks investing in source country assets.

Representative source-country firm, aside from local inputs, uses recipient country capital: $k_0$ $k_1$ $F(k_0, k_1)$ $\partial F(.)/\partial k_0 \partial k_1 > 0$

Without financial frictions, the optimum ( $\hat{k}_0^*, \hat{k}^*$) is:

$$\partial F(.)/\partial \hat{k}_0^* = \rho$$

Period-0 to period-2 source-currency interest rate

$$\partial F(.)/\partial \hat{k}^* = i$$

Period-1 to period-2 source-currency interest rate

# Funding shocks and sources of funding

Limited ability of recipient-country bank to attract period 1 source-currency

final $l^* \leq \bar{l} - \chi$

Available source currency $[0, \bar{l}]$

$\bar{l} \geq \hat{k}^*$

Max sufficient to fund frictionless

$G(\chi)$

Funding shock

# Funding shocks and sources of funding

Limited ability of recipient-country bank to attract period 1 source-currency finance:

$l^* \leq \bar{l} - \chi$ $\bar{l} \geq \hat{k}^*$ $G(\chi)$ $V_t^* = k^* + \chi - \bar{l}$

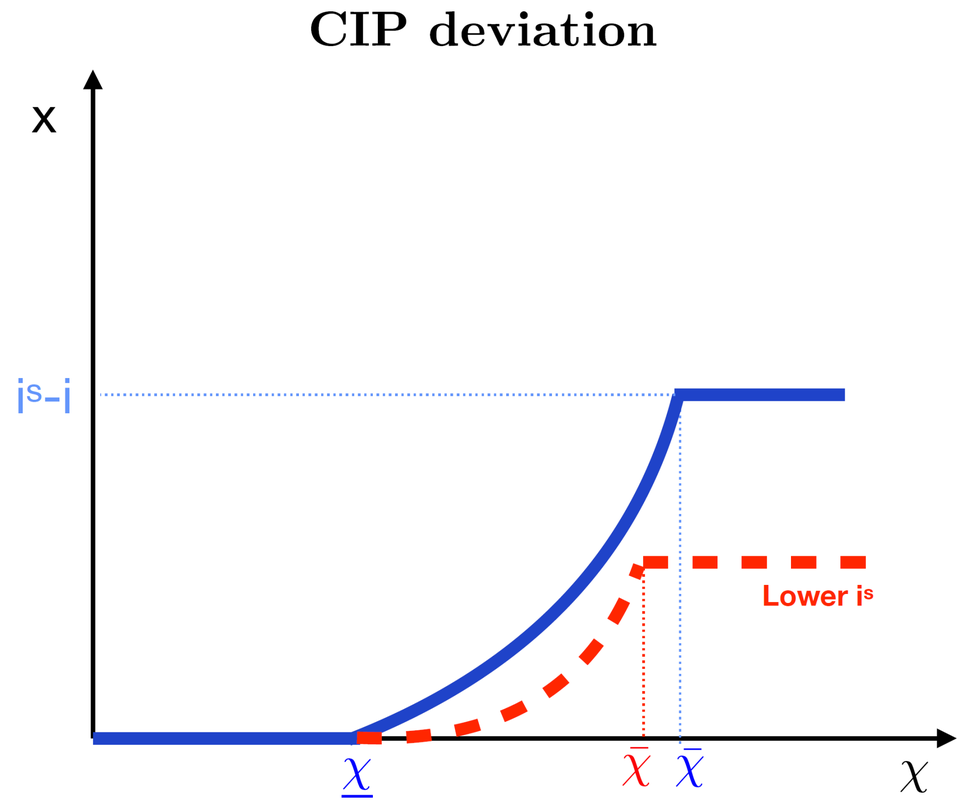
Demand for alternative

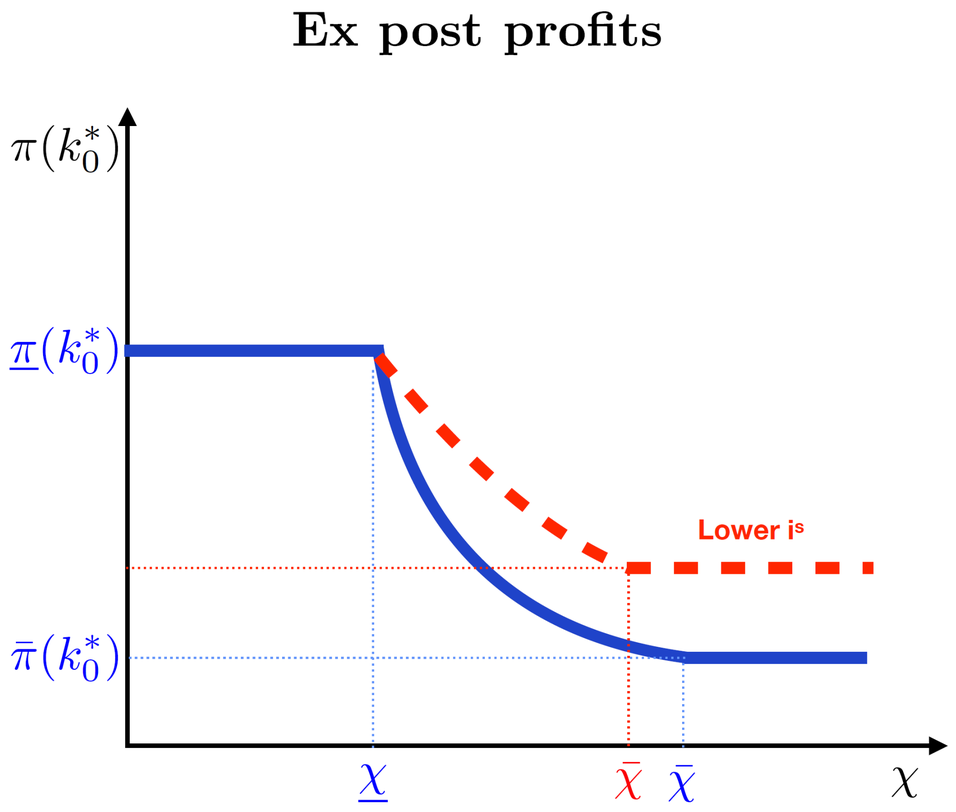
Alternative: borrow in recipient-currency, hedge with intermediaries as before at cost.

$$i + \bar{\delta} h(k^* + \chi - \bar{l}) + (1 - \bar{\delta})(i^s - i)$$

Simplify by assuming: (i) floor system, (ii) collateral/regulatory constraints not binding on swap line use (iii) banks have homogenous bargaining power. So, simpler ceiling result that $x < i^s - i$.

# Equilibrium




Period-0 first order condition:

$$G(\underline{\chi})\underline{\pi}'(k_0^*) + (1 - G(\bar{\chi}))\bar{\pi}'(k_0^*) + \int_{\underline{\chi}}^{\bar{\chi}} \pi'(k_0^*, \chi) dG(\chi) = \rho$$

# Theoretical Predictions

**Proposition:** *An decrease in the swap line rate:*

1. *Lowers the ceiling and expected realizations of CIP deviations;*
2. *Raises investment by recipient-country banks in source-currency capital;*
3. *Increases the expected profits of recipient-country banks that invest in source-currency capital.*

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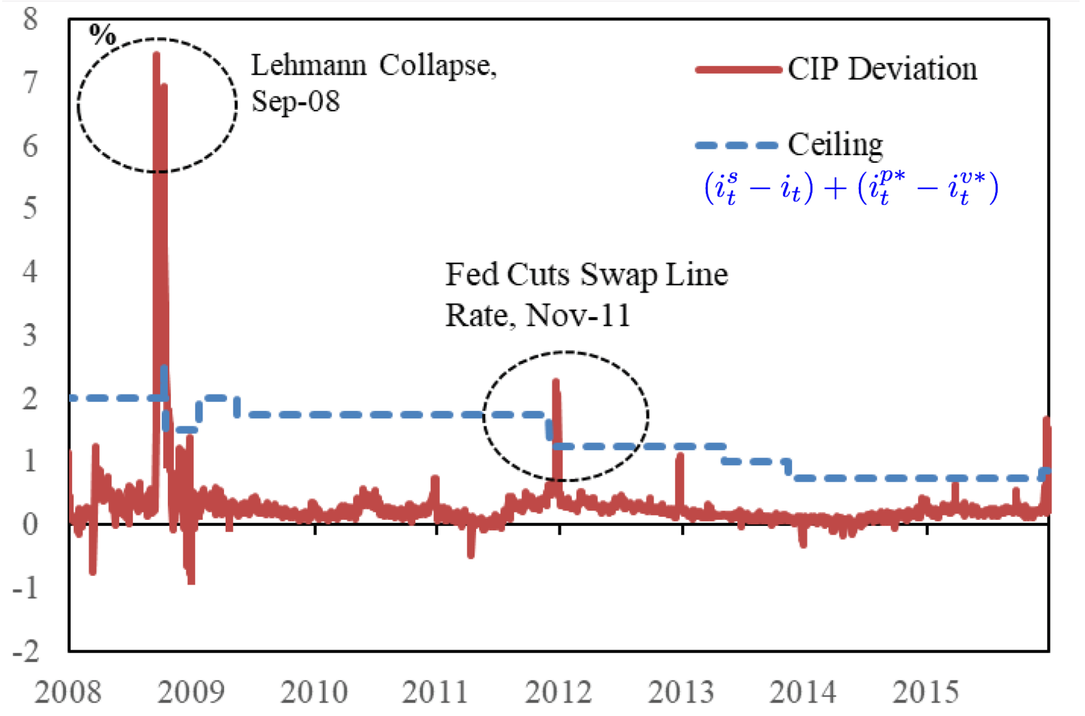
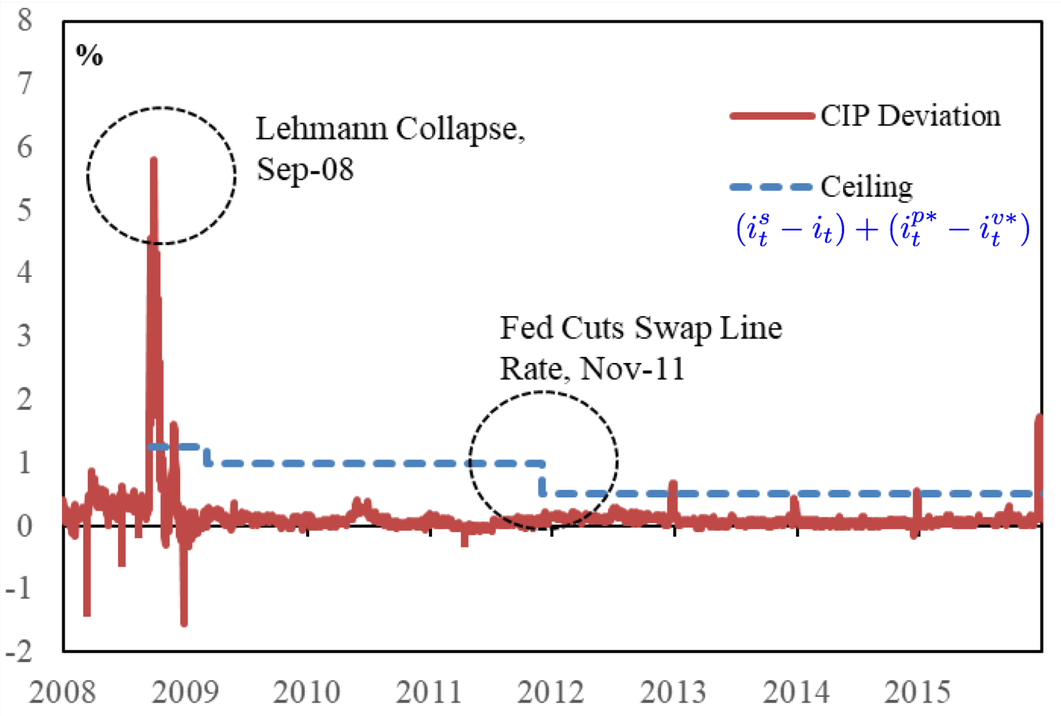
# 4. Empirics: The swap line and CIP deviations

# Euro and GBP (USD) bases and ceiling

EUR-USD




GBP-USD




- Swap lines start in 12/2007, all but 5 lapse in 2009.
- Ceiling held well until 2015 (2014 for JPY); except for year ends. Quarter-end violations after.
- Theory is sharp on what measure of CIP to use.
- Two strategies: (i) Diff-in-diff around rate cut, (ii) Variation in operation timing at Q-end

