

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

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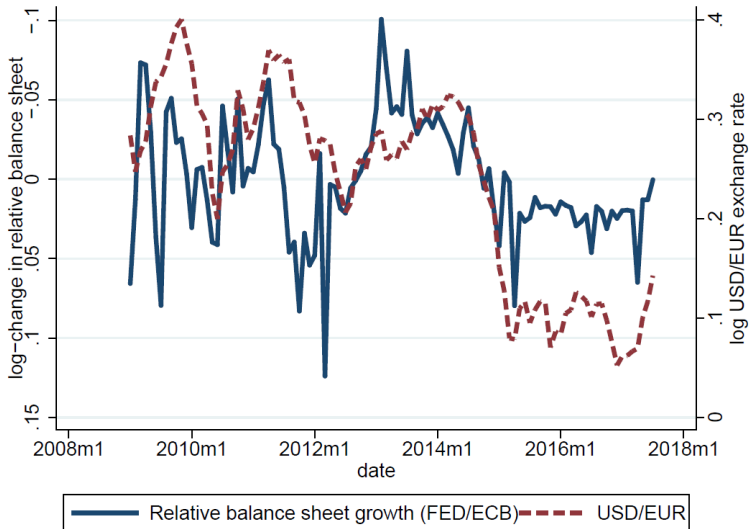
Monetary Policy in Non-standard Times
Frankfurt, 11-12 September, 2017

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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



- 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)

- 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

- 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),...

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

Empirical framework

Exchange rate determination in asset markets

- Under capital mobility, risk-adjusted return in dollar-euro *forward* and *spot* markets equalized, even with borrowing constraints:

$$1 \geq \mu_t^F = \frac{E_t \left(D_{t+1}^\$ \right) F_{t,t+1} R_t^\epsilon}{S_t} = \frac{E_t \left(D_{t+1}^\$ S_{t+1} \right) R_t^\epsilon}{S_t}$$

- Yet equalization of *synthetic* and *cash* \$ returns (CIP) may fail:

$$1 \geq \mu_t^F = \frac{E_t \left(D_{t+1}^\$ \right) F_{t,t+1} R_t^\epsilon}{S_t} = E_t \left(D_{t+1}^\$ \right) R_t^\$ \cdot \frac{\mu_t^F}{\mu_t^\$}, \quad \frac{\mu_t^F}{\mu_t^\$} \leq 1$$

- Generalized version of UIP (under log-normality):

$$s_t = E_t s_{t+1} + r_t^\epsilon - r_t^\$ - \lambda_t + \pi_{t,t+1}$$

$$\text{CIP deviations} : \lambda_t \equiv \ln \frac{\mu_t^F}{\mu_t^\$} \equiv r_t^\epsilon - \left[r_t^\$ - (f_{t,t+1} - s_t) \right]$$

$$\text{"risk premium"} : \pi_{t,t+1} \equiv \text{Cov}_t \left(d_{t+1}^\$, s_{t+1} \right) + \frac{1}{2} \text{Var}_t (s_{t+1})$$

- Generalized UIP consistent with most exchange rate theories under financial integration in money markets

- E.g., "monetary" model assumes:

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

- CIP deviations can reflect borrowing constraints due to financial frictions (Gabaix-Maggiore 2014), or even "liquidity preference" for cash \$
- Risk premium $\pi_{t,t+1}$ is actually a residual in our analysis — and thus captures drivers of wedge between observable future fundamentals and s_t , due to, e.g., forex "portfolio balance" channel (Kouri 1976) (not only compensation for FX risk)

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

$$s_t = E_t(s_{t+T}) + \sum_{j=0}^{T-1} E_t(r_{t+j}^{\text{€}} - r_{t+j}^{\text{\$}}) - \sum_{j=0}^{T-1} E_t\lambda_{t+j} + \sum_{j=0}^{T-1} E_t\pi_{t+j,t+j+1}$$

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

How shocks affect the exchange rate

- Write the change in the exchange rate as follows:

$$s_t - s_{t-1} = - \left(r_{t-1}^{\text{€}} - r_{t-1}^{\text{\$}} \right) + \lambda_{t-1} + \pi_{t-1,t} + \Gamma'_0 \varepsilon_t.$$

