Does a Big Bazooka Matter? Central Bank Balance-Sheet Policies and Exchange Rates

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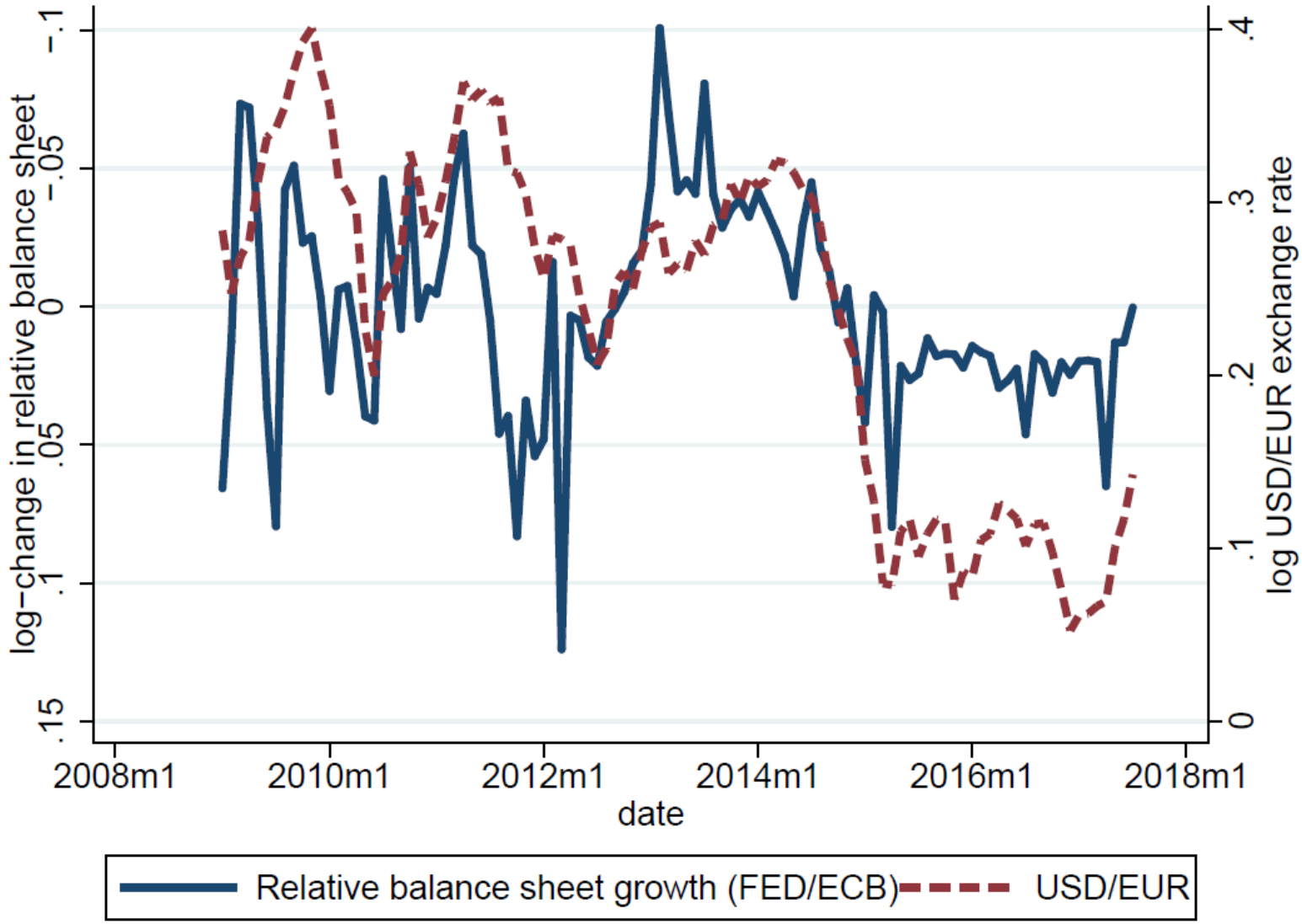
Motivation: Policy and model-building relevance

- What are the effects over time of unconventional monetary policy (QE/UMP)?
  - Some VAR evidence, but mostly high frequency, event studies
- What are their transmission channels?
  - Many frictions have been suggested to rationalize above evidence
  - Impact effects can also arise in frictionless asset markets, e.g., due to "signaling" of future policy rates — Cochrane (2012), Woodford (2012)
- Focus on dollar-euro exchange rate, interesting case study
  - Exchange rate depends on sum of expected future fundamentals, whose impulse responses can be estimated
  - Evidence of *frictions* such as failure of covered interest rate parity (CIP) — e.g., BIS (2016)

EUR/USD and the relative ECB-Fed balance sheet



What we do and why

- Look at effects of *actual* balance sheet changes occurring after QE/UMP announcements — 2SLS approach:
  - **Independent variable**: Change in ECB/Fed relative balance sheet, can estimate elasticities
  - **Instruments**: UMP announcements, controlling for other shocks
- Use local projections to estimate impulse responses of spot and forward exchange rate, interest rate differentials, CIP deviations,...
- Decompose exchange rate response into that of expected fundamentals conditional on UMP shocks, similarly to Engel (2016)

Findings

- UMP that increases ECB balance sheet relative to Fed's by 1%:
  - Depreciates euro-dollar rate by 1% and lowers 3-month interest differential by 3-4 bps, over $\simeq$10 months
  - Narrows 3-month CIP deviations in euro-dollar markets by 2 bps
  - Less significant effects beyond foreign exchange and money market rates
- Transmission channels of exchange rate response:
  - Bulk due to "currency risk premia" — actually a residual, similar to Engel (2016)
  - Limited role of signaling as exchange rate quickly mean-reverting, long-term rates not very affected
  - Smaller CIP deviations actually *dampen* euro depreciation

Selected literature review

- Plenty of informative event studies on QE, including with focus on exchange rates:
  Altavilla et al. (2015), Fratzscher et al. (2016), Georgiadis and Graeb (2016),Glick and Leduc (2015), Neely (2015), Rogers et al. (2014), ...
- A few important studies based on VAR approach:
  Gambacorta et al. (2014), Manganelli et al. (2015), Peersman et al. (2014), Weale and Wieladek (2016), Garcia Pascual and Wieladek (2016),...
- Contributions on CIP deviations:
  Avdjiev et al. (2016), Baba and Packer (2009), Borio et al.(2016), Bottazzi et al. (2012), Du et al. (2016), Ivashina et al. (2015), Mancini Griffoli and Ranaldo (2010),...

Outline

- Empirical framework based on IV and local projections
- Results: Evidence on the effects and trasmission of QE/UMP
- A few robustness checks
- Caveats and open issues

Empirical framework

Exchange rate determination in asset markets

- Solve generalized UIP forward over T periods for USD/EUR:

$$s_t = E_t\left(s_{t+T}\right) + \sum_{j=0}^{T-1} E_t\left(r^{€}_{t+j} - r^{\$}_{t+j}\right) - \sum_{j=0}^{T-1} E_t\lambda_{t+j} + \sum_{j=0}^{T-1} E_t\pi_{t+j,t+j+1}$$

where:

$$\text{"risk premium"} \quad : \quad \pi_{t,t+1} \equiv Cov_t\left(d^{\$}_{t+1}, s_{t+1}\right) + \frac{1}{2} Var_t\left(s_{t+1}\right)$$

$$\text{CIP deviations} \quad : \quad \lambda_t \equiv r^{€}_t - \left[r^{\$}_t - \left(f_{t,t+1} - s_t\right)\right]$$

- $\lambda_t > 0 \Rightarrow$ Return on "cash" euro $(r^{€}_t)$ higher than on "synthetic" euro $(r^{\$}_t - (f_{t,t+1} - s_t))$
  - Definition with opposite sign relative to market convention
- $E_t\lambda_{t+j} > 0 \Rightarrow$ *Larger depreciation* of spot euro vs dollar $(s_t \downarrow)$

Some remarks

- Generalized UIP consistent with most exchange rate theories under financial integration in money markets
  - E.g., "monetary" model assumes interest rate function of money demand:

$$\lambda r_t = \varphi y_t - (m_t - p_t)$$

- CIP deviations can reflect borrowing constraints of financial intermediaries (Gabaix-Maggiori 2014), or even "liquidity preference" for cash \$
- Risk premium $\pi_{t,t+1}$ is actually a residual in our analysis — thus captures wedge between observable future fundamentals and s_t, due to, e.g., forex "portfolio balance" channel (not only compensation for FX risk)