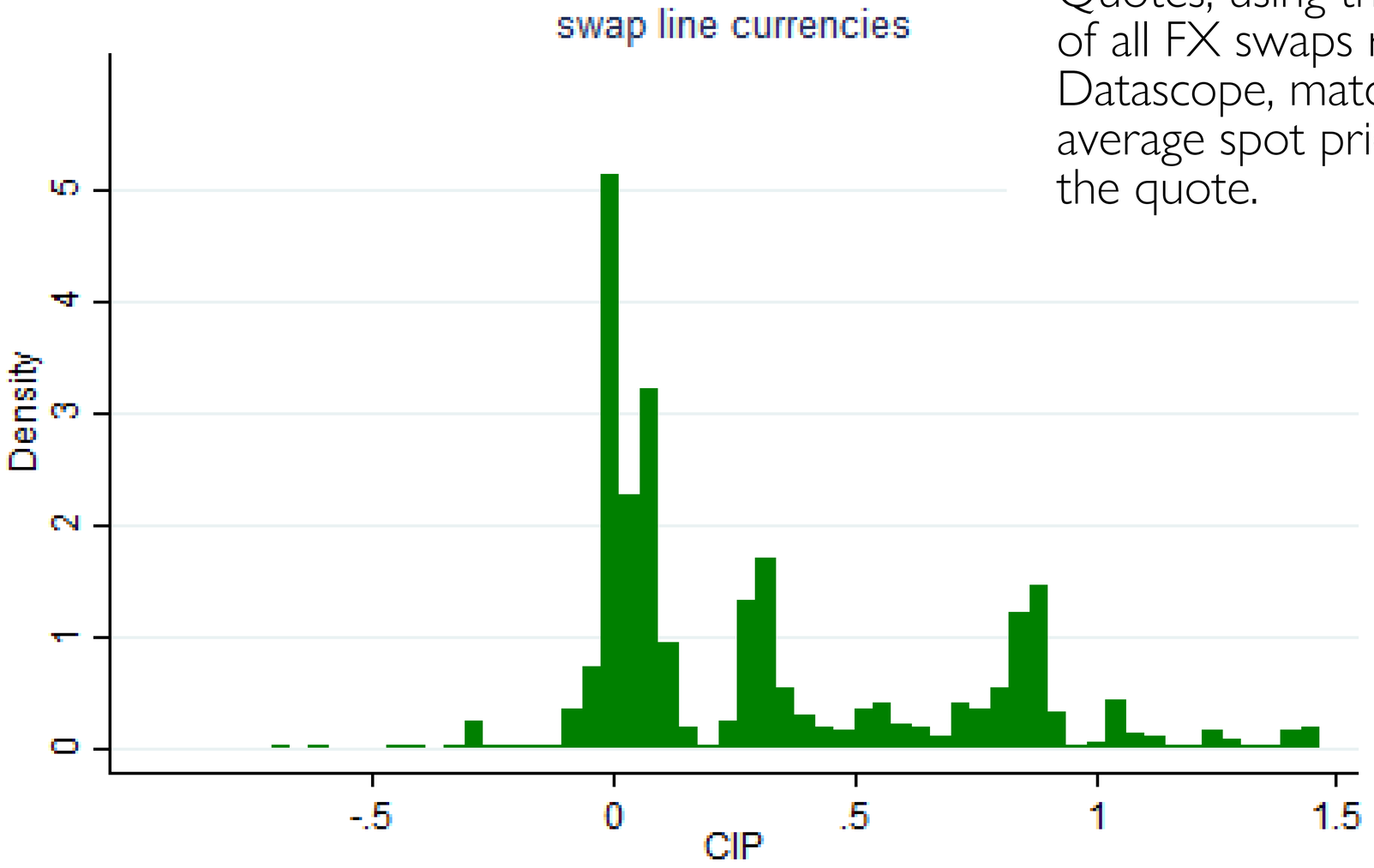
# Difference-in-differences identification strategy

- Nov. 30, 2011: Fed unexpectedly announced would lower swap rate spread from 1% to 0.5%.
- Compare CIP deviations for swap-line currencies (EUR, JPY, GBP, CAD, CHF) with non-swap line (SEK, DKK, NOK, AUD, NZD)

Exclusion restriction for identification with respect to CIP

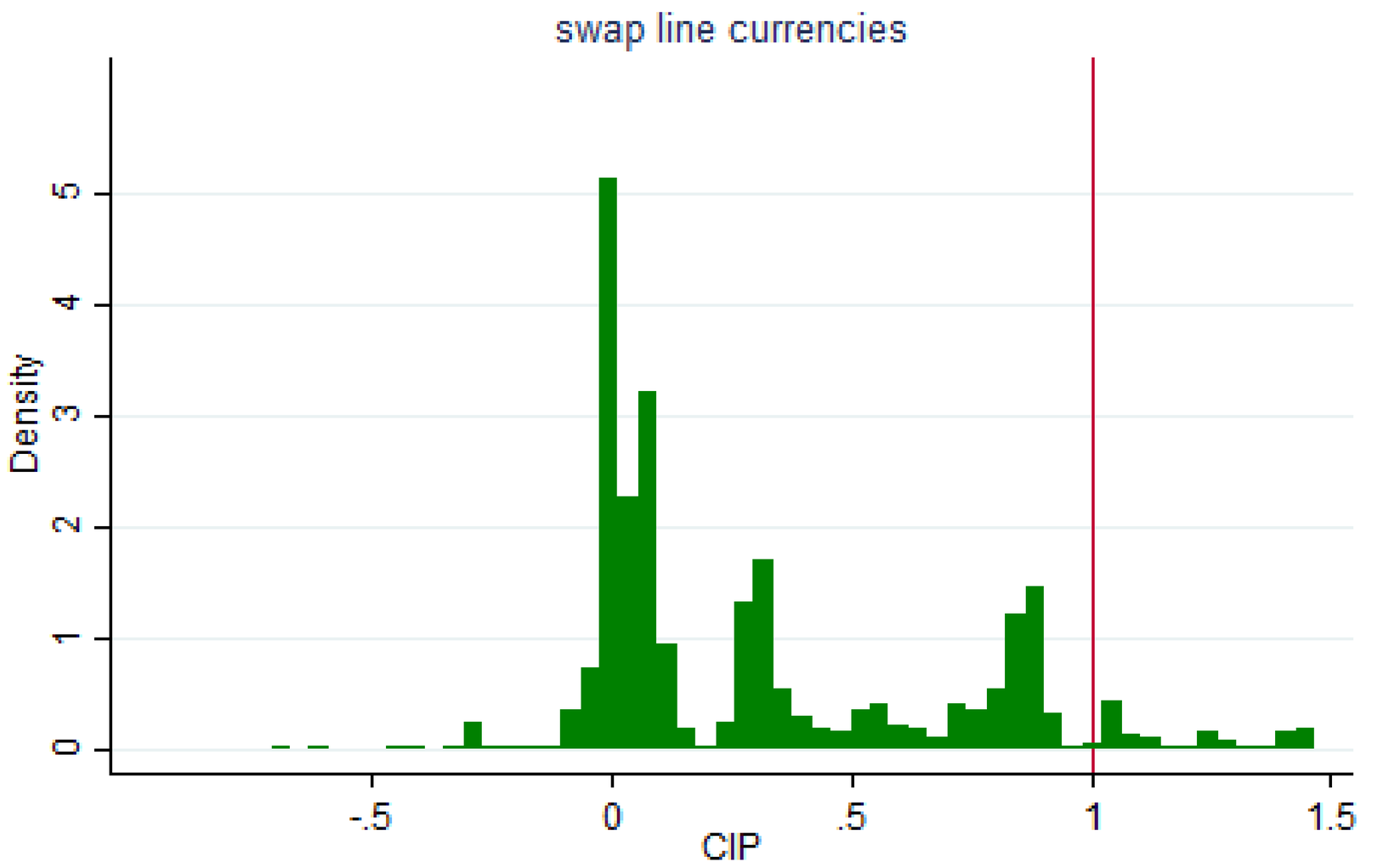
- The minutes of the meeting have no mention of recent 1-week CIP deviations
- Our measures were not particularly elevated the days or weeks before the change.
- Motivation was to normalise the operations of the swap line.
- Timing: outcome of lengthy discussions with foreign central banks.
- Size of the change partly random: serious discussion of 0.75% versus 0.5%
- The change affected all swap-line central banks, event though closer event was crisis in Euro-area (treated) and Nordic countries (untreated)
- Surprise to markets, little anticipation effect

# CIP deviations (quotes) - Nov 2011

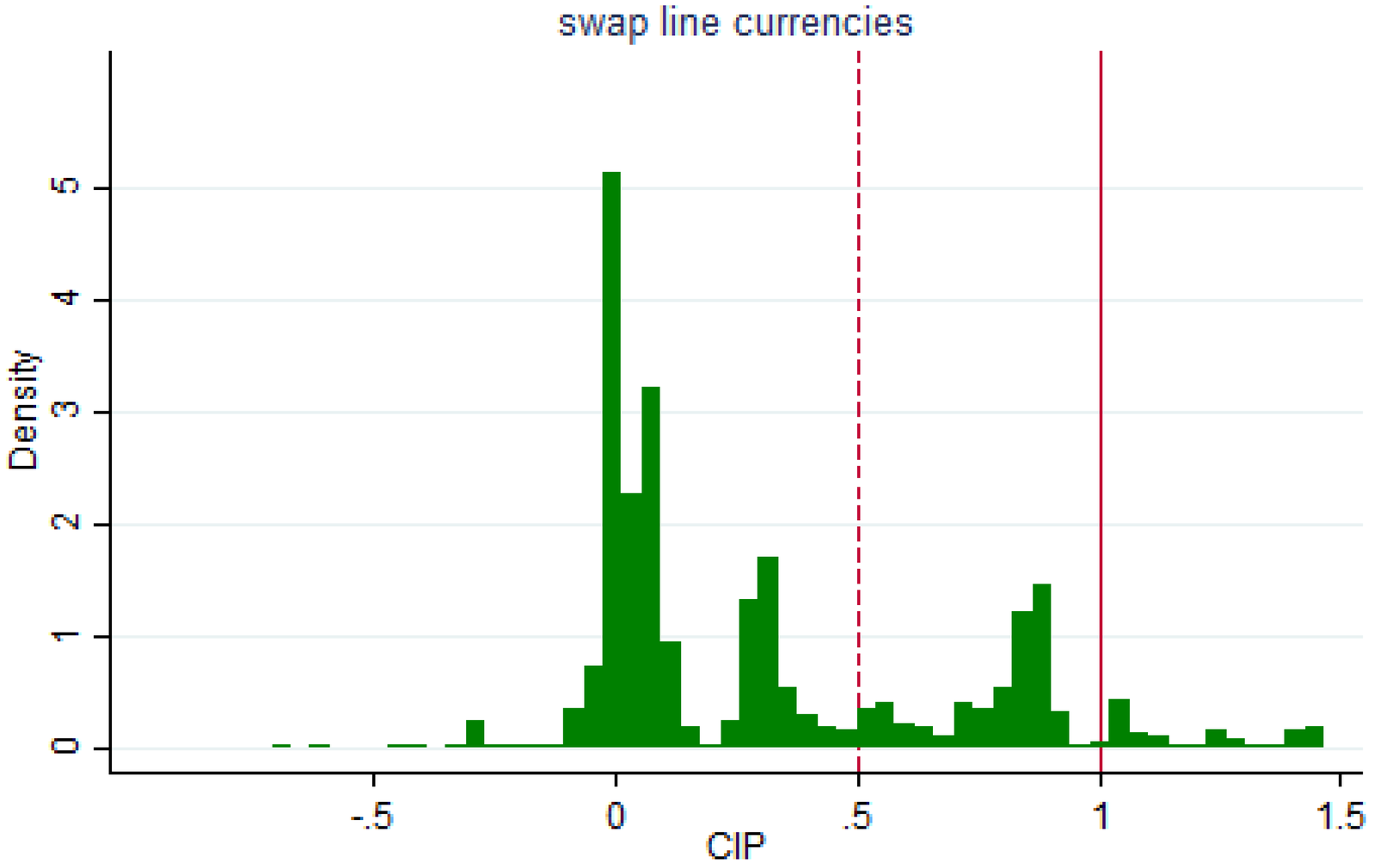



Quotes, using the mid-quoted price of all FX swaps recorded in Datascope, matched to match to average spot price in the minute of the quote.

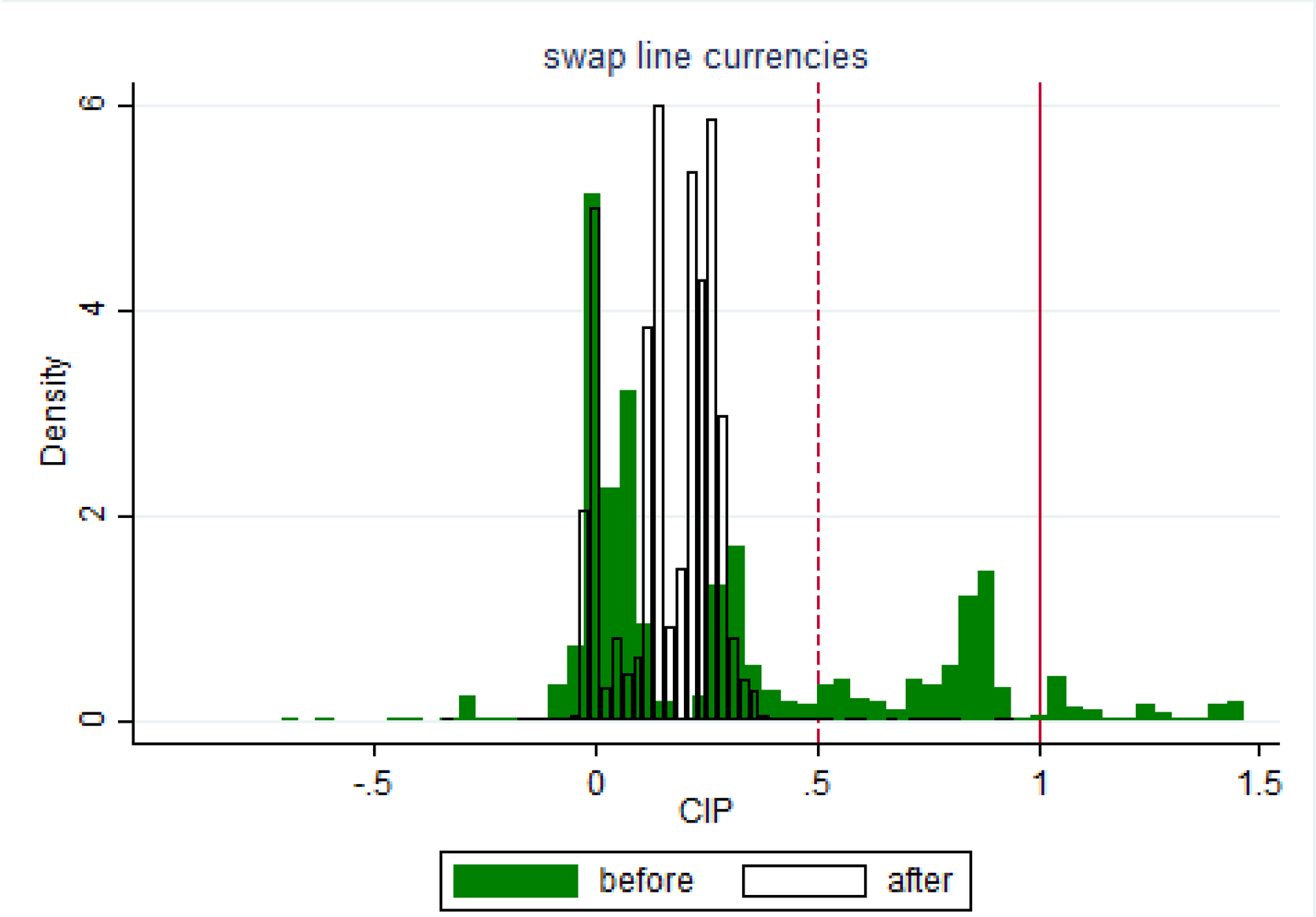
# CIP deviations (quotes) – 100bp ceiling