- Γ'_0 captures the effects of "innovations" ($E_{t-1}(\varepsilon_t) = 0$):

$$\begin{aligned} \Gamma'_0 \varepsilon_t \equiv & \sum_{j=0}^{T-1} \left[E_t \left(r_{t+j}^{\text{€}} - r_{t+j}^{\text{\$}} \right) - E_{t-1} \left(r_{t+j}^{\text{€}} - r_{t+j}^{\text{\$}} \right) \right] + \\ & - \sum_{j=0}^{T-1} [E_t \lambda_{t+j} - E_{t-1} \lambda_{t+j}] + \sum_{j=0}^{T-1} [E_t \pi_{t+j,t+j+1} - E_{t-1} \pi_{t+j,t+j+1}] \\ & + E_t (s_{t+T}) - E_{t-1} (s_{t+T}) \end{aligned}$$

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

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

$\Rightarrow E_t (s_{t+T})$ 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 the ECB and the Fed, and "money demand" shocks to relative balance sheet)

- Assume ε_t^{QE} includes *both* contemporaneous shock ($\eta_{t|t}^{QE}$) *and* shock known as of t but affecting 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 $\eta_{t+1|t}^{QE}$:

$$s_t - s_{t-1} = - \left(r_{t-1}^{\text{€}} - r_{t-1}^{\text{\$}} \right) + \lambda_{t-1} + \pi_{t-1,t} + \Gamma'_{0,2} \varepsilon_{2t} + \gamma_0^{QE} \left(\eta_{t|t}^{QE} + \phi \eta_{t+1|t}^{QE} \right)$$

Empirical strategy

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

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

- Substitute out $\eta_{t+1|t}^{QE}$ in exchange rate equation (possibly motivated by "monetary" model, as suggested by Tomasz):

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

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

A 2SLS approach

- Assume that 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:

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

2nd stage:

$$s_t - s_{t-1} = \gamma_0^{QE} \left(\Delta \widehat{BS}_{t+1} / \phi \right) - \left(r_{t-1}^{\text{€}} - r_{t-1}^{\text{\$}} \right) + \lambda_{t-1} - \gamma_0^{QE} \rho' X_t + \zeta_t$$

- 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 $\eta_{t|t}^{QE}$
 - 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
- Alternatively, substitute out $\eta_{t|t}^{QE}$ and $\eta_{t+1|t}^{QE}$ for both ΔBS_t and ΔBS_{t+1} :

$$s_t - s_{t-1} = \gamma_0^{QE} (\Delta BS_{t+1}/\phi + \Delta BS_t) - (r_{t-1}^E - r_{t-1}^\$) + \lambda_{t-1} + \dots$$

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

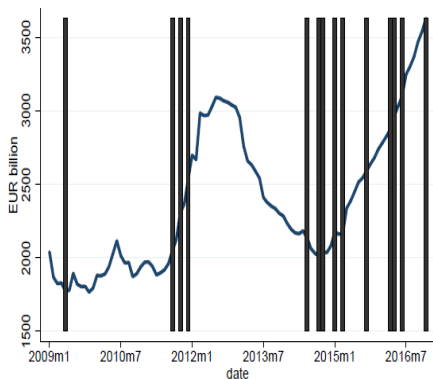
What else can go wrong?

- 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)
 - UMP shocks equal to residuals of 1st stage equation for $(\Delta BS_{t+1} + \Delta BS_t)$ in month of announcements by ECB and Fed, controlling for above variables in X_t
- (Some) QE announcements not really (expansionary) surprise/news
 - Then exchange rate, asset prices should not react
 - But assuming all announcements the same 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

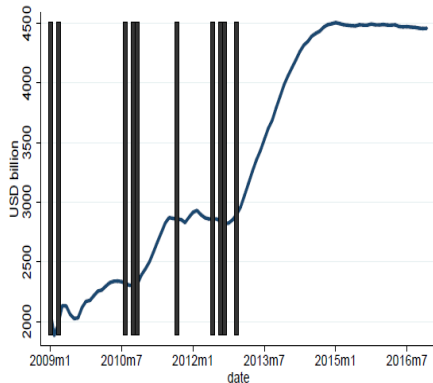
Announcements

- 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 balance sheet 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
- 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 the announcement days consistent with announcements as surprise policy actions

Announcements



— ECB balance sheet ■ ECB QE Announcements



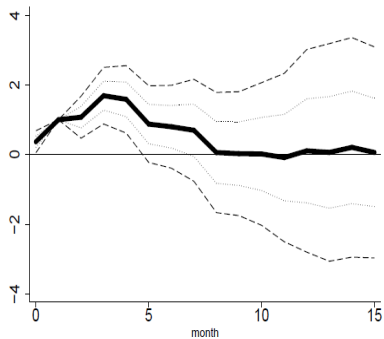
— US Fed balance sheet ■ Fed UMP Announcements