How shocks affect the exchange rate

- Write the change in the exchange rate as follows:

$$s_t - s_{t-1} = -\left(r^{€}_{t-1} - r^{\$}_{t-1}\right) + \lambda_{t-1} + \pi_{t-1,t} + \Gamma_0' \varepsilon_t.$$

- Γ_0' captures the effects of "innovations" $\left(E_{t-1}\left(\varepsilon_t\right) = 0\right)$:

$$\Gamma_0' \varepsilon_t \equiv \sum_{j=0}^{T-1} \left[E_t\left(r^{€}_{t+j} - r^{\$}_{t+j}\right) - E_{t-1}\left(r^{€}_{t+j} - r^{\$}_{t+j}\right)\right] +$$

$$- \sum_{j=0}^{T-1} \left[E_t \lambda_{t+j} - E_{t-1}\lambda_{t+j}\right] + \sum_{j=0}^{T-1} \left[E_t \pi_{t+j,t+j+1} - E_{t-1}\pi_{t+j,t+j+1}\right]$$

$$+ E_t\left(s_{t+T}\right) - E_{t-1}\left(s_{t+T}\right)$$

- Can estimate impulse responses at horizon h by local projections:

$$E_t s_{t+h} - s_{t-1} = \Omega_{h,t-1} + \Gamma_h' \varepsilon_t$$

$=>$ $E_t\left(s_{t+T}\right)$ reflects "signaling" at horizons beyond T (future policy rates, but not only)

Anticipated QE/UMP shocks

- Dub ε_t^{QE} the UMP shock to the relative balance sheet:

$$\varepsilon_t = \left[\varepsilon_t^{QE}, \varepsilon_{2t}\right]$$

  where all other shocks are in ε_{2t} (including shocks to the policy interest rates of ECB and Fed, and "money demand" shocks)
- Assume ε_t^{QE} includes *both* contemporaneous shock ($\eta_{t|t}^{QE}$), *and* shock known as of t that affects balance sheet in $t+1$ ($\eta_{t+1|t}^{QE}$):

$$\varepsilon_t^{QE} = \eta_{t|t}^{QE} + \phi\eta_{t+1|t}^{QE}$$

- Exchange rate will react also to anticipated ("news") shock $\eta_{t+1|t}^{QE}$:

$$\begin{aligned} s_t - s_{t-1} &= -\left(r_{t-1}^{€} - r_{t-1}^{\$}\right) + \lambda_{t-1} + \pi_{t-1,t} + \\ &\quad \Gamma_{0,2}'\varepsilon_{2t} + \gamma_0^{QE}\left(\eta_{t|t}^{QE} + \phi\eta_{t+1|t}^{QE}\right) \end{aligned}$$

Empirical strategy

- $\eta^{QE}_{t+1|t}$ unobserved but will affect relative balance sheet in $t+1$:

$$\begin{aligned}\Delta BS_{t+1} &= \delta_0 + \eta^{QE}_{t+1|t} + \eta^{QE}_{t+1|t+1} + \delta' \varepsilon_{2t+1} + \rho' X_t \\ \Longrightarrow \quad \eta^{QE}_{t+1|t} &= \Delta BS_{t+1} - \left[\delta_0 + \delta' \varepsilon_{2t+1} + \eta^{QE}_{t+1|t+1} + \rho' X_t\right]\end{aligned}$$

- Substitute out $\eta^{QE}_{t+1|t}$ in exchange rate equation (possibly motivated also by "monetary" model):

$$\begin{aligned}s_t - s_{t-1} = &- \left(r^{€}_{t-1} - r^{\$}_{t-1}\right) + \lambda_{t-1} + \gamma_0^{QE}\left(\Delta BS_{t+1}/\phi\right) - \gamma_0^{QE}\rho' X_t \\ &\underbrace{+\gamma_0^{QE}\eta^{QE}_{t|t} + \pi_{t-1,t} + \Gamma'_{0,2}\varepsilon_{2t} - \gamma_0^{QE}\left(\delta_0 + \delta' \varepsilon_{2t+1} + \eta^{QE}_{t+1|t+1}\right)}_{\zeta_t}\end{aligned}$$

- Endogeneity bias if ΔBS_{t+1} correlated with residual ζ_t through ε_{2t+1}, $\eta^{QE}_{t+1|t+1}$

A 2SLS approach

- Assume QE announcements as of time t (a_t^{ECB},a_t^{FED}) forecast $\eta_{t+1|t}^{QE}$:

$$\eta_{t+1|t}^{QE} = \mu_0 + \mu_1 a_t^{ECB} + \mu_2 a_t^{FED} + u_t$$

- 2SLS estimation of γ_0^{QE} (after normalization for ϕ)
  1st stage:

$$\Delta BS_{t+1} = \widetilde{\delta}_0 + \mu_1 a_t^{ECB} + \mu_2 a_t^{FED} + \rho' X_t + \nu_t$$

  2nd stage:

$$s_{t+h} - s_{t-1} = \gamma_h^{QE} \left(\Delta \widehat{BS}_{t+1} / \phi \right) - \left(r_{t-1}^{€} - r_{t-1}^{\$} \right) + \lambda_{t-1} - \gamma_h^{QE} \rho' X_t + \zeta$$

- Assume a_t^{ECB},a_t^{FED} uncorrelated with shocks in ζ_t
  $\left(\eta_{t+1|t+1}^{QE}, \eta_{t|t}^{QE}, \varepsilon_{2t+1}, \varepsilon_{2t} \right)$, *after controlling for* X_t

What if announcements also about contemporaneous QE?

- Announcement in t may also contain information about current QE shock $\eta^{QE}_{t|t}$
  - Unfortunately a feature of our monthly dataset as many ECB announcements took place at the beginning of the month, so this cannot be ruled out
- Then, substitute out $\eta^{QE}_{t|t}$ and $\eta^{QE}_{t+1|t}$ for both ΔBS_t and ΔBS_{t+1} :

$$s_t - s_{t-1} = \gamma_0^{QE} \left(\Delta BS_{t+1} / \phi + \Delta BS_t \right) - \left(r^E_{t-1} - r^{\$}_{t-1} \right) + \lambda_{t-1} + ...$$

- First stage with $(\Delta BS_{t+1} + \Delta BS_t)$ under further assumption $\phi = 1$ — This is our *baseline specification*

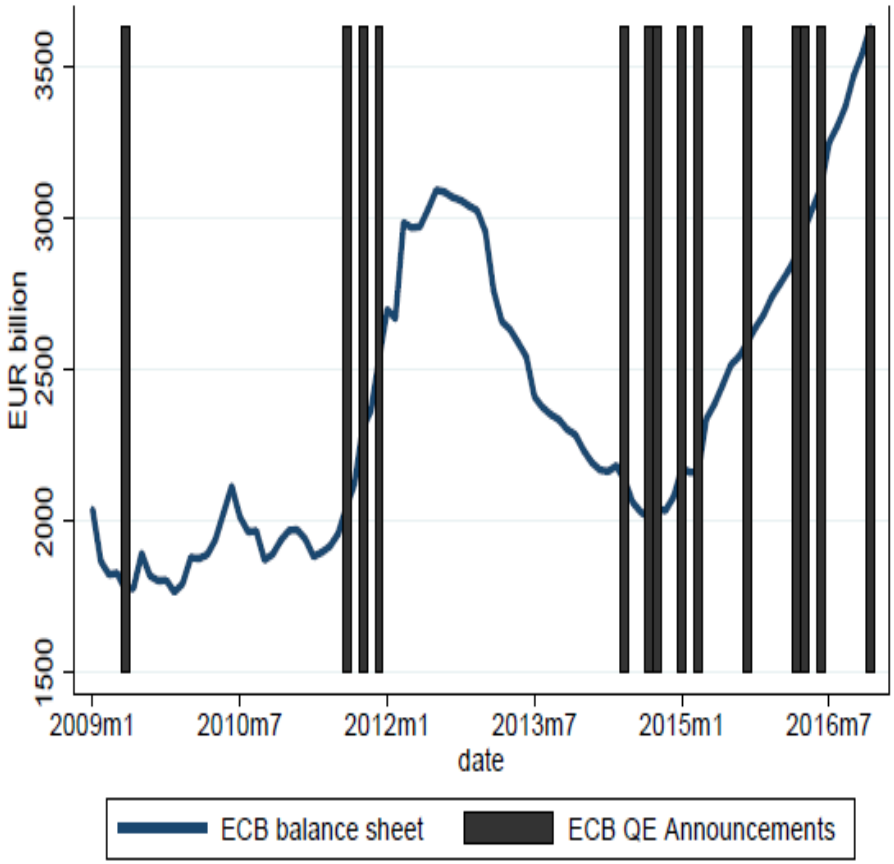
What else can go wrong?