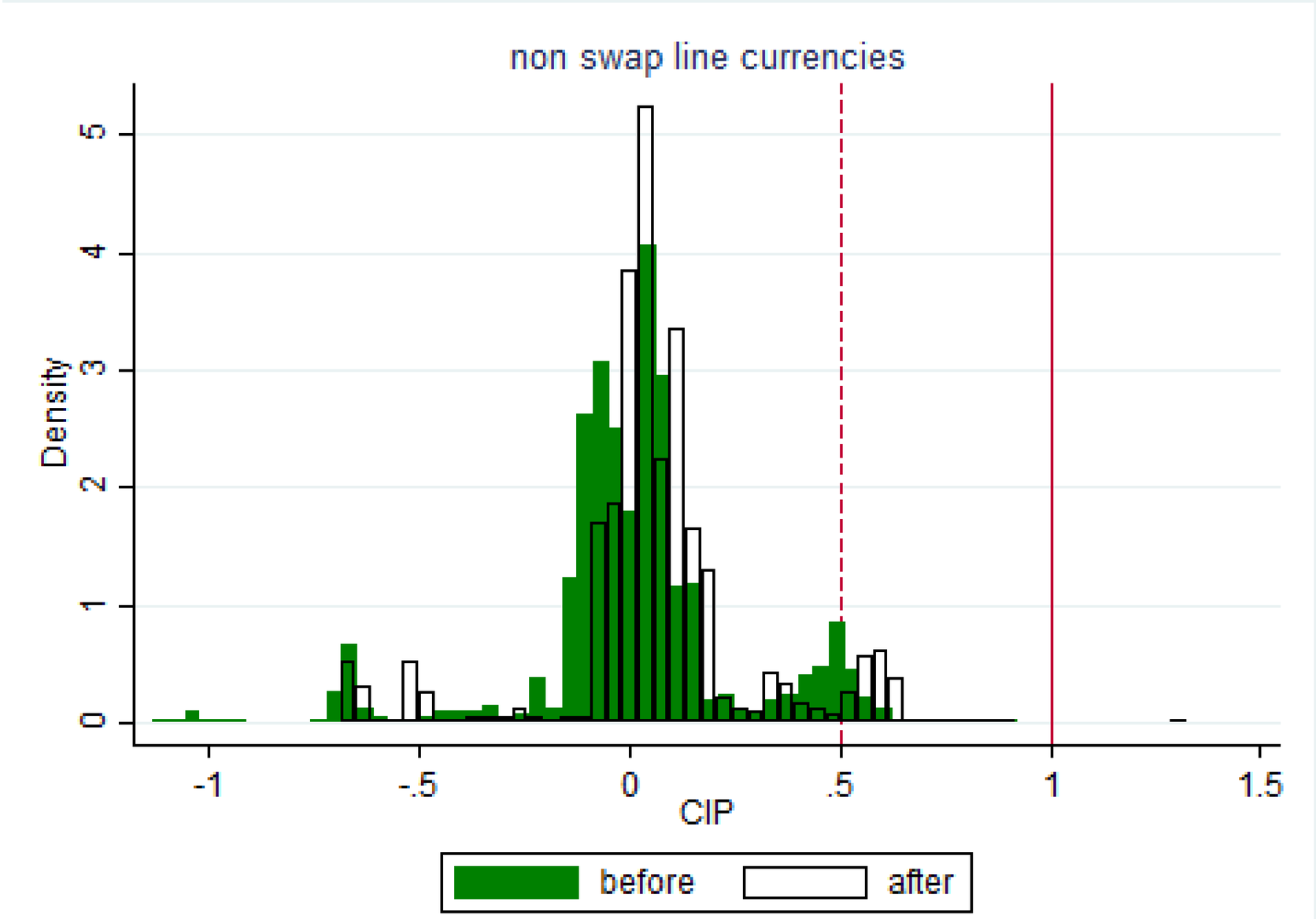
# 30th Nov-2011: 50bp cut



# Dramatic fall in CIP deviations



# Not replicated in non-swap-line currencies

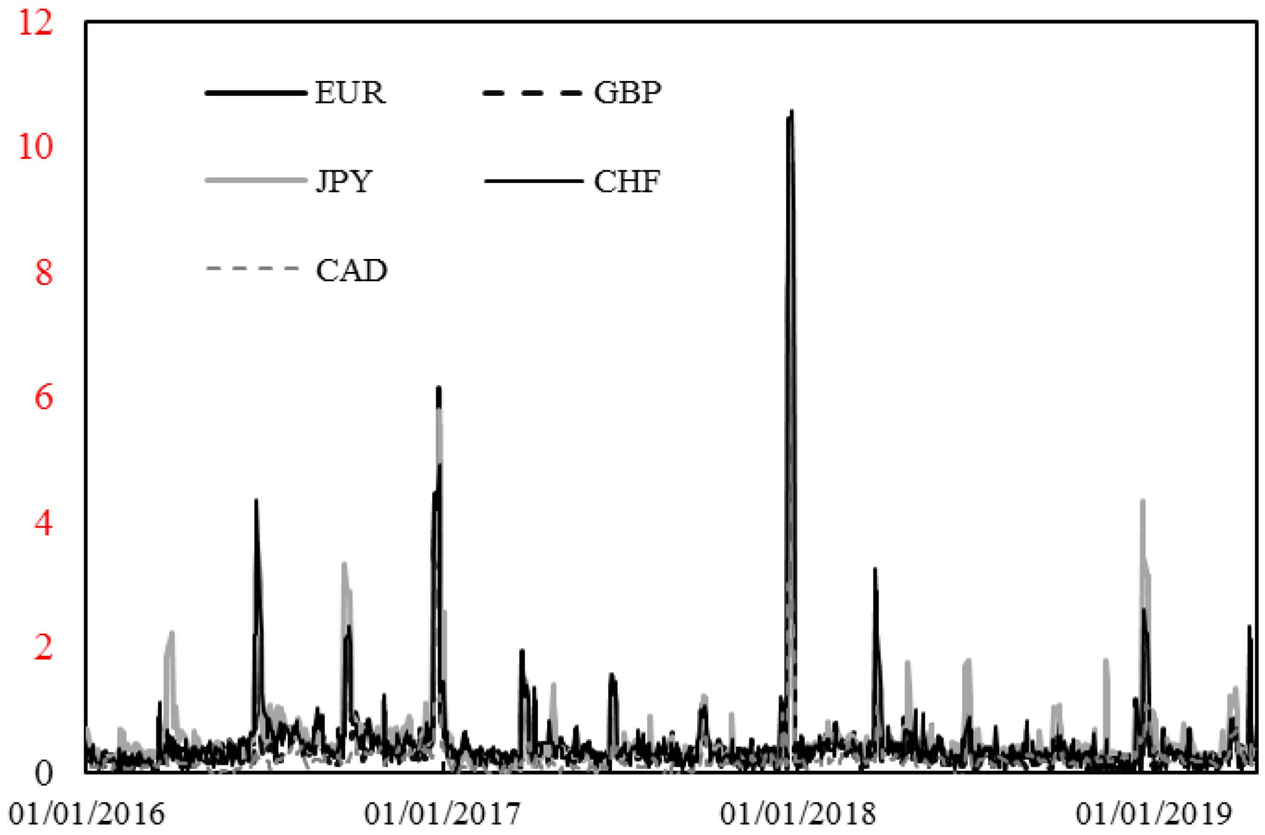


# Inspecting treated and control groups

| | (1) *Baseline: 23/11-29/11 vs 8/12-13/12, Quotes* | (2) *23/11-29/11 vs 1/12-7/12, Quotes* | (3) *Nov vs Jan, Quotes* | (4) *23/11-29/11 vs 8/12-13/12, No Euro, Quotes* | (5) *23/11-29/11 vs 8/12-13/12, European Currencies, Quotes* | (6) *23/11-29/11 vs 8/12-13/12, EUR, CHF vs DKK, NOK, Quotes* | (7) *Nov vs Jan Daily Data* |
|---|---|---|---|---|---|---|---|
| Mean | -.281*** | -.225*** | -.285*** | -.212** | -.118 | -.452*** | -.184** |
| | (.108) | (.084) | (.110) | (.098) | (.143) | (.070) | (.092) |
| Median | -.208 | -.197 | -.015 | -0.187 | -.024 | -.375*** | -.146 |
| | (.195) | (.167) | (.169) | (.127) | (.208) | (.138) | (.147) |
| 75 %tile | -.286 | -.283** | -.407 | -.223 | -.491** | -.608*** | -.155 |
| | (.220) | (.141) | (.289) | (.142) | (.199) | (.087) | (.113) |
| 90 %tile | -.586*** | -.207* | -.703* | -.354** | -.401** | -.522*** | -.281*** |
| | (.174) | (.111) | (.382) | (.148) | (.180) | (.109) | (.090) |
| $N$ | 288374 | 283932 | 1228637 | 253889 | 120555 | 95434 | 430 |

*Notes: Swap Line Currencies refers to EUR, GBP, CAD, JPY, CHF (treatment group). Non-swap line currencies refers to AUD, NZD, SEK, NOK, DKK (control group). Column (1): Compares CIP deviations from all quotes in the FX swap market recorded between 23/11/11-29/11/11 versus 8/12/11-13/12/11. Column (2): Changes the post announcement window to 1/12/11-7/12/11, covering the 5 trading days through to the first European auctions at the new rate. Column (3): Extends the event windows to monthly and compares November 2011 to January 2012. Column (4): As Column (1) but Euro excluded from sample. Column (5): As Column (1) but excludes JPY, CAD, AUD and NZD from the sample. (6): As Column (1) but restrict sample to EUR, CHF versus NOK, DKK. Column (7): As Column (3) but uses daily data on CIP deviations based on prices at close in FX forward and spot markets. Standard errors, block bootstrapped at the currency level, in brackets. *** denotes significance at the 1% level; ** 5% level;* 10% level.*

# Ceiling violations since 2016




- Perhaps due to compliance with leverage ratio only being required at end of quarter.
- Our framework can account for this: spikes represent shift in shadow value of reg. constraint.
- More importantly, swap line is not a *standing facility*. Operations occur weekly…
- New test of theory.

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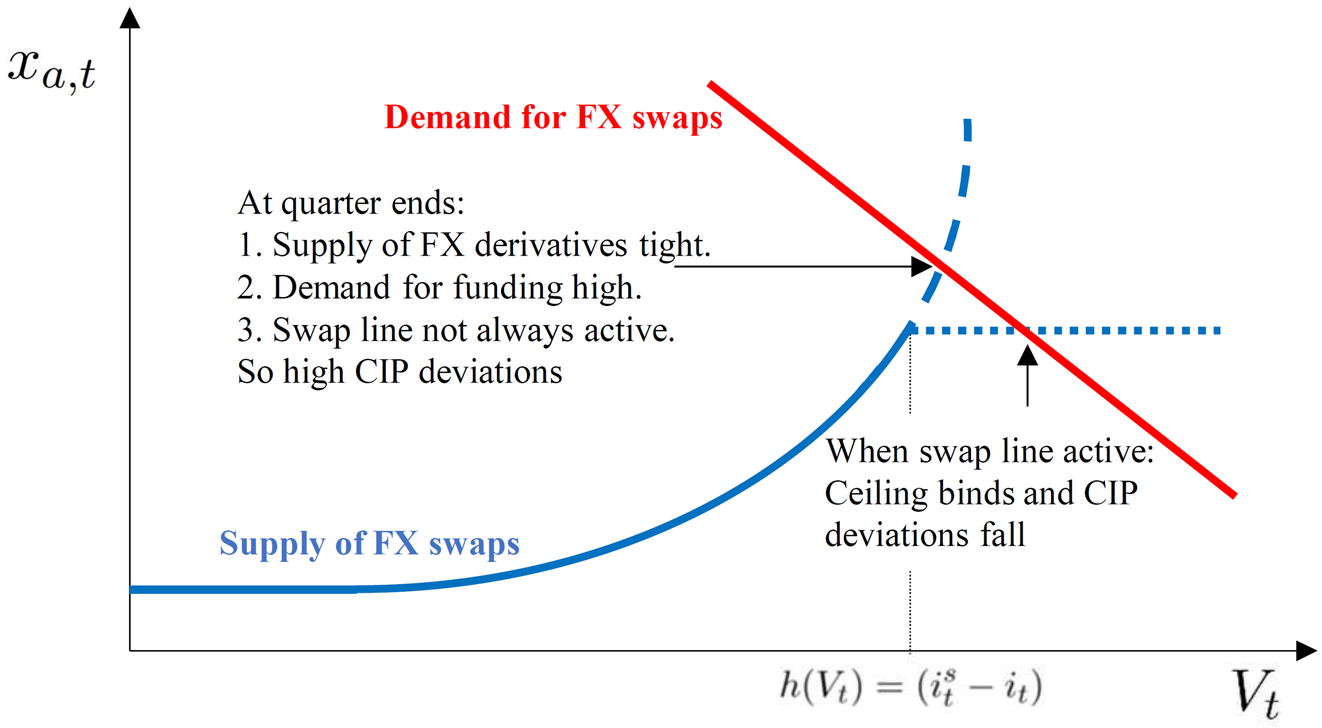
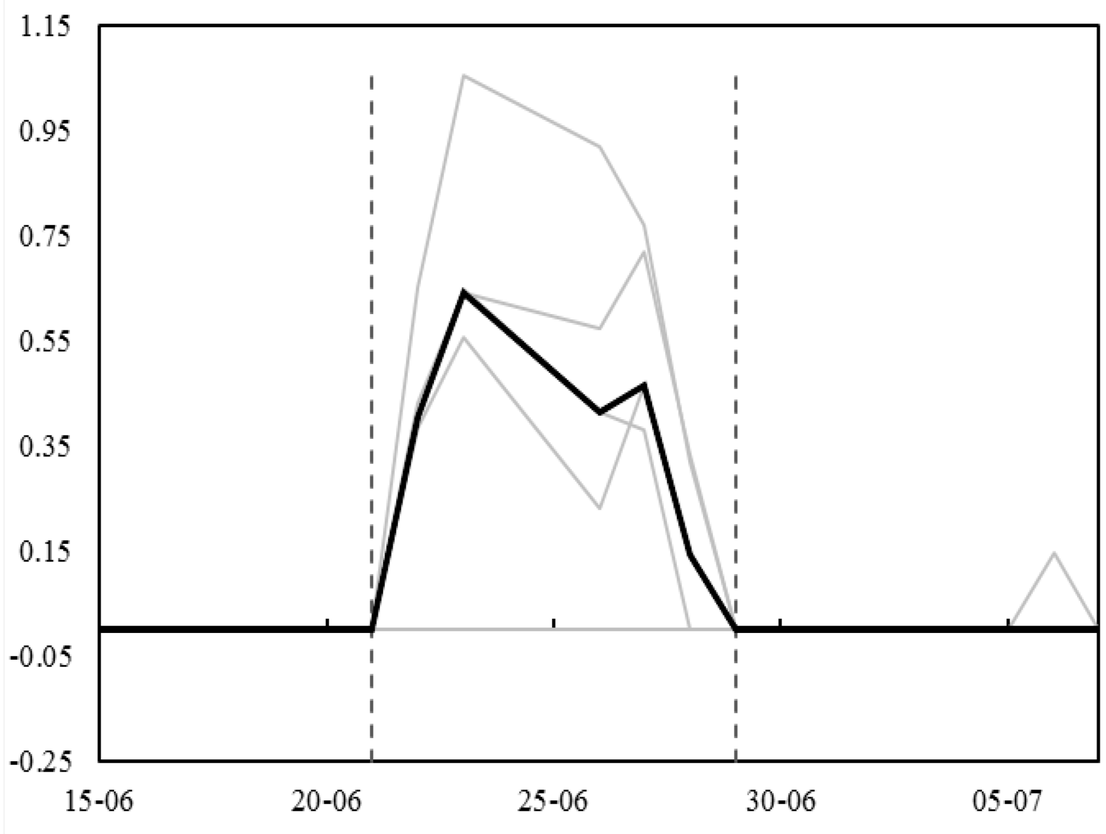