Results

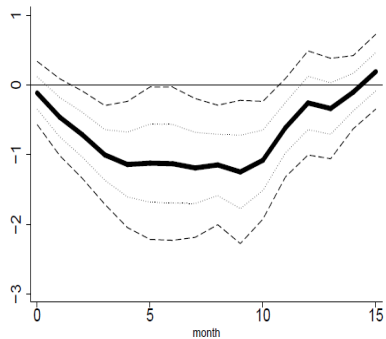
Result 1

- 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

Relative balance sheet
(deviation from baseline in %)

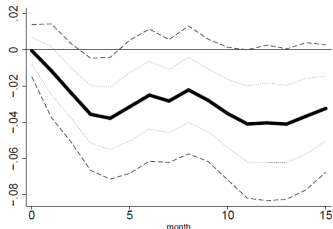


US dollar-euro exchange rate
(US dollar per euro, deviation from baseline in %)

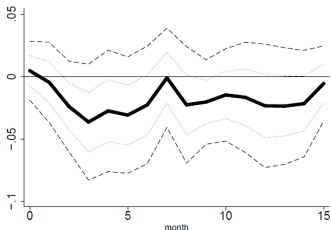


Money market interest rates decline

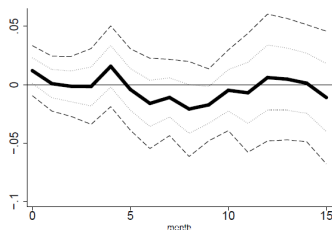
Three-month money market rate differential ($r_{\text{€},3m} - r_{\text{\$},3m}$)
(deviation from baseline in %-age points)



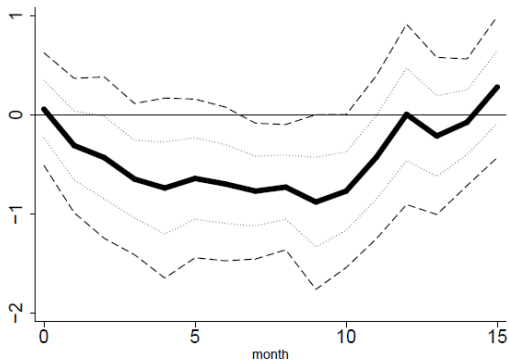
Two-year sov. yield differential ($r_{\text{€},2y} - r_{\text{\$},2y}$)
(deviation from baseline in %-age points)



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



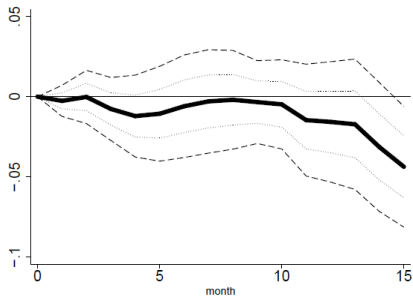
Real exchange rate depreciates



Counfounding effects from policy rates unlikely

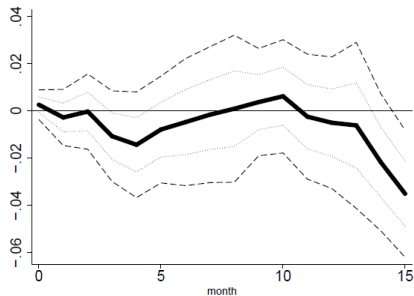
MRO - Fed Funds rate

(deviation from baseline in %-age points)



DFR - Fed Funds rate

(deviation from baseline in %-age points)



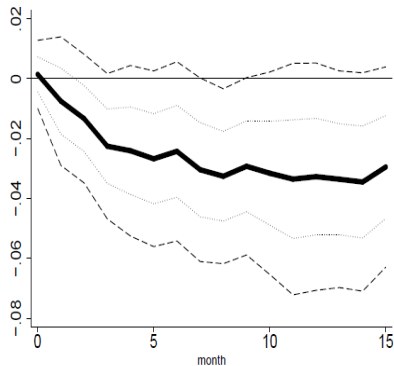
Result 2: What drives the exchange-rate response?