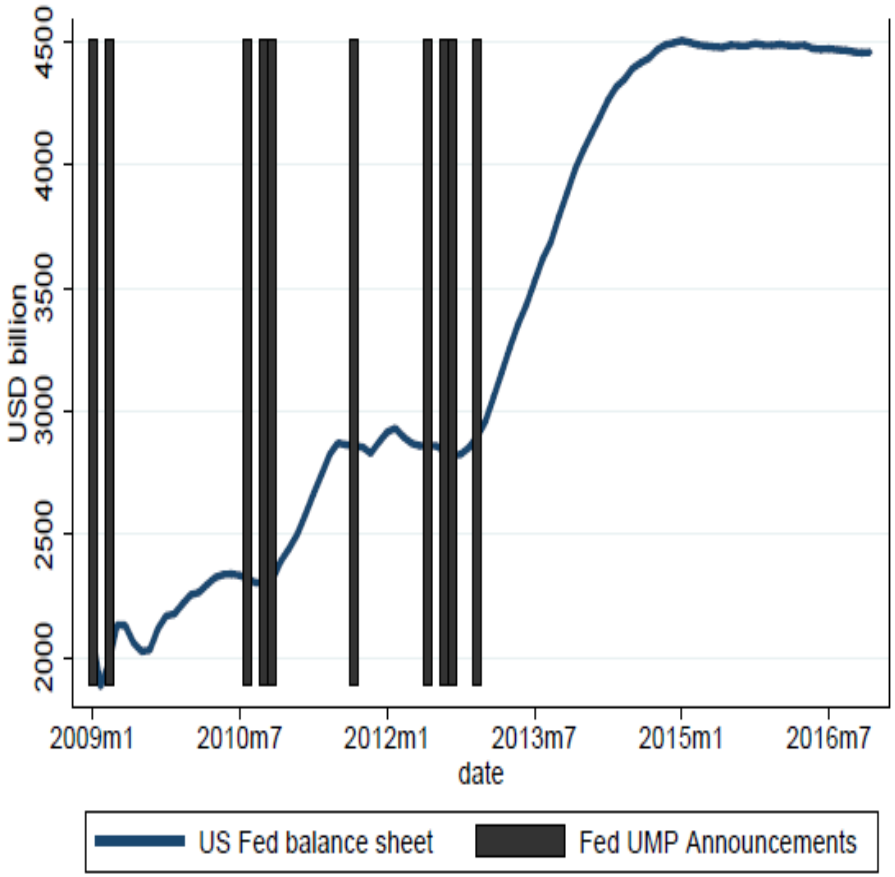
- QE correlated with other shocks, e.g., interest rate policy
  - Change in relative balance sheet orthogonal to: contemporaneous policy rates, macro news for US and euro area, VIX (Choleski ordering)
  - Thus UMP shocks equal to residuals of 1st stage equation for $(\Delta BS_{t+1} + \Delta BS_t)$ in month of announcements by ECB or Fed, controlling for above variables in X_t
- (Some) QE announcements not really (expansionary) surprise/news
  - Then exchange rate, asset prices should not react (in the same way)
  - Assumption that all announcements are similar can lead to downward bias, weaker instruments
- Announcements reveal Fed, ECB information about economy
  - Difficult to control for Fed, ECB forecasts, complicating interpretation of some results

Announcements

- Sample period: January 2009 to December 2016
  - $\Delta BS_{t+1} + \Delta BS_t :=$ cumulated change in log of ratio of ECB nominal balance sheet to Federal Reserve's in respective currencies
- Two sets of dummy variables a_t^{ECB},a_t^{FED}, equal to 1 if ECB (Fed) announces a QE measure in period t
- Focus on announcements with tangible impact on the size of central bank balance sheets — 7+7 ECB events
  - Exclude "Whatever it takes" and Outright Monetary Transactions program in 2012, since they have not resulted in asset purchases so far
  - Also exclude Securities Market Program in 2010, since asset purchases were sterilised, did not increase ECB's balance sheet
  - Follow Rogers et al. (2014) for Fed (11 events, including Operation Twist does not matter)
- High volatility of changes in yields on announcement days consistent with announcements as surprise policy actions

Announcements





Results

Result 1

- ECB QE shock leads to persistent but temporary expansion in relative balance sheet and euro nominal and real depreciation
- Persistent decline in 3-month interest rate differential, no strong association with policy rates over horizon of exchange rate response
- Mean-reverting response of exchange rate seems inconsistent with strong impact of "signaling" over longer horizons

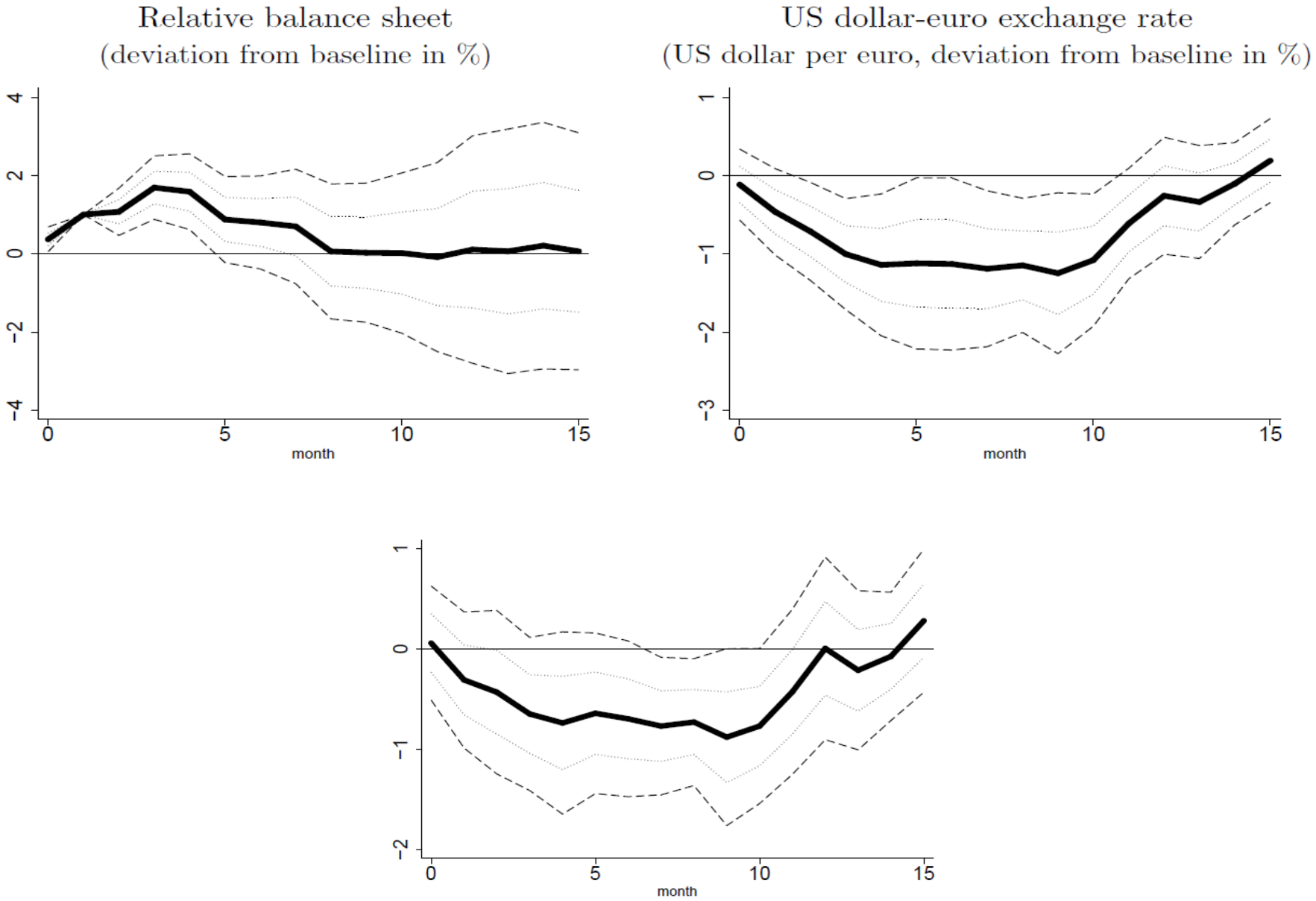
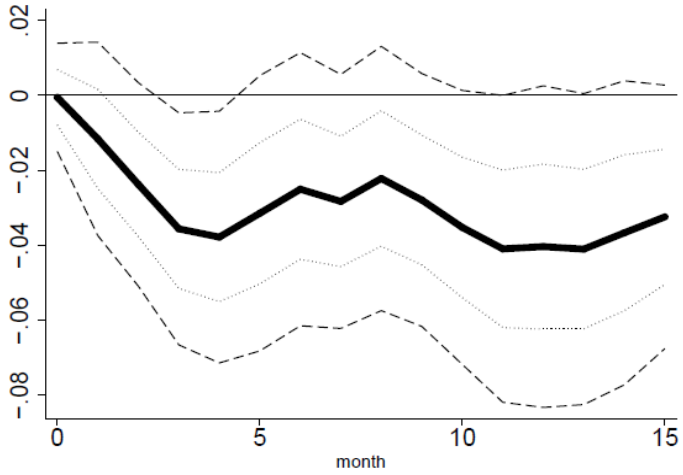