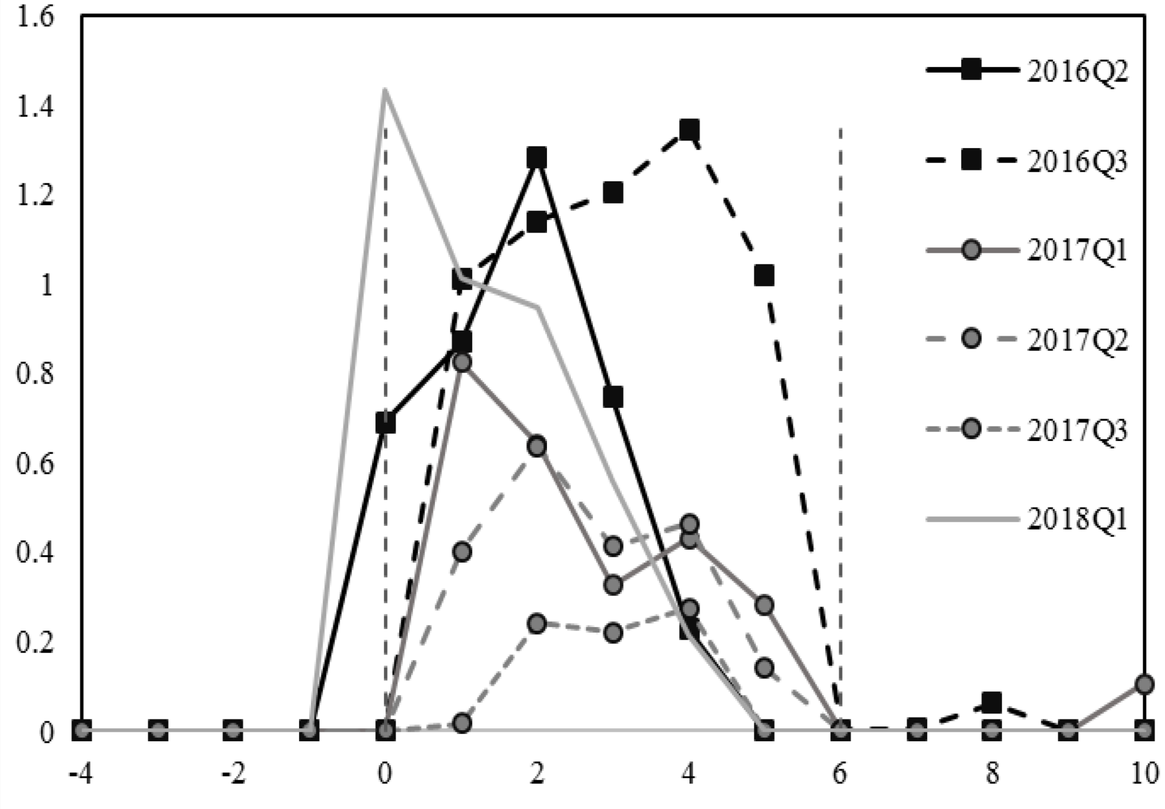

- Perhaps due to compliance with leverage ratio only being required at end of quarter.
- Our framework can account for this: spikes represent shift in shadow value of reg. constraint.
- More importantly, swap line is not a *standing facility*. Operations occur weekly…
- New test of theory.

# Spikes coincide with swap line operations

(a) Five swap-line currencies and their median around the end of 2017Q



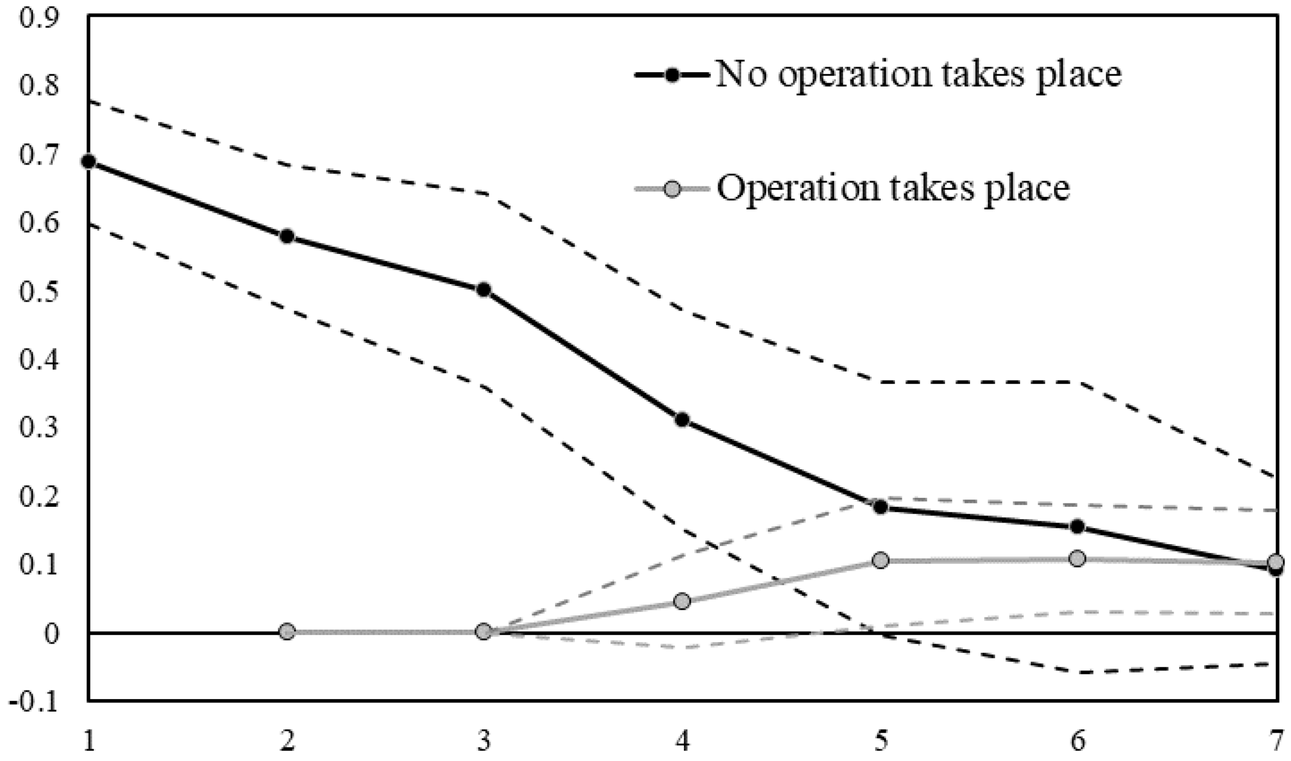

(b) Median across currencies for different quarter ends




*Notes: Ceilling violations around quarter end. Panel (a): Plots* $max(x_{j,t} - (i_t^s - i_{j,t}) - (i_t^{p*} - i_{j,t}^{v*}), 0)$ *where* $x_{j,t}$ *is the one-week OIS CIP deviation of the CAD, CHF, EUR, GBP, and JPY vis-a-vis the USD (grey lines) and the black line is the median of the 5 currencies. Vertical lines correspond to the dates of swap line operations by the ECB, BoE and SNB. Panel (b): As the black line in panel (a) but for alternative quarter ends. Zero on the x-axis corresponds to the trading day when bids for the second to last European swap line operation of the quarter was taken. The next operation is settled on the 6th trading day after that.*

# Ceiling violations don't persist through swap line ops

$$\mathbf{1}(viol_{j,t+h}) = \beta^h_{j,0} \times (1 - \mathbf{1}(Settled_{j,t+h})) \times \mathbf{1}(viol_{j,t}) + \beta^h_{j,1} \times \mathbf{1}(Settled_{j,t+h}) \times \mathbf{1}(viol_{j,t}) + \varepsilon_{j,t+h},$$

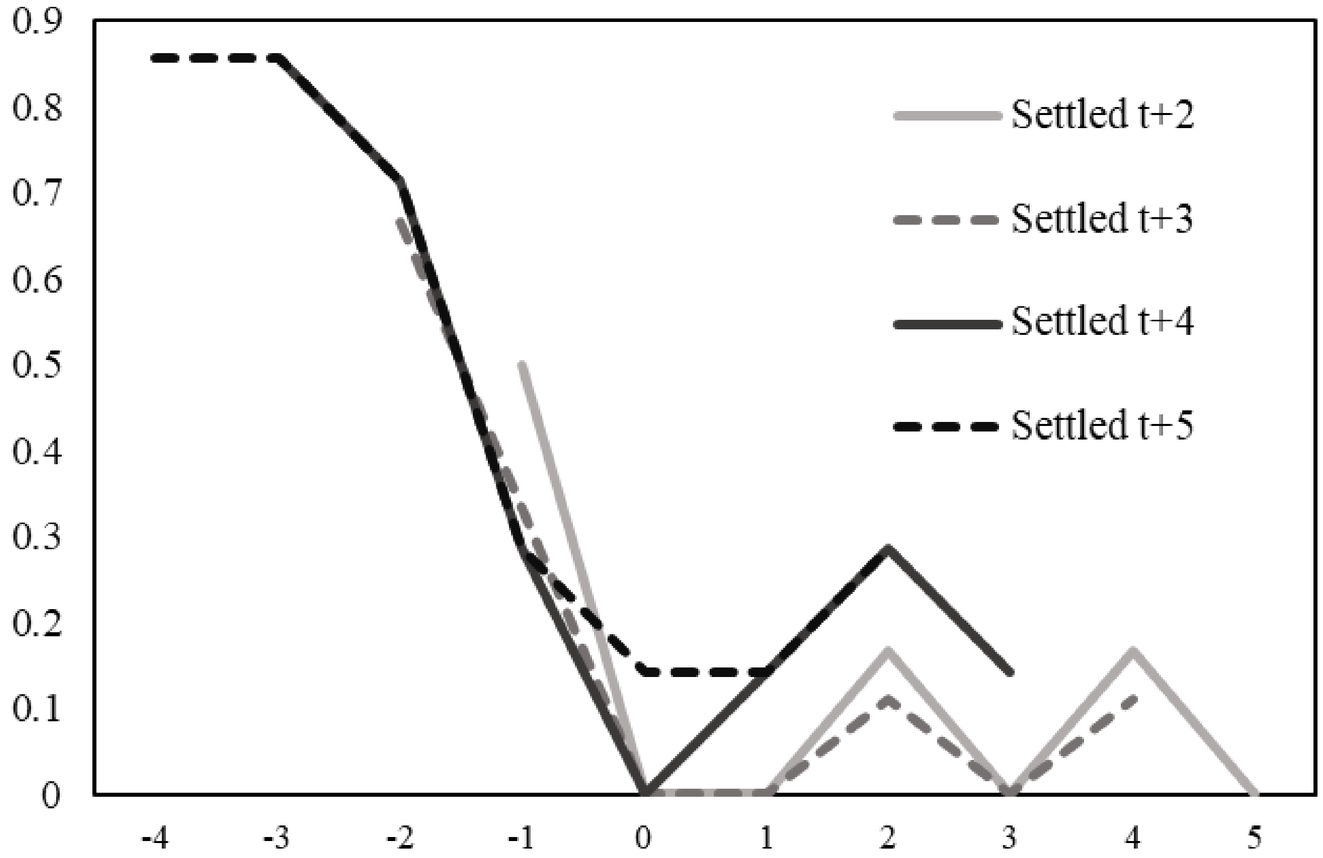



- $\beta_0$: probability ceiling violated at date t+h, conditional on being violated at t, if there was no swap-line auction settled in between
- $\beta_1$: probability ceiling violated at date t+h, conditional on being violated at t, if there was a swap-line auction settled in between