- Persistent decline in CIP deviations actually dampens euro depreciation:

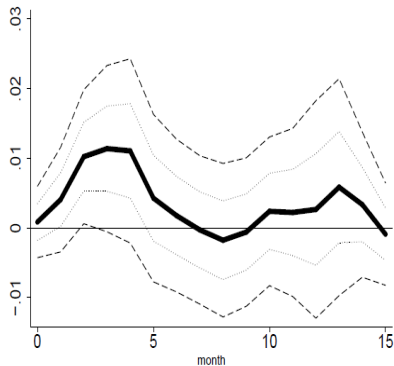
$$r_{t,t+3}^{\text{€}} - \left[r_{t,t+3}^{\text{\$}} - (f_{t,t+3} - s_t) \right] = \lambda_{t,t+3} \downarrow$$

- Narrower spread between money market euro rate and synthetic euro 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

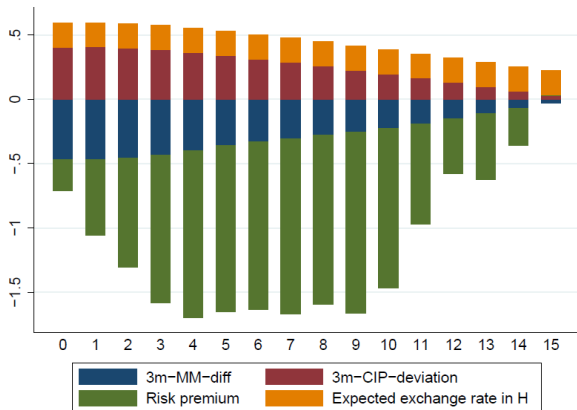
CIP deviation ($\lambda_t = f_{t,t+1}^{3m} - s_t + r_t^{\text{€},3m} - r_t^{\text{\$,3m}}$)
 (deviation from baseline in %-age points)



Forward-spot rate diff. ($f_{t,t+1}^{3m} - s_t$)
 (deviation from baseline in %)



Decomposition of exchange rate response



$$s_t = E_t(s_{t+T}) + \sum_{j=0}^{T-1} E_t(r_{t+j}^{\text{€}} - r_{t+j}^{\text{\$}}) - \sum_{j=0}^{T-1} E_t \lambda_{t+j} + \sum_{j=0}^{T-1} E_t \pi_{t+j, t+j+1}$$

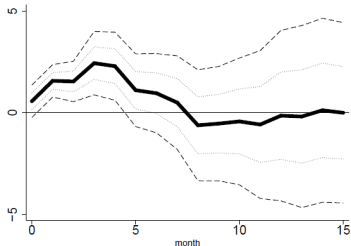
Result 3

- Little response in longer-term interest rates, a bit stronger increase in EA stock prices
- Consistent with dominant role in estimation of ECB QE measures prior APP
- Small effect on inflation in both EA and US, little effect on industrial production

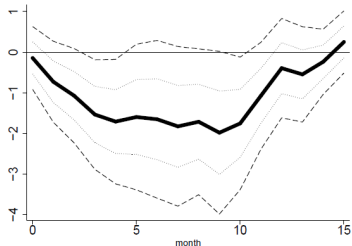
- Only future change in relative balance sheet ΔBS_{t+1} as independent variable — anticipation effects
- Drop ECB APP-related announcements — heterogeneity in UMP measures
- Drop all Fed announcements — not significant in baseline, often wrong sign
- News in announcements proxied with stock market change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

Only future balance sheet change

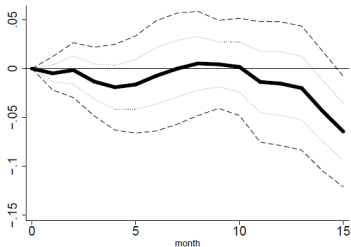
Relative balance sheet



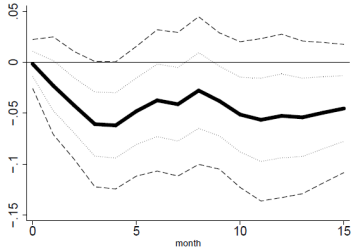
US dollar-euro exchange rate



Policy rate differential (MRO - Fed Funds rate)

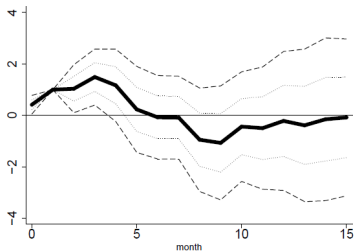


Three-month money market rate differential

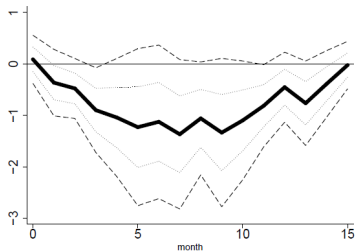


Excluding ECB's APP announcements

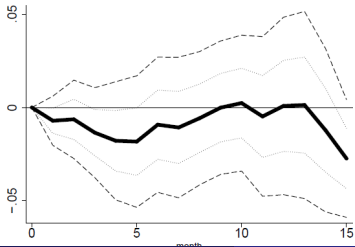
Relative balance sheet



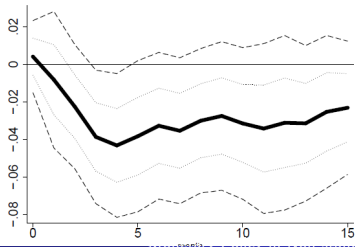
US dollar-euro exchange rate



Policy rate differential (MRO - Fed Funds rate)