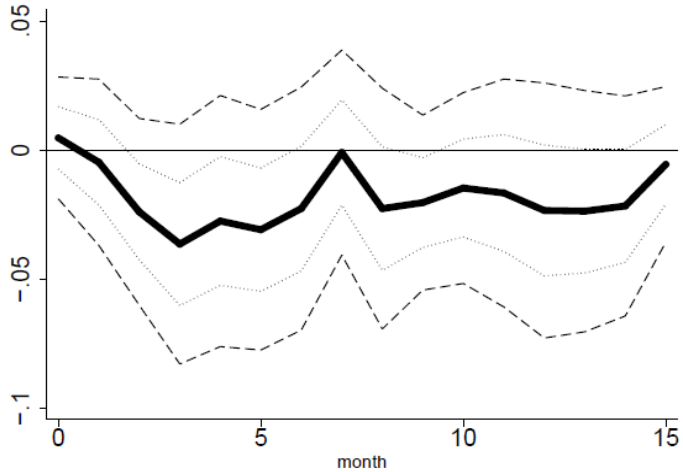
Figure: Real exchange rate

Money market interest rates decline

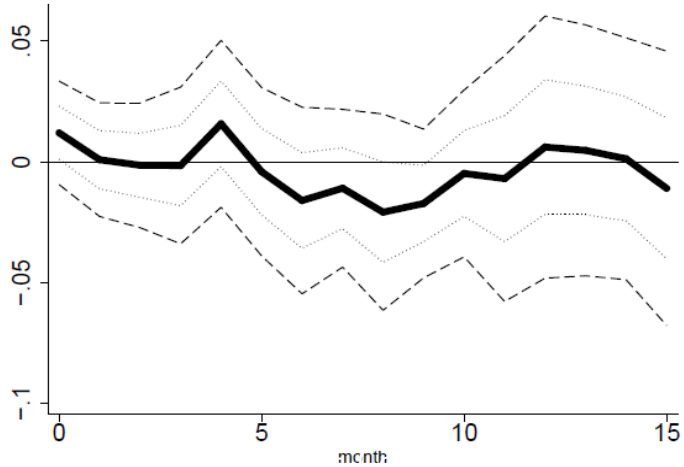
Three-month money market rate differential ($r^{€,3m} - r^{\$,3m}$)
(deviation from baseline in %-age points)



Two-year sov. yield differential ($r^{€,2y} - r^{\$,2y}$)
(deviation from baseline in %-age points)

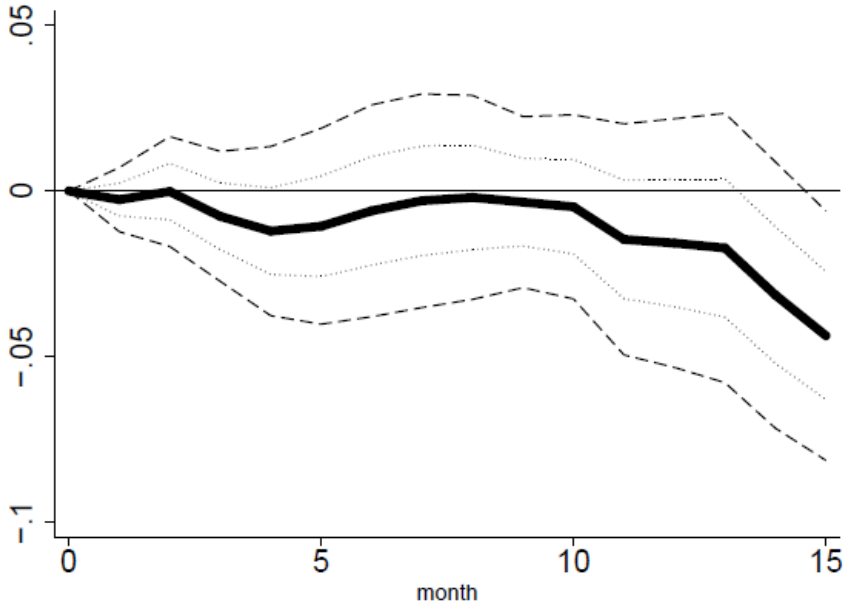


Ten-year sov. yield differential ($r^{€,10y} - r^{\$,10y}$)
(deviation from baseline in %-age points)

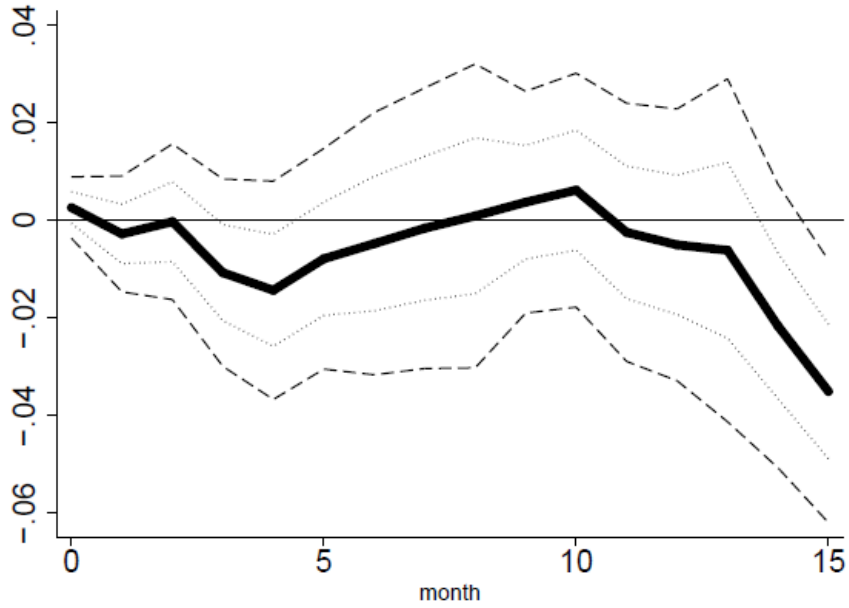


Counfounding effects from policy rates unlikely

MRO - Fed Funds rate
(deviation from baseline in %-age points)



DFR - Fed Funds rate
(deviation from baseline in %-age points)



Result 2: What drives the exchange-rate response?