# Ceiling violations die with next settlement

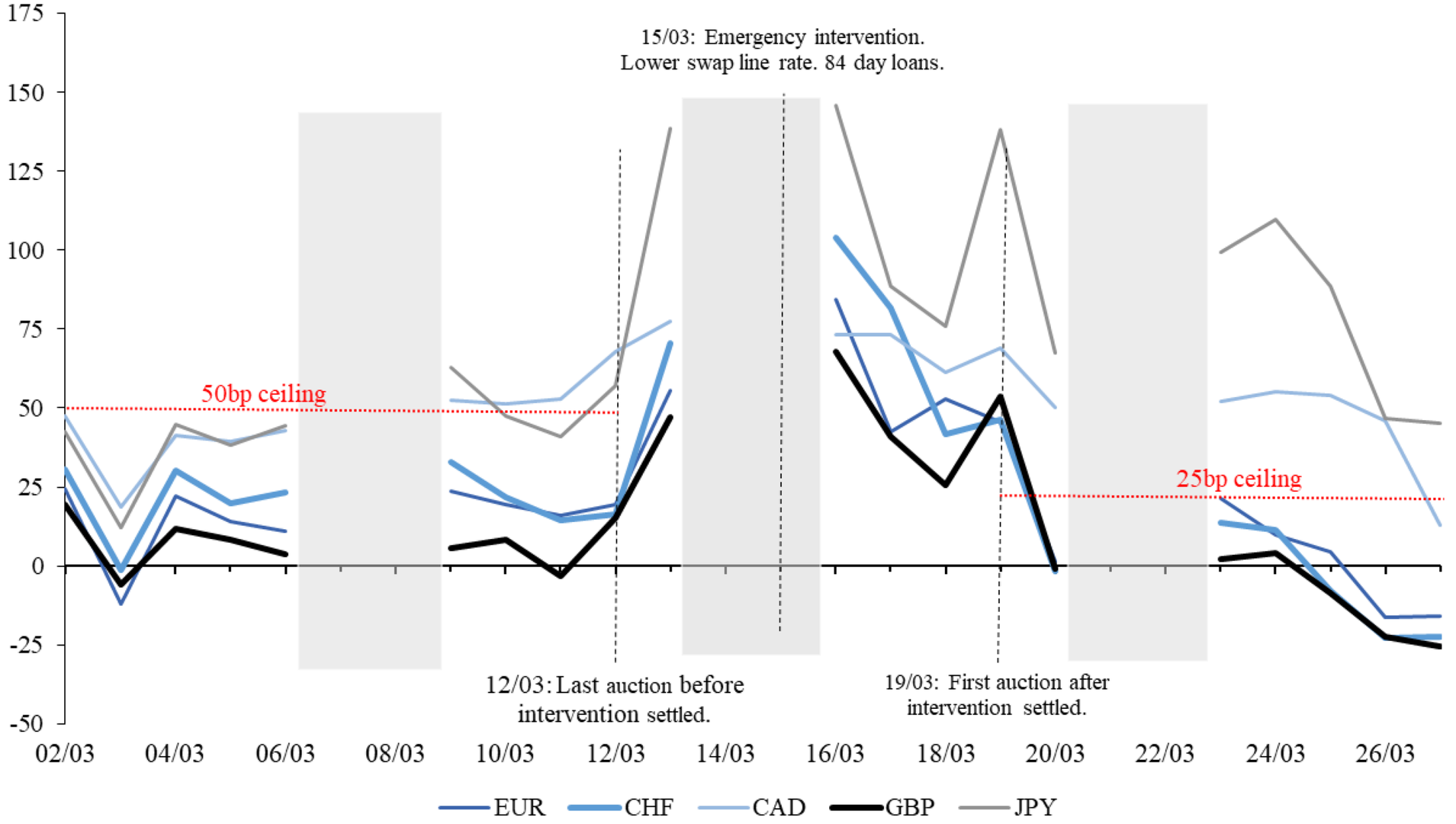
*Conditional on a ceiling violation at date t − i, and given that the next operation settlement is at date t, then what is the probability of a ceiling violation in period h from t − i onwards?*

(b) Probability of breaking ceiling as move away from swap line settlement at date 0




- h: horizontal axis
- Null: zero when h=0.

# The Covid-19 Spike – March 2020



# 5. Empirics: Bank behaviour and asset values

# Empirical strategy 1: investments

- Banks in countries with access to USD via their central bank's swap line should demand more USD-denominated assets relative to other banks and relative to non-USD bonds

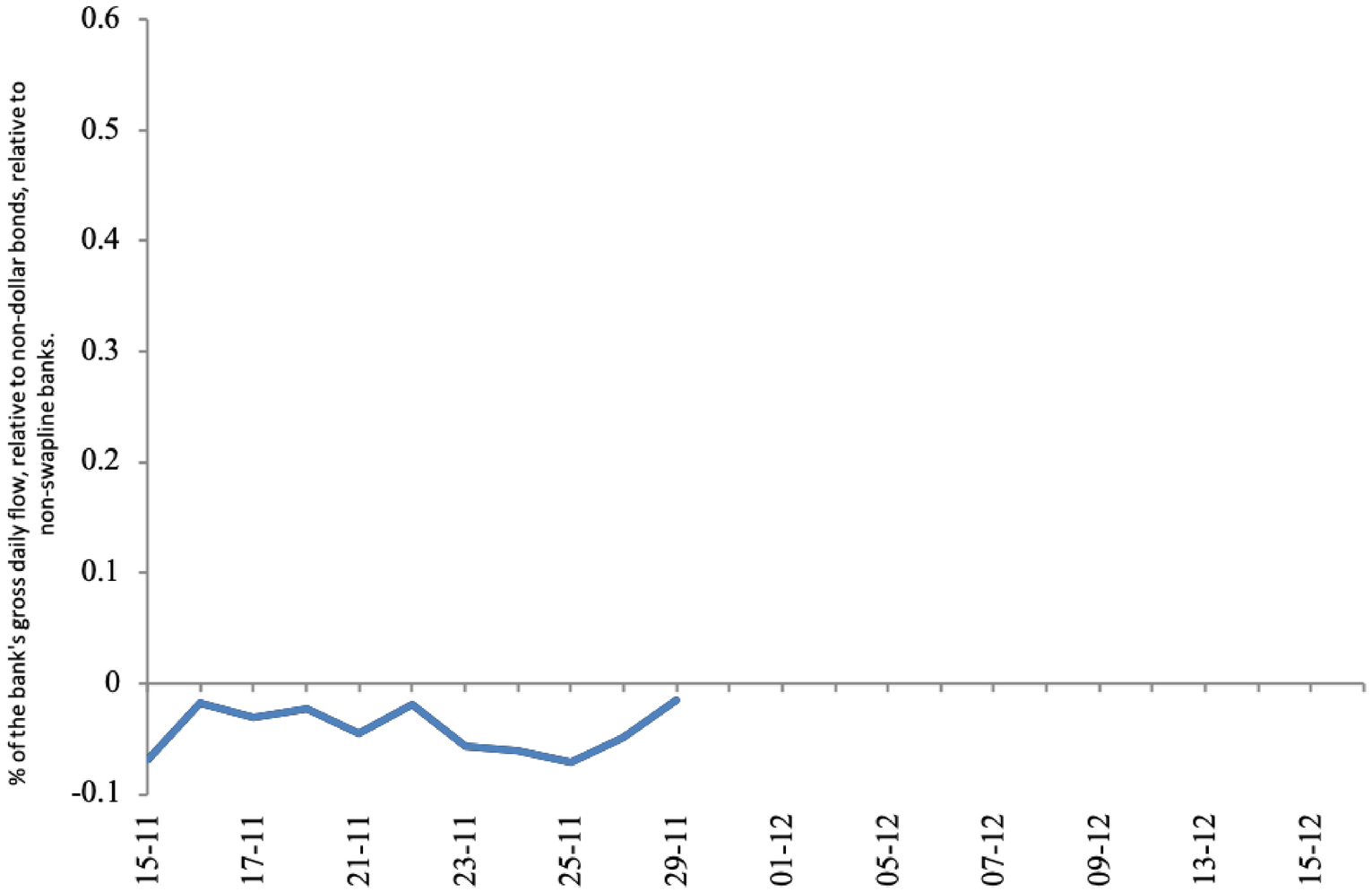
- Triple difference-in-difference
  - (i) across time: swap rate change, days before and after
  - (ii) across banks: swap and non swap line across currencies
  - (iii) across investments: USD-denominated bonds versus bonds in other currencies

# Data

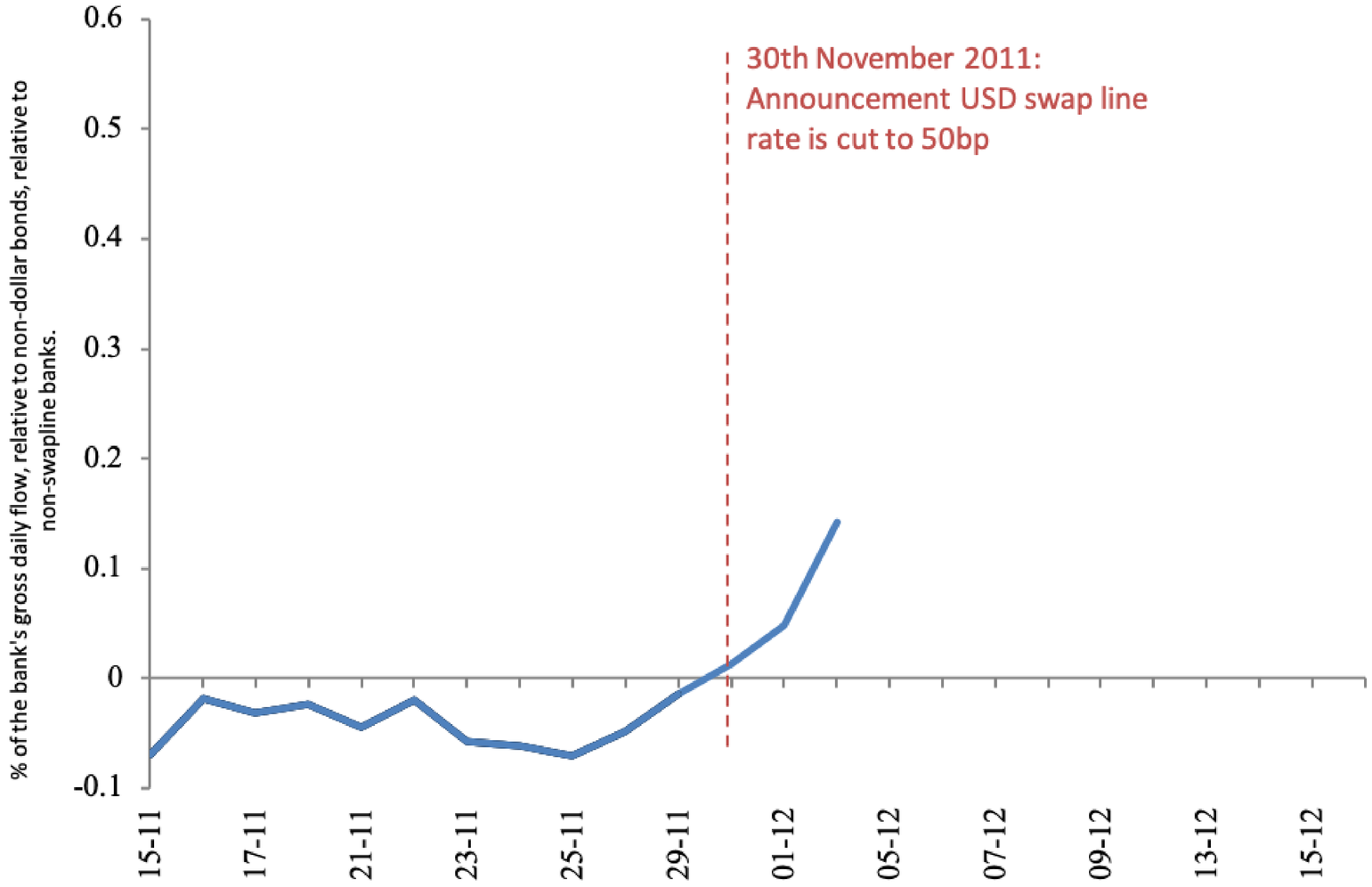
- ZEN database:
  - All trades by EEA-regulated financial firms of either UK-issued corporate bonds or traded by UK-based firms (London financial center)
  - Individuals transactions, millions of observations. 26 (19) banks, 790 (69 bonds).
  - Aggregate to measure net daily flow from firm a, into corporate bond b, at trading date t, scaled by average flow: $n_{a,b,t}$.

- Later, also:
  - All USD-bonds in BAML indices, separate those that are actively traded by swap line banks, then match them to those with similar characteristics.
  - All bank stock prices in recipient countries , separating those with U.S. presence.

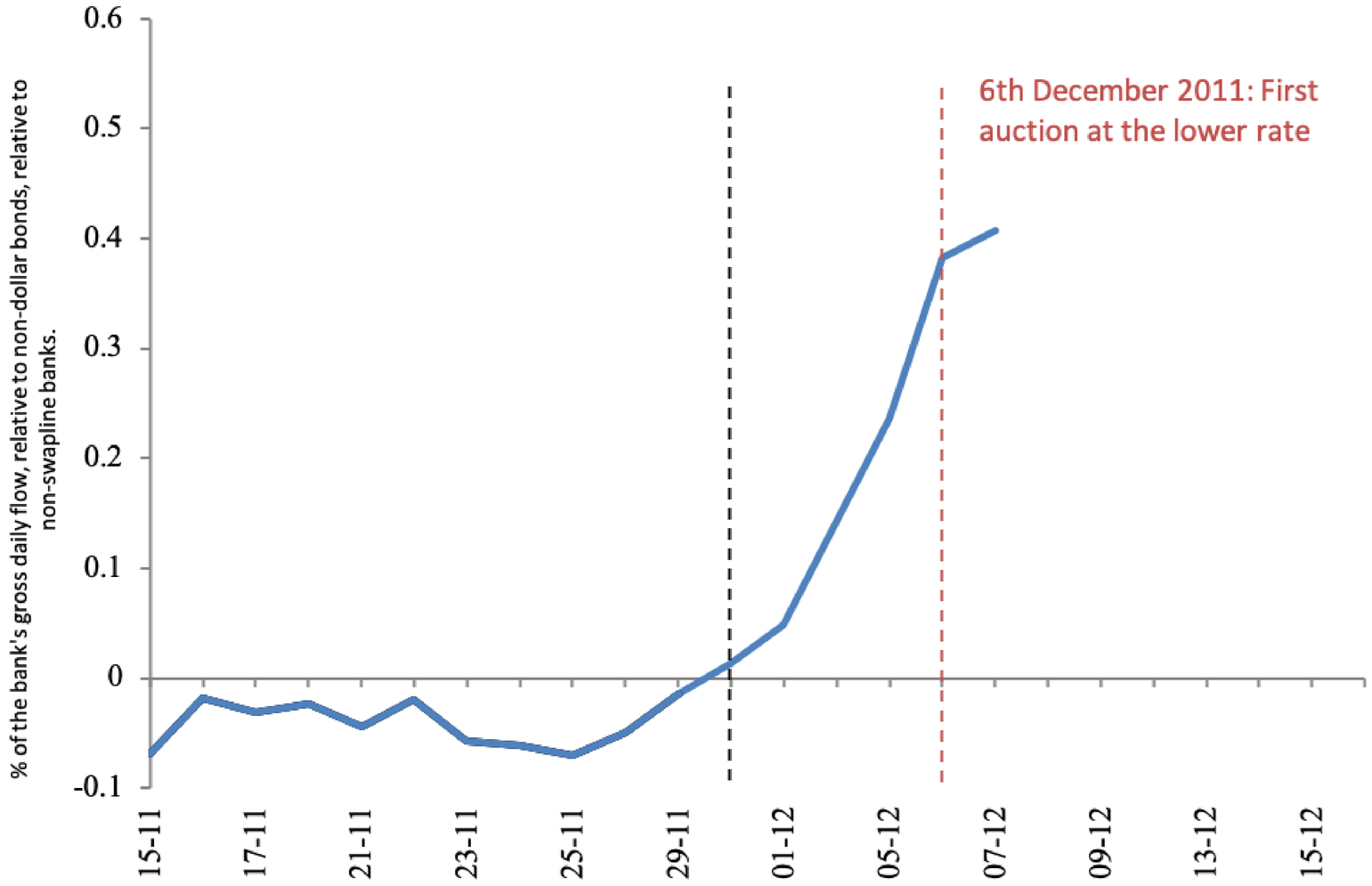
# Cumulative inflow into USD corporate bonds