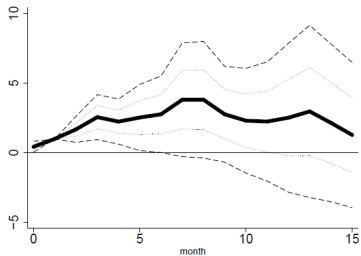


Three-month money market rate differential

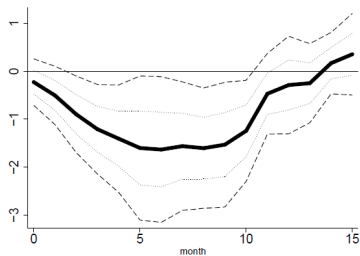


Excluding Fed's announcements

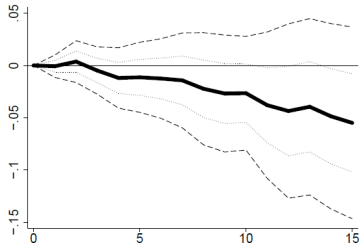
Relative balance sheet



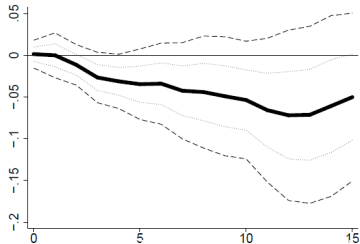
US dollar-euro exchange rate



Policy rate differential (MRO - Fed Funds rate)

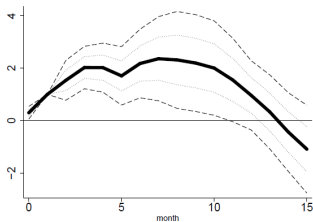


Three-month money market rate differential

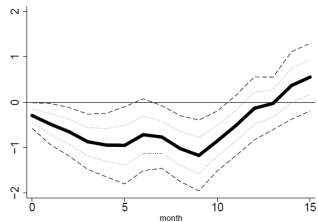


Stock-market-weighted announcements

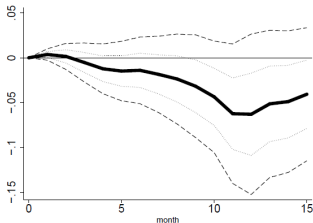
Relative balance sheet



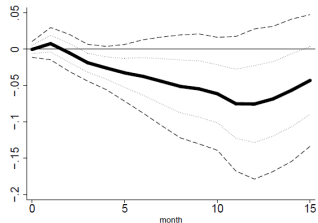
US dollar-euro exchange rate



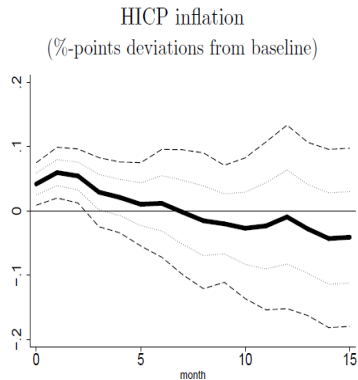
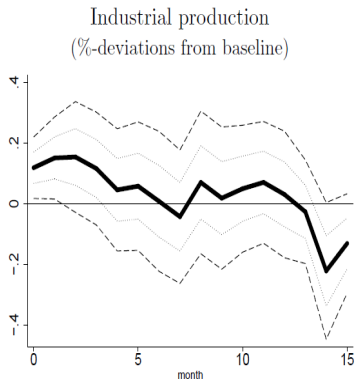
Policy rate differential (MRO - Fed Funds rate)



Three-month money market rate differential



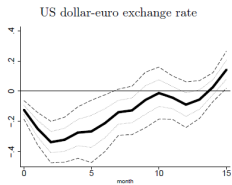
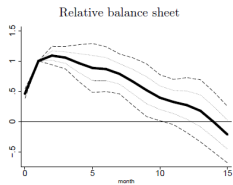
Stock-market weighted announcements



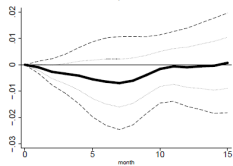
Conclusions and open issues

- 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 rates differential
 - Reduction in CIP deviations, little role for signaling, but large effects from 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 results with weekly data

OLS estimation



Policy rate differential (MRO - Fed Funds rate)



Three-month money market rate differential