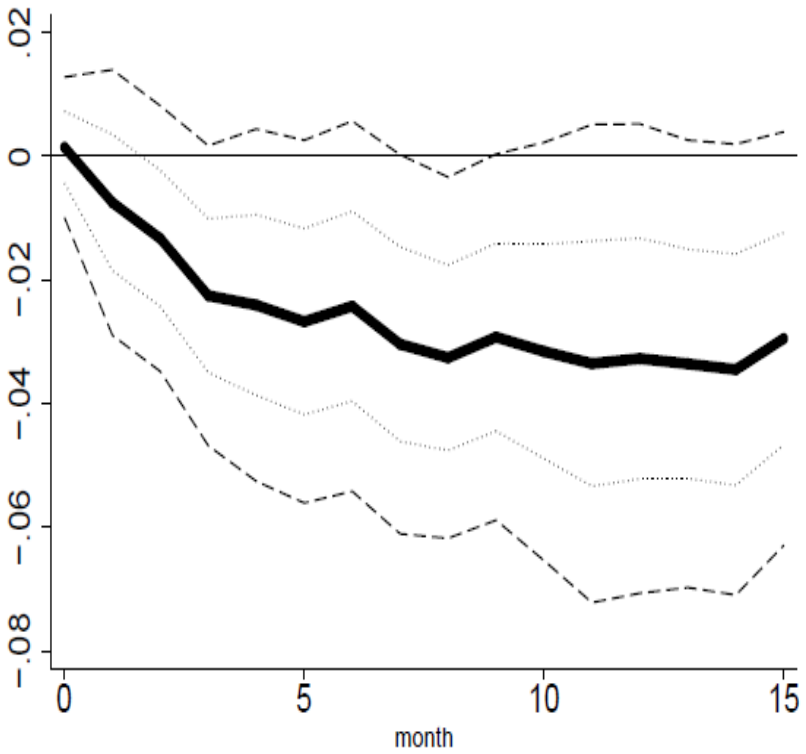
- Persistent decline in short-term rate differentials drives euro down
- Persistent decline in CIP deviations actually dampens euro depreciation:

$$r^{€}_{t,t+3} - \left[r^{\$}_{t,t+3} - (f_{t,t+3} - s_t) \right] = \lambda_{t,t+3} \downarrow$$

- Narrower spread between euro money market rate and synthetic rate
  - Forward rate discount $(f_{t,t+3} - s_t)$ does not fully offset fall in interest rate differential
- But bulk of depreciation accounted for by "currency risk premia"
  - Actually a residual, also consistent with several frictions

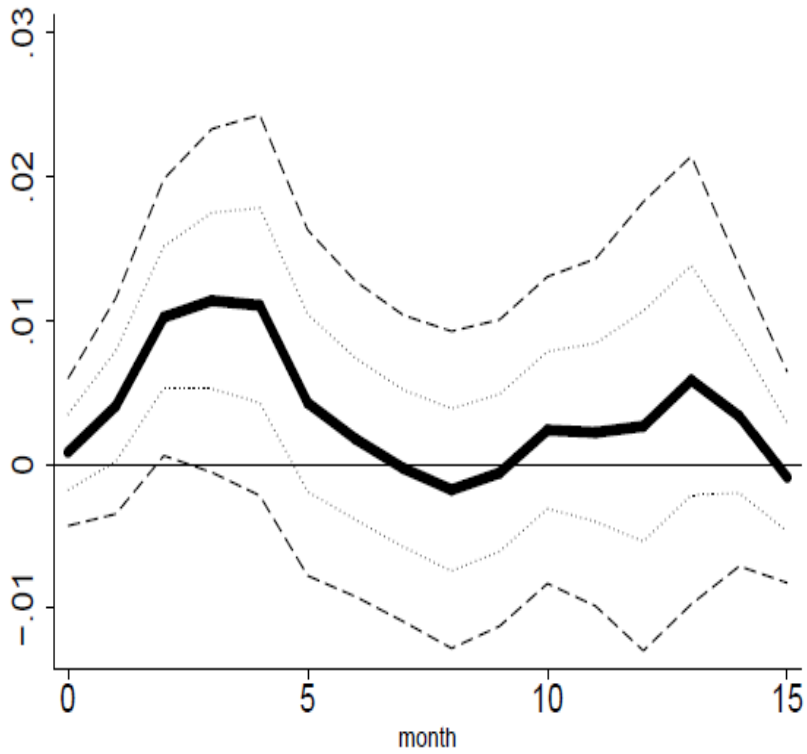
CIP deviation ($\lambda_t = f^{3m}_{t,t+1} - s_t + r^{€,3m}_t - r^{\$,3m}_t$)

(deviation from baseline in %-age points)

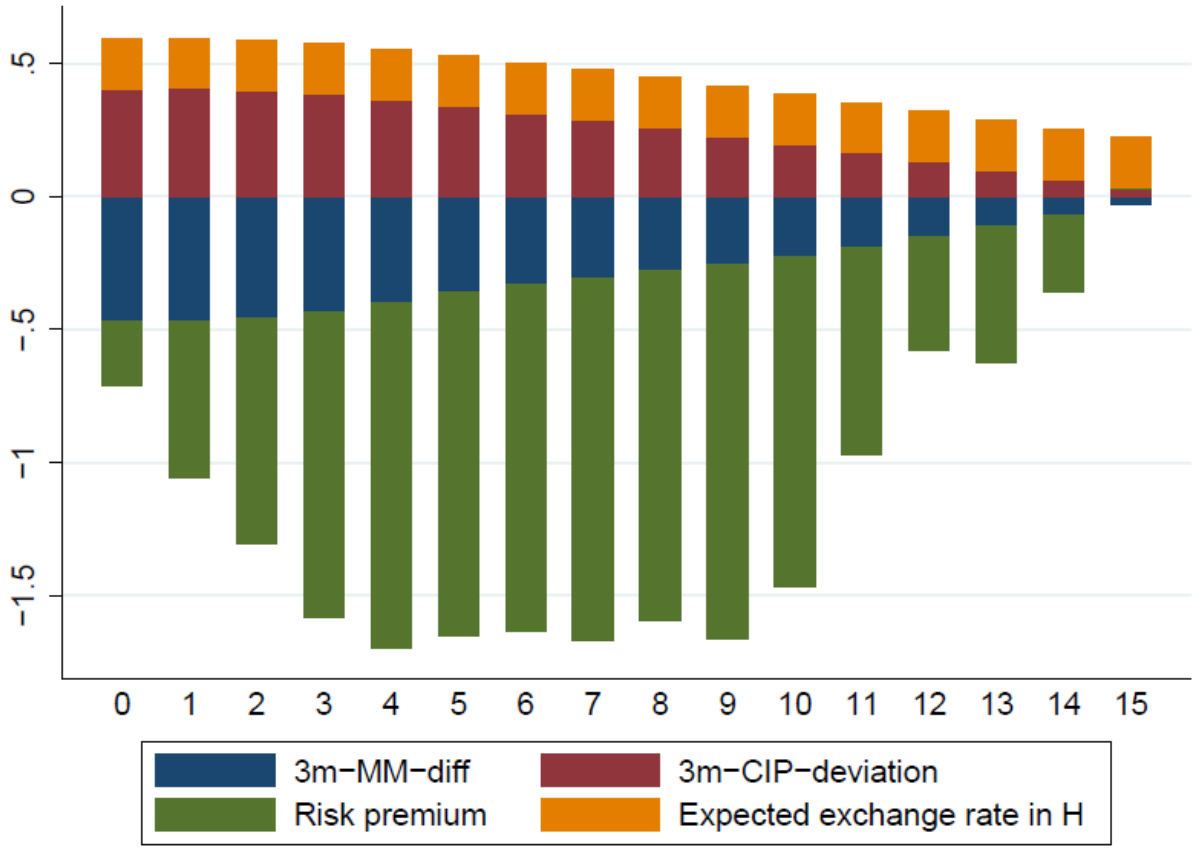


Forward-spot rate diff. ($f^{3m}_{t,t+1} - s_t$)

(deviation from baseline in %)



Decomposition of exchange rate response



$$s_t = E_t\left(s_{t+T}\right) + \sum_{j=0}^{T-1} E_t\left(r^{€}_{t+j} - r^{\$}_{t+j}\right) - \sum_{j=0}^{T-1} E_t\lambda_{t+j} + \sum_{j=0}^{T-1} E_t\pi_{t+j,t+j+1}$$