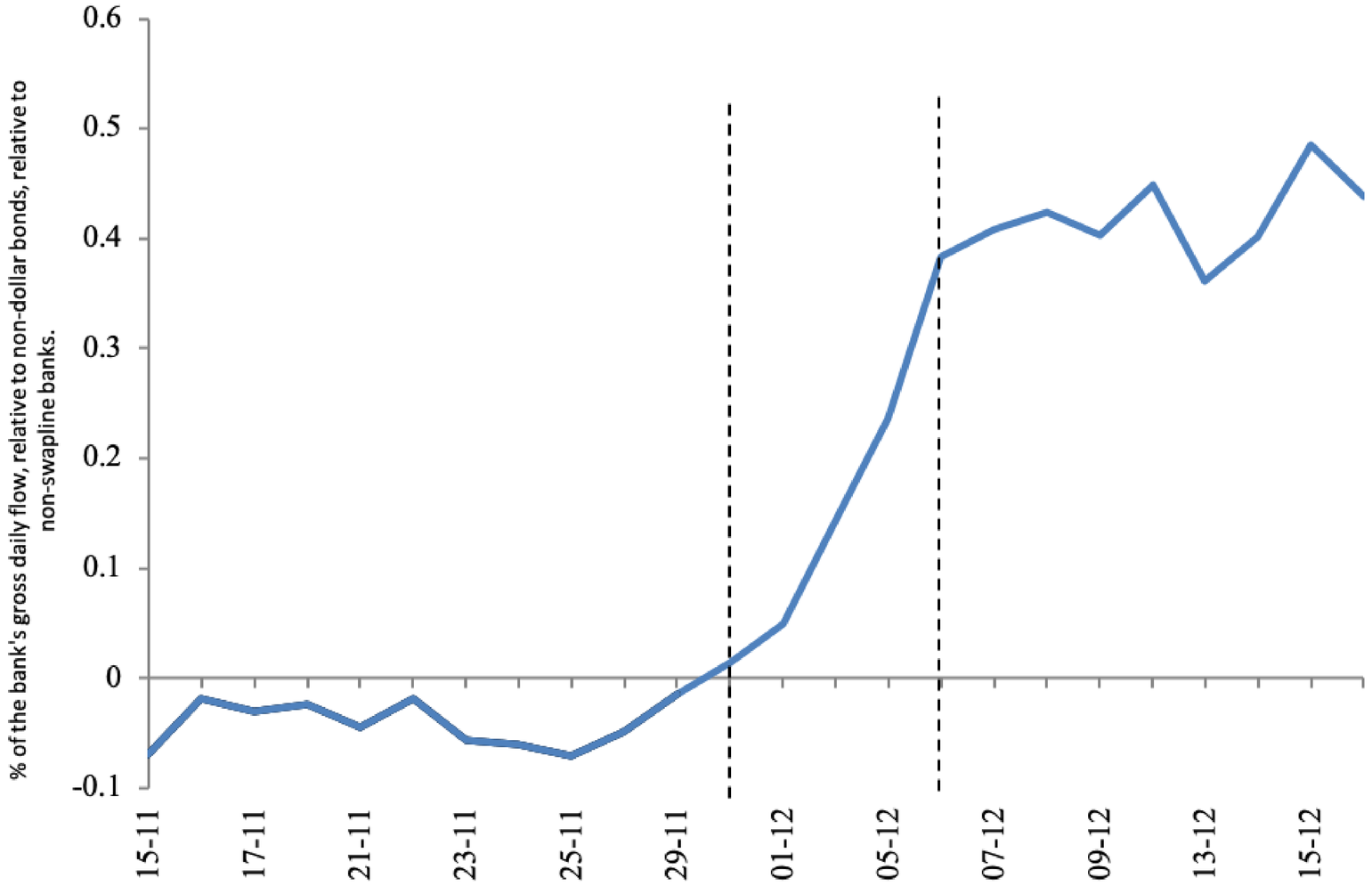
# Cumulative inflow into USD corporate bonds



# Cumulative inflow into USD corporate bonds

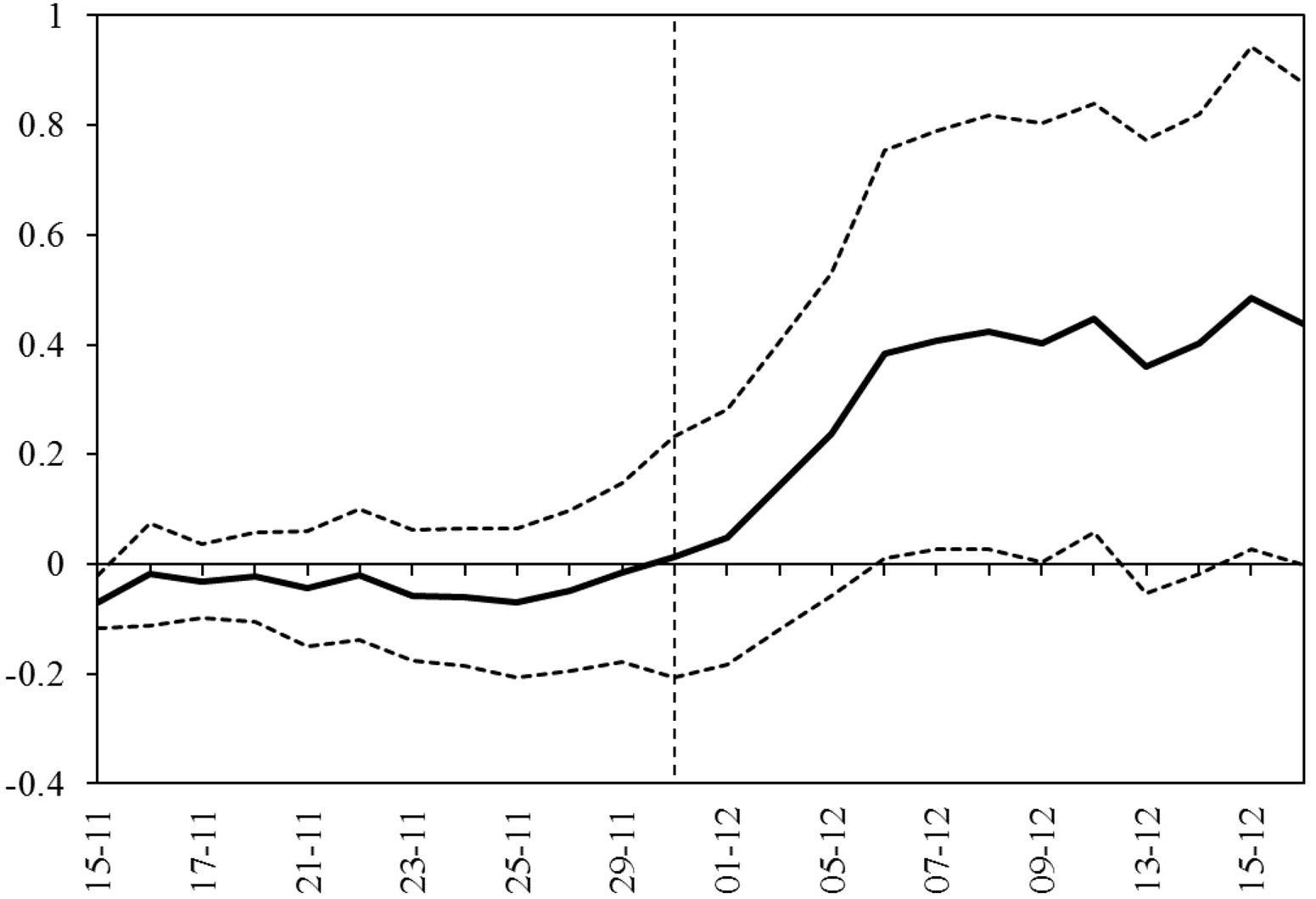


# Cumulative inflow into USD corporate bonds



# Excess demand for USD bonds from swap-line banks

$$n_{a,b,t} = \beta_t \times SwapLine_a \times USDBond_b + \alpha_{a,t} + \gamma_{b,t} + \varepsilon_{a,b,}$$



$$n_{a,b,t} = \beta \times Post_t \times SwapLine_a \times USDBond_b + \alpha_{.,t} + \varepsilon_{k,j,t}$$

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | | | *Fixed Effects* | |
| | *baseline* | *currency, bank* | *currency, bank, bond char.* | *saturated* |
| $Post_t \times Swap_a \times USDBond_b$ | 0.077* | 0.077* | 0.077* | 0.079* |
| | (0.035) | (0.038) | (0.037) | (0.039) |
| $N$ | 205227 | 205227 | 205227 | 205227 |
| *bank* × *period* f.e. | No | Yes | Yes | Yes |
| *bank* × *currency* f.e. | No | Yes | Yes | No |
| *bank* × *issuer* f.e. | No | No | Yes | No |
| *bank* × *duration* f.e. | No | No | Yes | No |
| *bank* × *bond* f.e. | No | No | No | Yes |
| *period* × *currency* f.e. | No | Yes | Yes | No |
| *period* × *issuer* f.e. | No | No | Yes | No |
| *period* × *duration* f.e. | No | No | Yes | No |
| *period* × *bond* f.e. | No | No | No | Yes |

# Features and how large

- Further features:
  - Triple difference allows us to control for bond specific factors, like shocks to the issuer's credit worthiness, and to identify shifts in preferences among banks for bonds of different denominations.
  - Stronger effect on lower credit ratings, stronger effect for infrequent traders

- How large was effect of 0.5% fall in swap line rate?
  - Within sample, increase in gross flows of $230 million, 4.8% of their absolute flow.
  - Extrapolating out of sample to all bonds issued by U.S. non-financial excluding the government in the flow of funds: $8.31 billion shift in capital flows.

# Empirical strategy 2: asset prices

- Bonds that are heavily held by foreign banks should see their prices rise.

- Difference-in-difference
  - (i) across time: swap rate change, 5 days before and after
  - (ii) across USD bonds: those held by foreigners versus those that are not. Starting from all bonds in BAML index, nearest-nearest-neighbor match to treated bonds on characteristics.

# Effect on bond prices

| | Nearest Neighbour | Exact Match on Euro Issuers | Exact Match on Industry |
|---|---|---|---|
| $frequentlytraded_b$ | -0.086** | -0.122*** | -0.080** |
| | (0.036) | (0.036) | (0.034) |
| $N$ | 5474 | 5474 | 2656 |

*Notes: The dependent variable is the change in the average yield of the bond in the 5 trading days following the swap rate change on the 30th of November 2011, versus the 5 days before. The independent variable is a dummy for whether the bond is frequently traded by our sample of European banks. Column (1): nearest neighbor estimates, using Abadie and Imbens (2011) bias correction, that single matches on five bond characteristics: (i) credit rating, converted into a numerical scale, (ii) log residual maturity, (iii) coupon, (iv) log of the face value outstanding, and (v) average yield in the 5 days prior to 30th November. Column (2): includes exact match on whether the bond issuer is located in a Euroarea country. Column (3): includes an exact match on issuer industry, industry classification level 3 of 4 in the BAML dataset; control sample modified to overlap with the industry classifications in the treated sample; two treated bonds which appear uniquely in an industry classification dropped. Robust standard errors in brackets. *** denotes statistical significance at the 1% level; ** 5% level;* 10% level.*

# How large?

- Gertler and Karadi (2015): conventional monetary policy shock that raises the one-year yield by 50bp, raises the commercial paper spread rises by 12.5bp.