Result 3

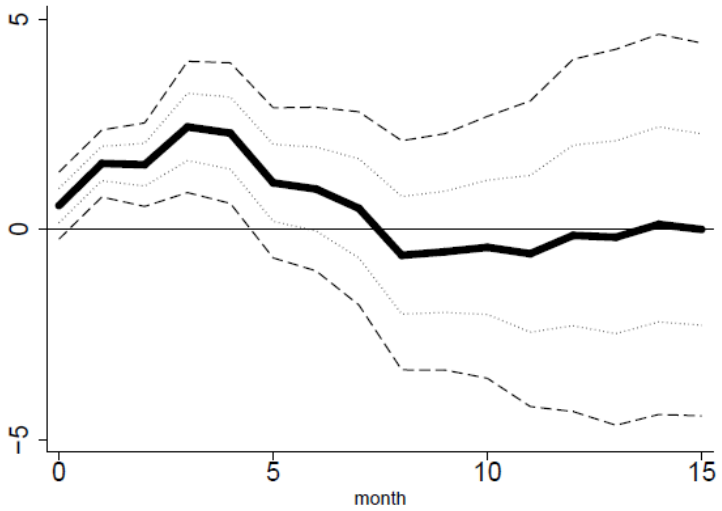
- Little response in longer-term interest rates, stock prices increase somehow
- Consistent with dominant role in estimation of ECB QE measures *prior* to APP
- Small effect on inflation in EA, stronger in US

Some robustness

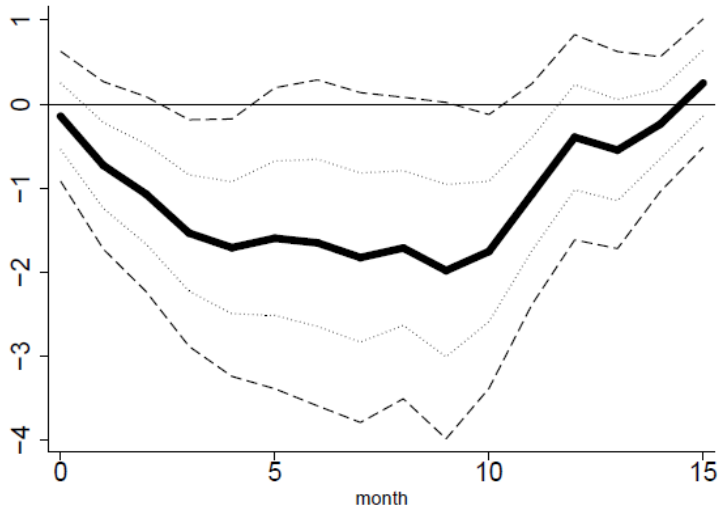
- Only future change in relative balance sheet ΔBS_{t+1} as independent variable — anticipation effects
- Drop ECB APP-related annuncements — heterogeneity in UMP measures
- Drop all Fed announcements — not significant in baseline, wrong sign
- Announcement news proxied with signed stock market change (positive/negative) in same day: $a_t \cdot (\Delta EP_t < 0)$, $a_t \cdot (\Delta EP_t > 0)$

Only future balance sheet change

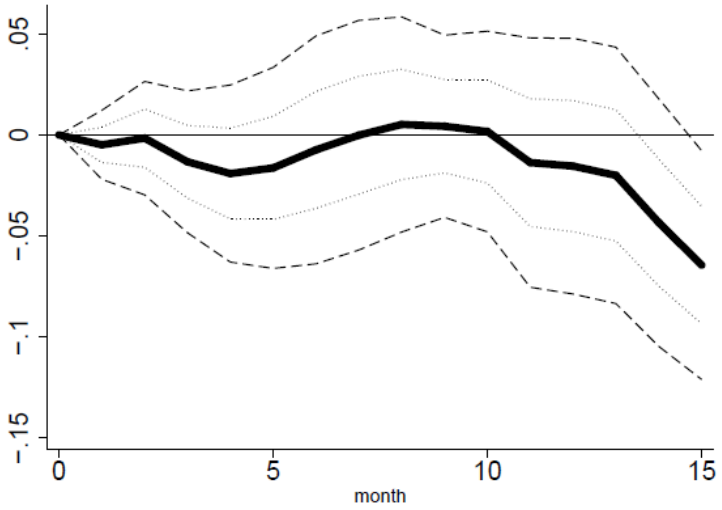
Relative balance sheet



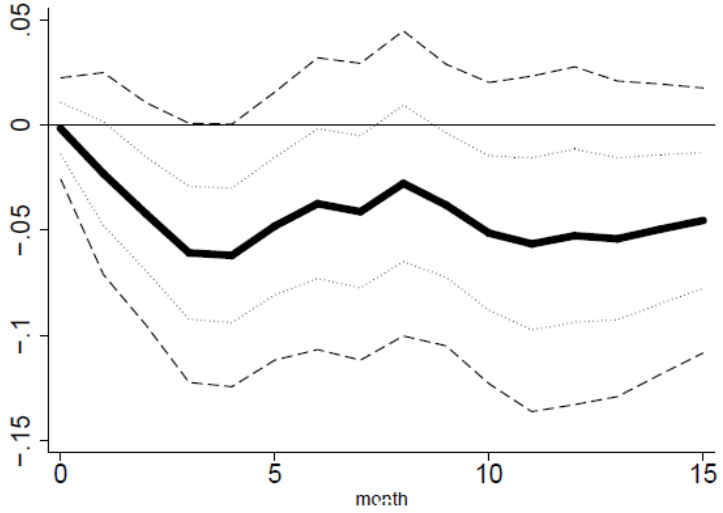
US dollar-euro exchange rate



Policy rate differential (MRO - Fed Funds rate)

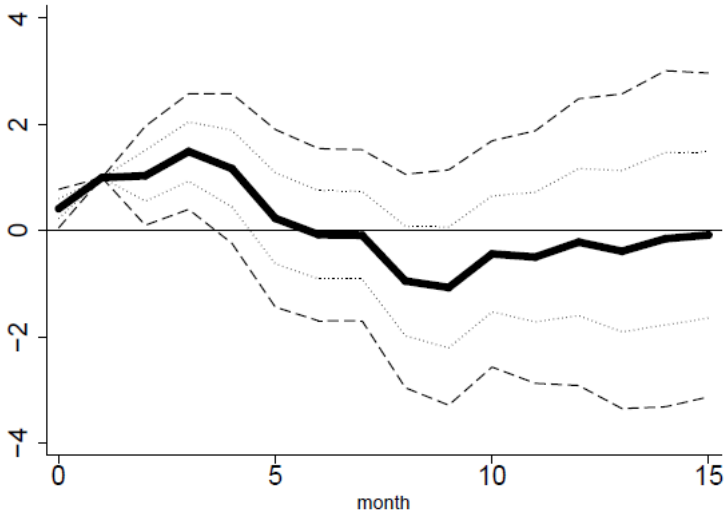


Three-month money market rate differential

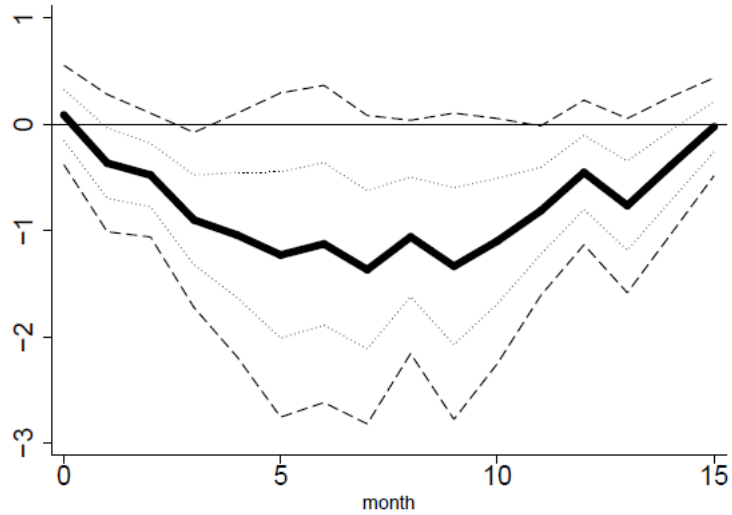


Excluding ECB's APP announcements

Relative balance sheet



US dollar-euro exchange rate



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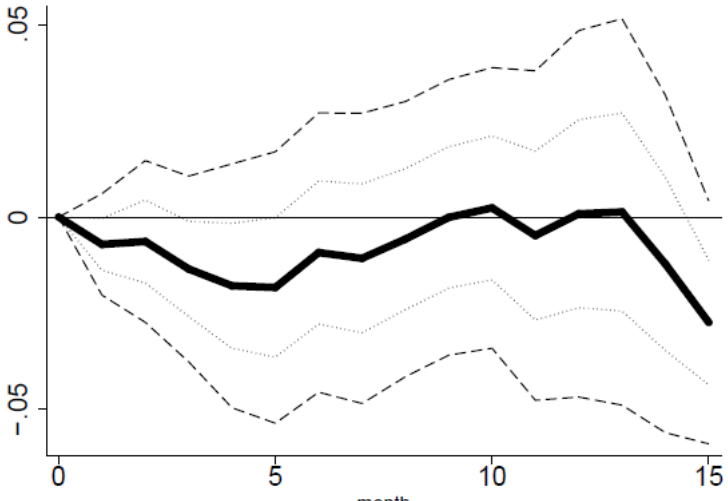
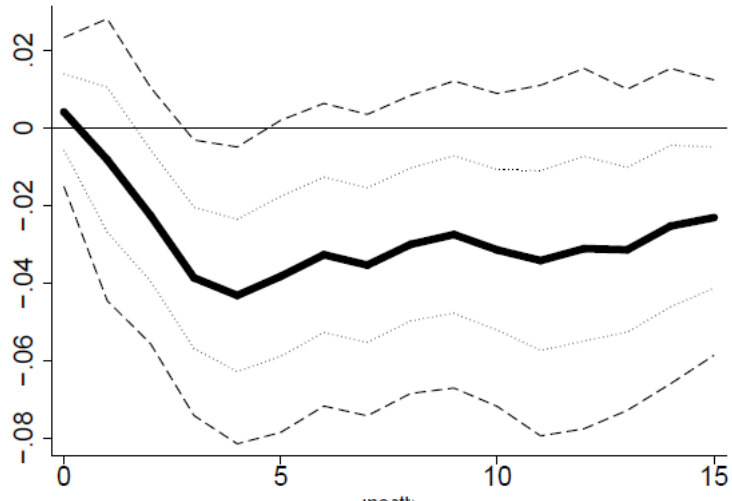
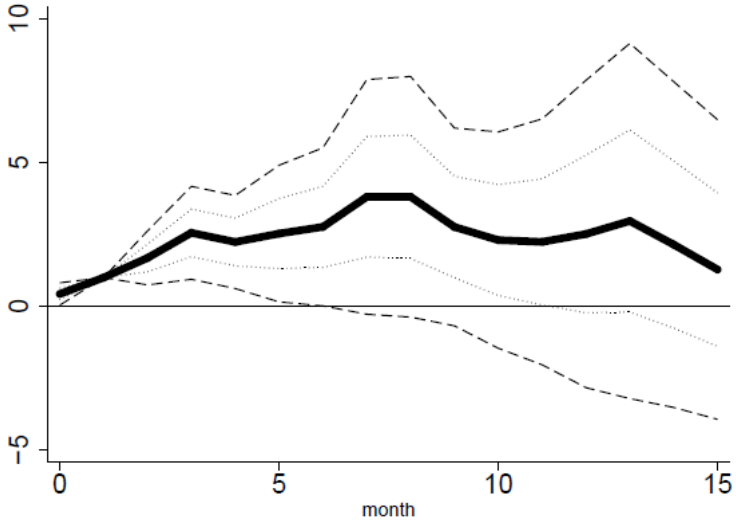


Three-month money market rate differential

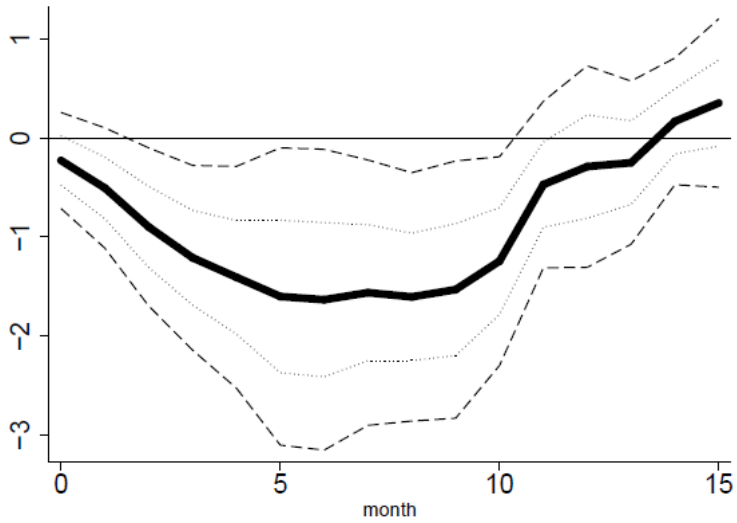


Excluding Fed's announcements

Relative balance sheet



US dollar-euro exchange rate



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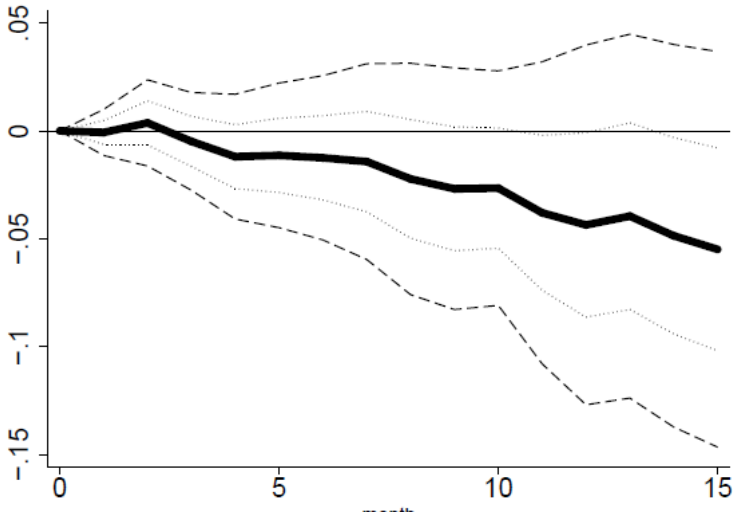
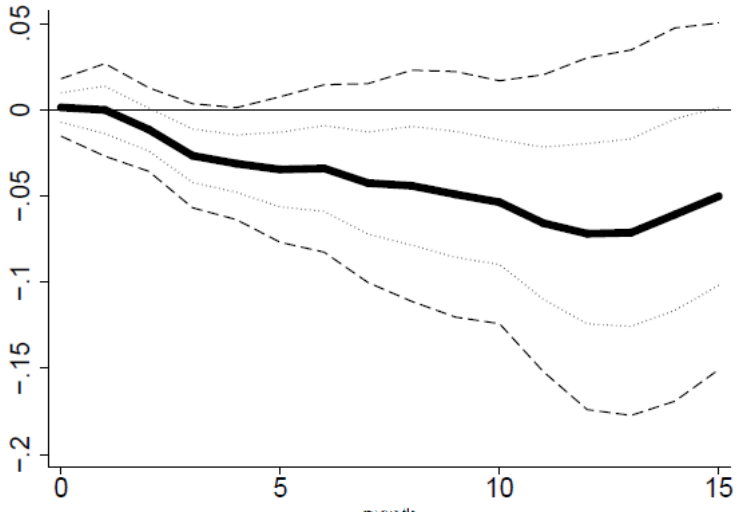
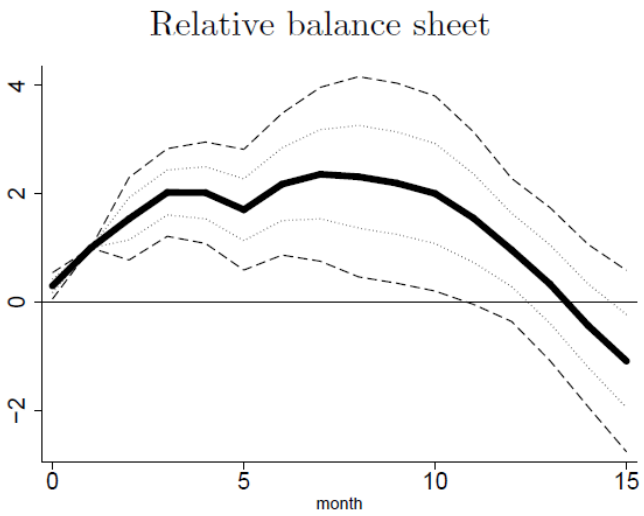
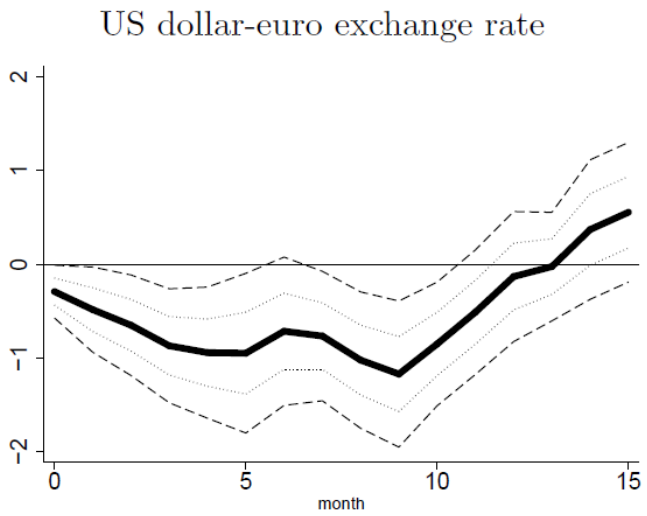