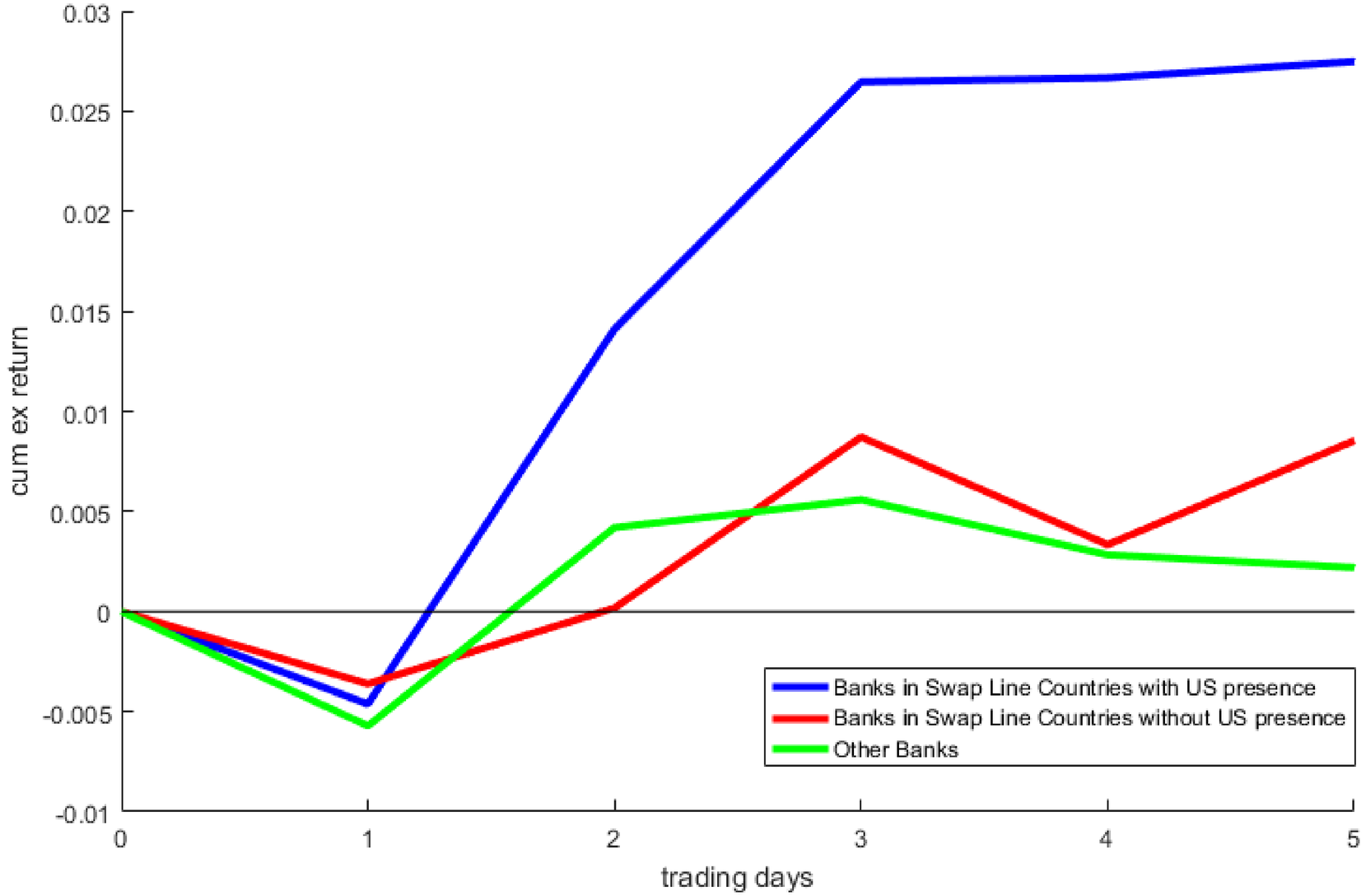
- We find that an unconventional monetary policy shocks to the swap line rate of 50bp lowers the corporate bond yield by up to 12.2bp.

# Empirical strategy 3: bank values

- Banks in countries that receive dollar swap lines should have excess returns around announcements since now safer, protected from funding shocks.

- Triple difference-in-difference
  - (i) across time: swap rate change, 5 days after
  - (ii) across currencies: swap and non swap line across currencies
  - (iii) across banks: with US presence or not

# Returns around swap rate line change



# Estimates and standard errors

Table 5: Average bank excess returns after swap line rate change

| | Swap Line Banks | | US Banks | Other Banks |
|---|---|---|---|---|
| | *US Presence* | *No US Presence* | | |
| *Average* | 0.0265* | 0.0087 | 0.0063 | -0.0033 |
| | (0.0140) | (0.0068) | (0.0084) | (0.0098) |
| *Size Weighted* | 0.0251** | 0.0281*** | 0.0290* | 0.0047 |
| | (0.0125) | (0.0086) | (0.0154) | (0.0103) |
| *N* | 36 | 72 | 310 | 24 |

*Notes: Excess returns are computed accumulating over 3 days using a beta-to-local market return that is estimated over the 100 days prior to 01/11/11. Swap line banks are headquartered in Canada, Euro-area, Japan, Switzerland, or the United Kingdom. U.S. presence is taken from "U.S. Agencies and Branches of Foreign Banking Organisations" dataset. Bootstrapped confidence intervals in brackets are constructed by randomly sampling event dates over the window 01/06/10-31/11/11. *** denotes statistical significance at the 1% level; ** 5% level;* 10% level.*

# 5. Conclusion

# Conclusion

- *Central bank swap lines:* important to understand international financial architecture, and provide new data to test old Bagehot ideas.

- Swap line *provides cross currency-liquidity* to foreign banks using the foreign central bank as agent and bearer of risk. LOLR for global banks.

- Swap line spread plus foreign difference between policy and deposit central bank rates puts a *ceiling on CIP deviations.* Empirically, 1% fall in ceiling lowers average CIP by 0.6% and 90$^{th}$ percentile by 1.1%. Spikes in CIP only when no swap line auctions.

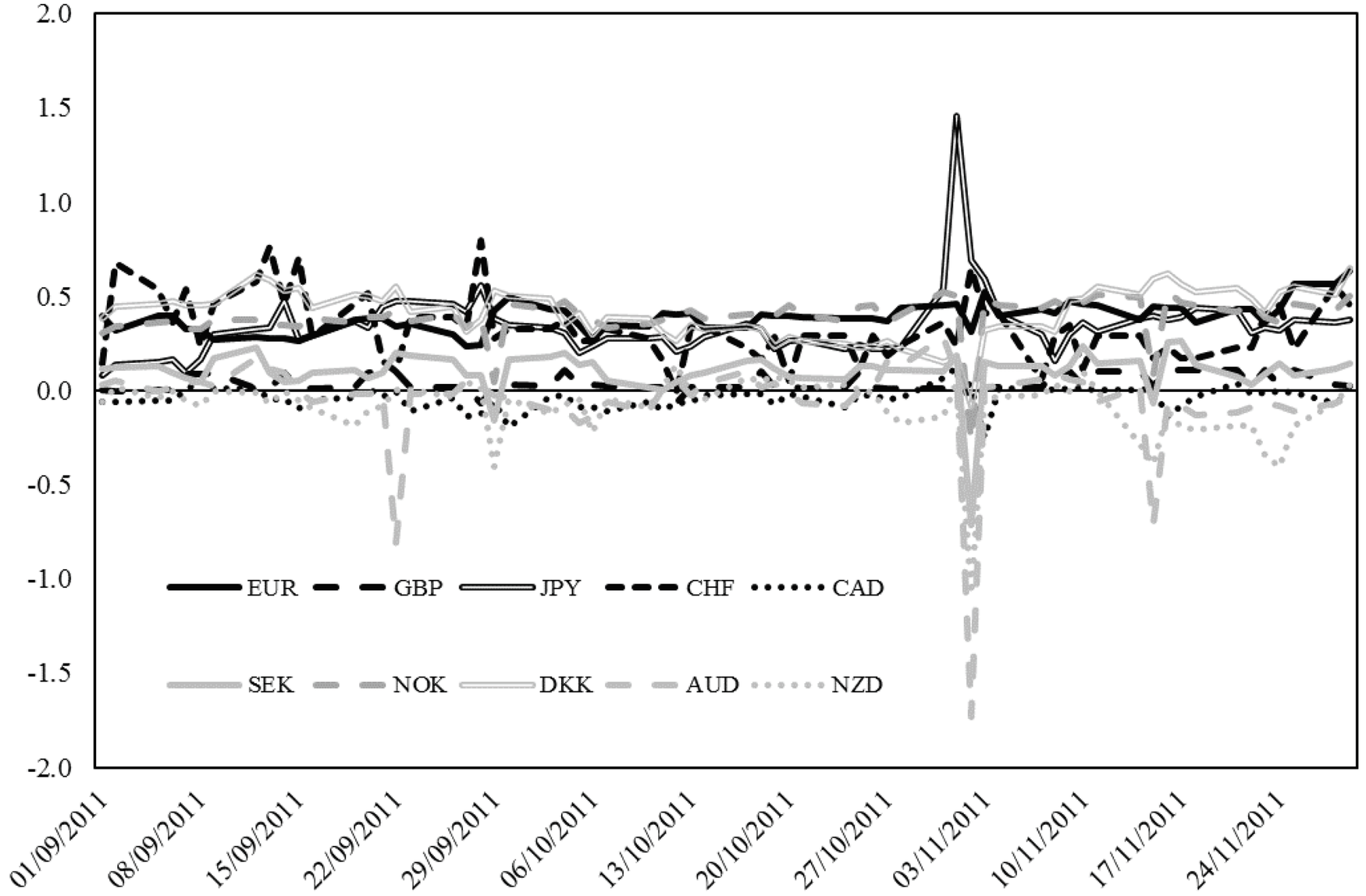
- Swap line encourages investment in USD assets ex ante, prevents fire sales ex post. Empirically see *portfolio tilt* towards bonds of 4.8% of flows, increase in price of USD bonds traded by foreigners, (maybe) increase in share price of foreign banks.

# Further questions

- Rules versus discretion and the future?
- What is the optimal design of the swap line contract?
- Is encouraging cross-currency mismatches leading to macro-financial fragility?
- Coordination between two central banks?
- International and multilateral organization: role of IMF?
- PBOC RMB swap lines: quite different, goal is to create a forward market, lower costs of invoicing in RMB. Effectiveness of increasing usage of RMB?

# Extras

# Diff in Diff Pre Trends



# Time series variation

$$x_{j,t} = \alpha_j + \beta c_{j,t} + \varepsilon_{j,t}$$

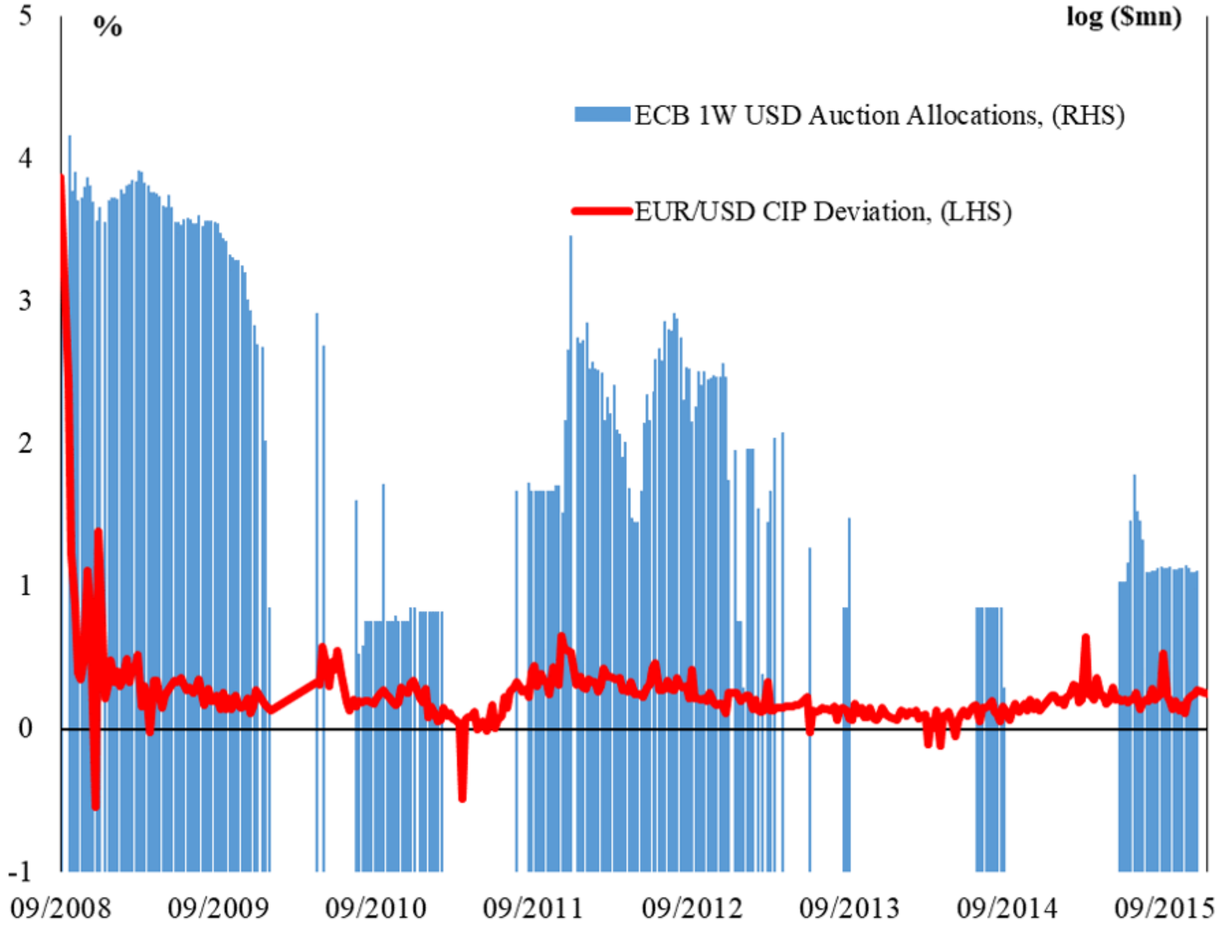
| | Baseline | Censored | Time Fixed Effect | Exc. Feb-Apr 2010 | Exc. week b/f policy mtg | Allotment days |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Ceiling ($c_{it}$) | 0.211*** | 0.777** | 0.118 | 0.229*** | 0.1805** | 0.2312* |
| | (0.041) | (0.239) | (0.059) | (0.043) | (0.052) | (0.091) |
| $N$ | 9500 | 950 | 9500 | 9150 | 7666 | 1900 |
| Adjusted $R^2$ | 0.08 | 0.16 | 0.67 | 0.67 | 0.08 | 0.08 |