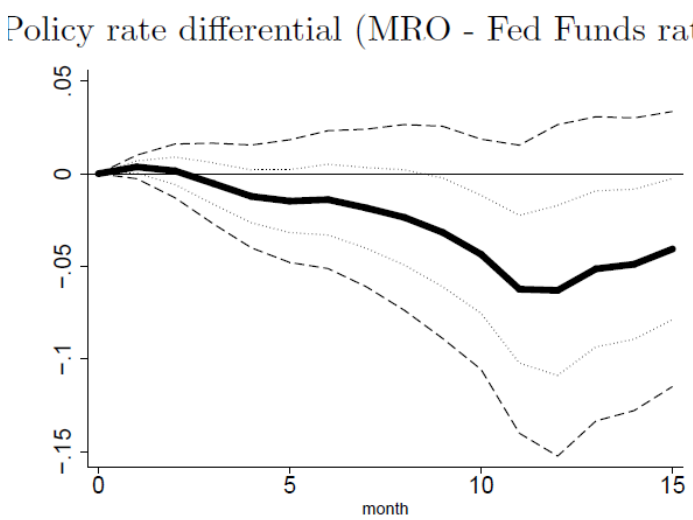
Three-month money market rate differential

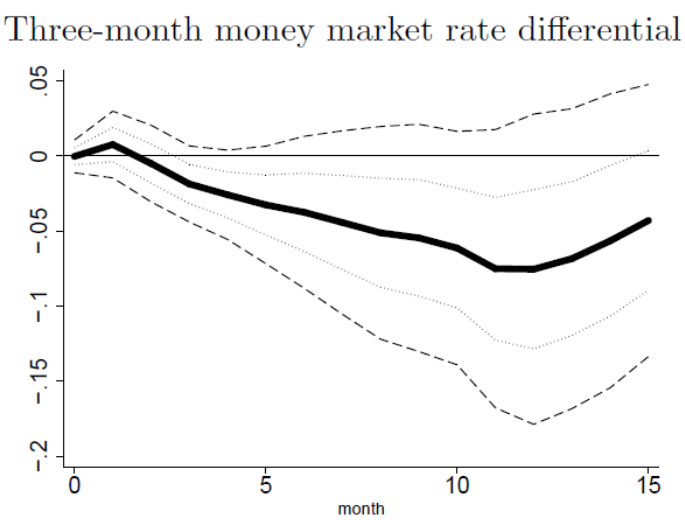


Stock-market-weighted announcements

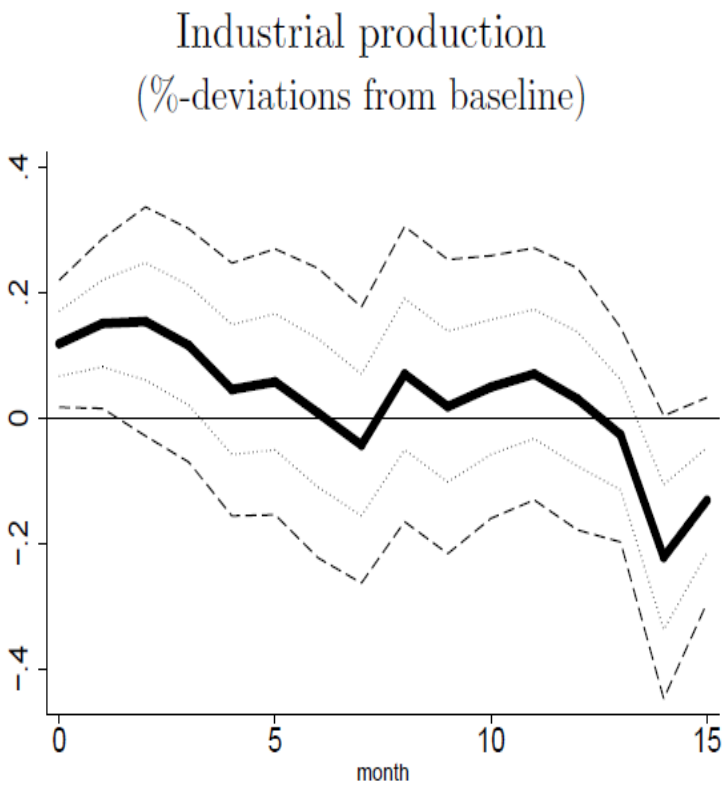


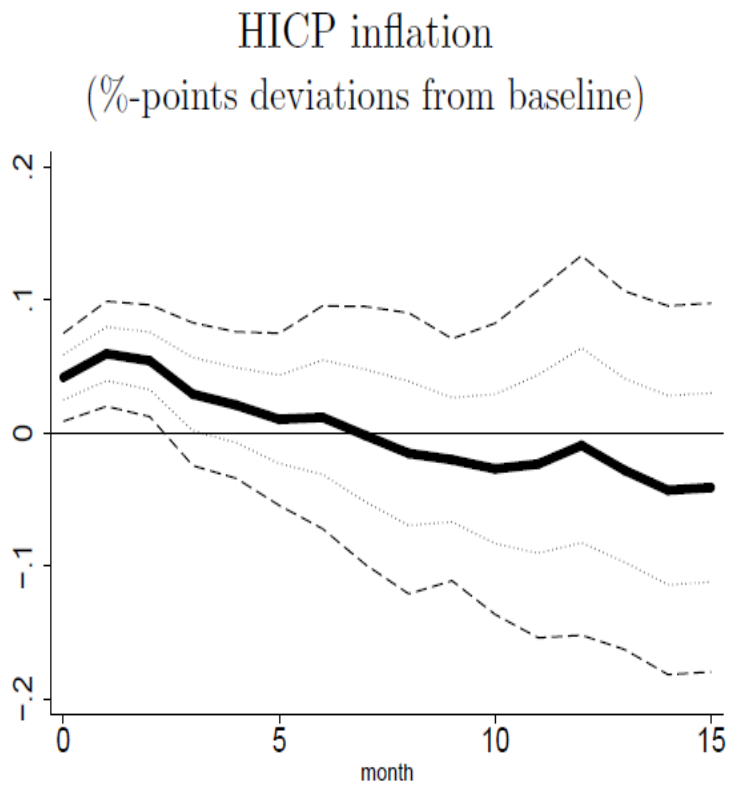






Stock-market weighted announcements





Conclusions and open issues

- Evidence of dynamic effects of QE in foreign exchange markets
  - 1% increase in ECB/Fed relative balance sheet leads to 1% euro depreciation, decline in money market rate differentials
  - Narrower CIP deviations, little role for signaling, but large effects of risk premia
- Caveats
  - Empirical model good approximation of market's expectations of fundamentals
  - Not easy to control for ECB, Fed private info and forecasts
- Room for improvement
  - Indications of weak instruments, strengthen identification with "narrative" elements
  - Fed announcements wrong sign, not very significant
  - Include analysis with weekly data

OLS estimation