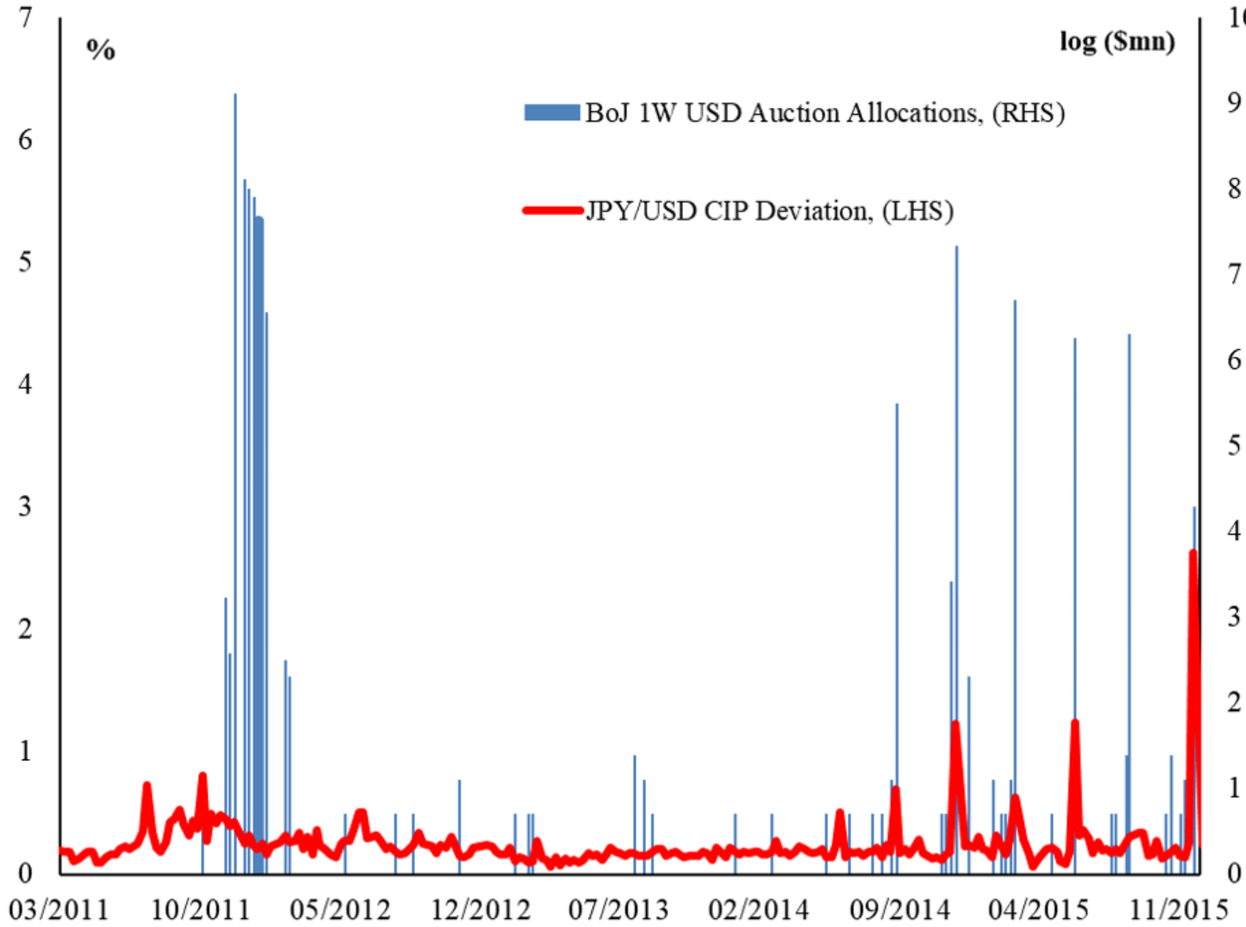
Standard errors clustered by currency and day level in parentheses

* $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$

*Notes: Estimates of equation (7). The dependent variable is the 1-week CIP deviation of the CAD, CHF, EUR, GBP, and JPY vis-a-vis the USD. The sample runs from 19th September 2008 (the date of the first multilateral Federal Reserve swap agreement) through to 31st December 2015. All regressions include currency fixed effects. Column (1): panel least squares estimator. Column (2): panel least squares estimator conditional on $x_{j,t}$ being in the 90th percentile of the unconditional distribution. Column (3): includes time fixed effects. Column (4): Removes observations between Febuary and April 2010 when the swap line was suspended. Column (5): Excludes weeks before policy meeting. Column (6): Wednesdays only when European operation are alloted. Standard errors, clustered by currency and date, are in brackets. *** denotes statistical significance at the 1% level; ** 5% level; * 10% level.*

# Swap dollar funding allocation



# Elasticity of allotment to gain

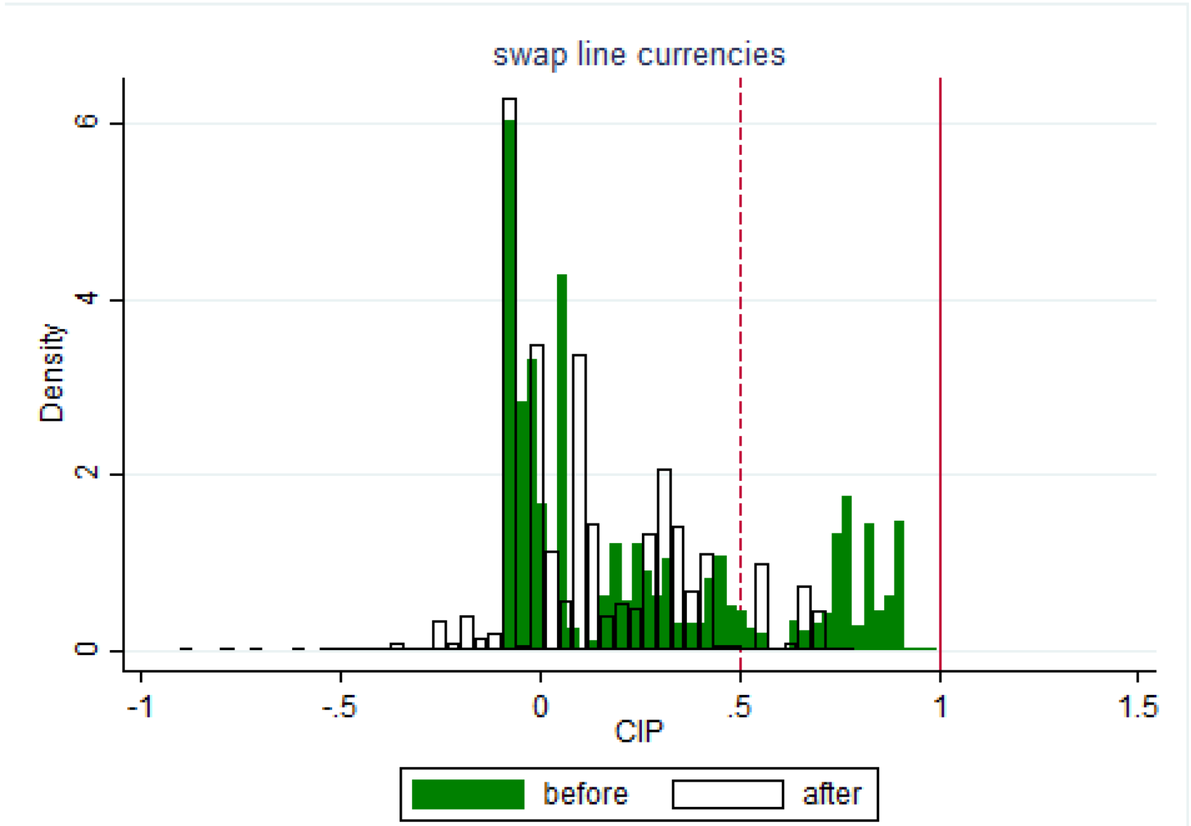
$$\log(q_{j,t}) = \alpha_j + \beta_j x_{j,t-1} + \varepsilon_{j,t}$$

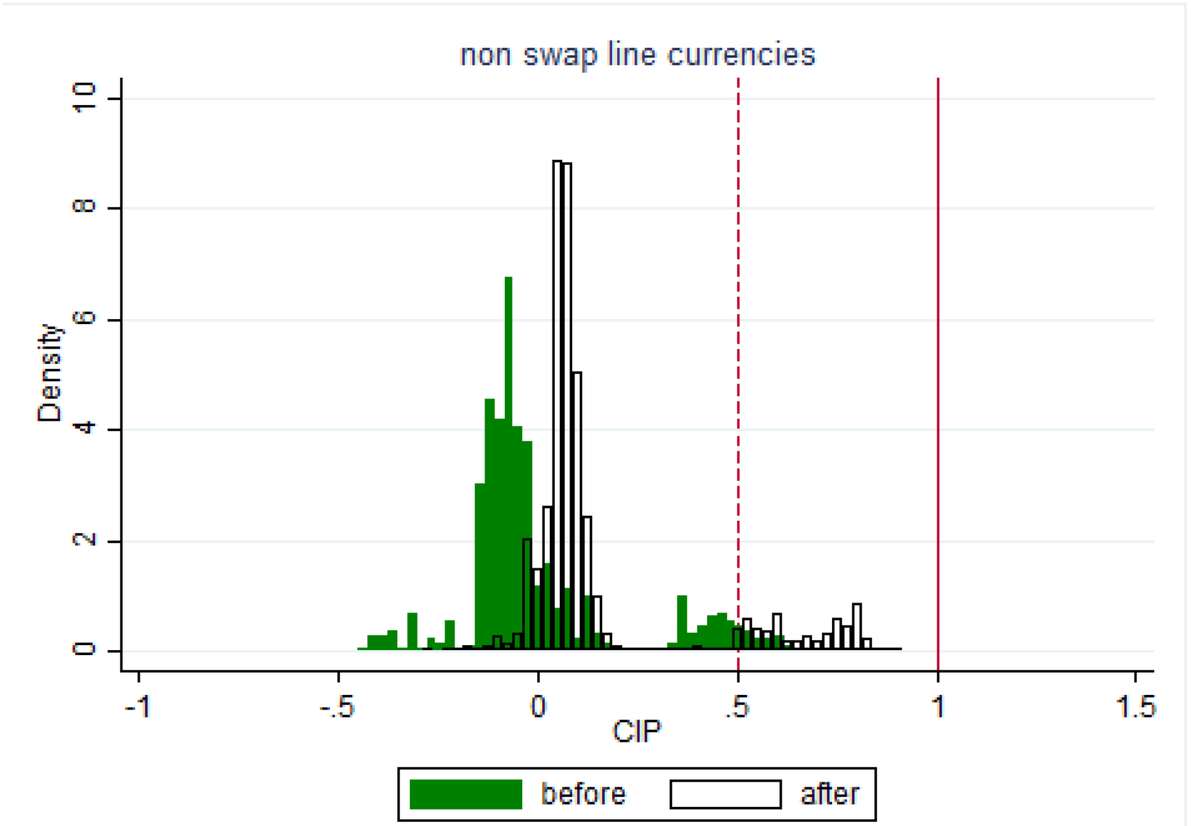
| | ECB: USD Auctions $\log(q_{j,t})$ | BoJ: USD Auctions $\log(q_{j,t})$ | ECB: EUR Auctions $\log(q_{j,t})$ |
|---|---|---|---|
| $x_{j,t-1}$ : CIP Deviation | 2.2353*** | 2.4262*** | |
| | (0.527) | (0.9891) | |
| $x_{j,t-1}$ : 1-week Libor-OIS | | | 1.5804*** |
| | | | (0.587) |
| $N$ | 217 | 90 | 388 |
| Adjusted $R^2$ | 0.08 | 0.14 | 0.14 |

*Notes: Estimates of equation (A6). CIP deviation is the 1-week EUR or JPY vis-a-vis the USD on the day prior to the auctions. We consider auctions where a positive amount is alloted between the 19th September 2008 (the date of the first multilateral Federal Reserve swap agreement) through to 31st December 2015. Robust standard errors are in brackets. *** denotes statistical significance at the 1% level; ** 5% level;* 10% level.*

# Effect on distribution of CIP deviations

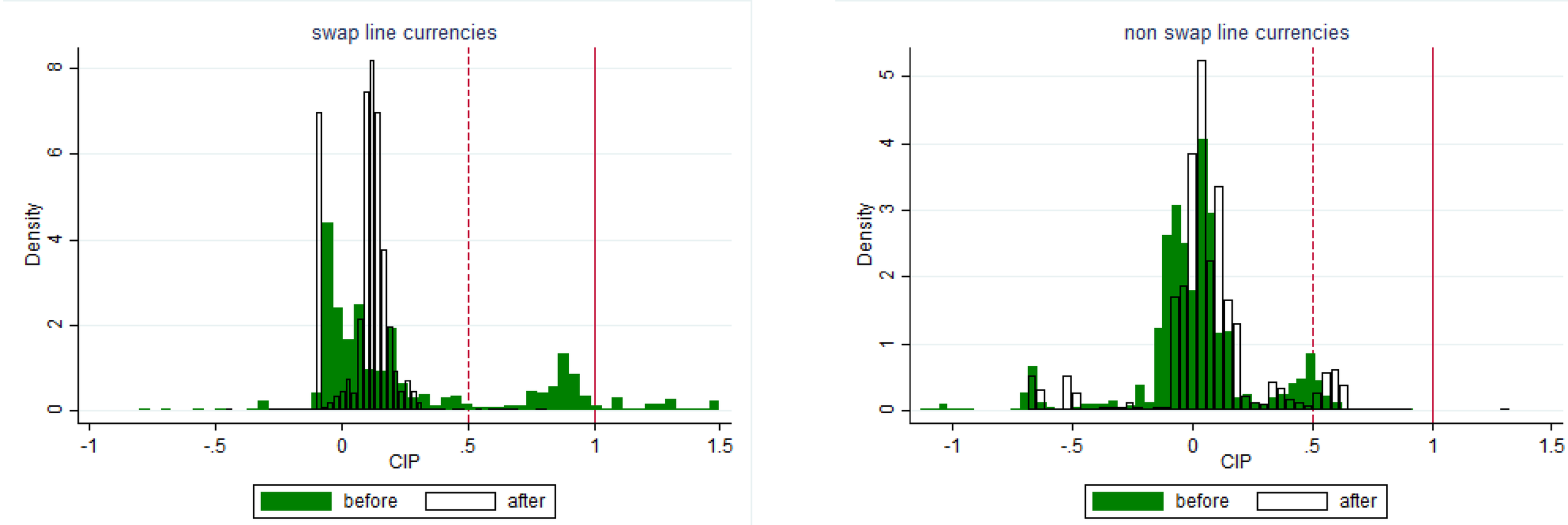
(a) Price quotes in 23-29 of November versus 8-13 December



# Month instead of week

(b) Price quotes in November versus January



# Daily data

(c) Daily data in November versus January