The Asset Purchase Programmes in the Euro Area: Lessons for Financial Stability

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ESCB APPs in context

- Which APP is most effective in combatting disinflation?
- APPs: central bank buys financial assets in exchange for newly created money (bank reserves)
- ESCB Asset Purchase Programmes (APPs)
  - small first round (€142bn from 2009 to 14)
  - second round (€3.06**trn** by Dec. 2016), with explicit goal "to address the risks of a prolonged period of low inflation"
  - extended until end-2017
- studies on US and UK QE: positive effect on GDP and inflation, usually larger in VARs than DSGEs (Baumeister and Benati, 2013 & Kapetanios et al., 2012 vs. Chen et al., 2012)

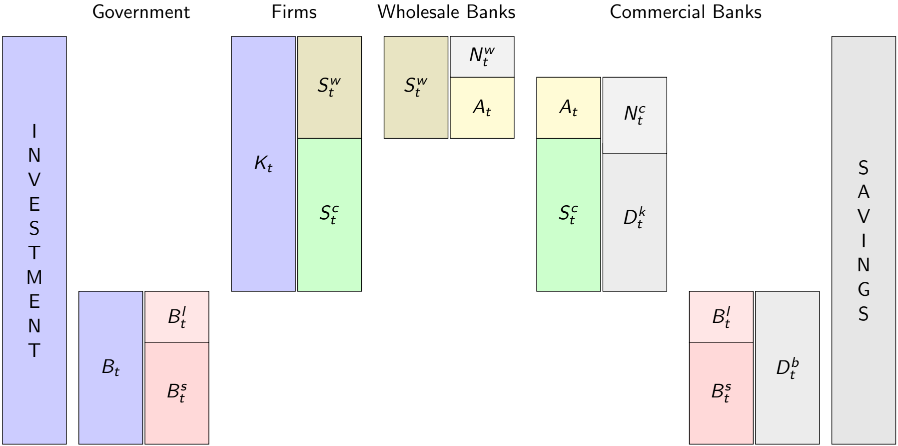
Preview of analysis and results

- analysis: build and estimate NK-DSGE model with
  - purchases of long-term sovereign debt (SMP, PSPP)
  - purchases of securitised assets (CBPP1-3, ABSPP)
  - direct intermediation of firm debt (CSPP)
- results:
  - expansionary effect of all APPs, but small in size
  - purchases of €60bn government debt for 12 consecutive months increase inflation by about 0.5% (50bp) on impact
  - government bond purchases most effective

Model setup

- risk-averse households consume and supply labour monopolistically
- firms produce with K and L, zero profits
- retailer adds markup, capital producer adds a price for K
- conventional mon. pol.
- usual market-clearing conditions apply
- **new**: unconventional monetary policy via purchases of
  - long-term government debt (B_t)
  - financial assets (A_t)
  - direct intermediation of firm debt (S_t)

Balance sheets of financial sector in my model



Note: D deposits; S loans; A assets; N net worth; B gov. bonds
[graph not to scale of calibration]

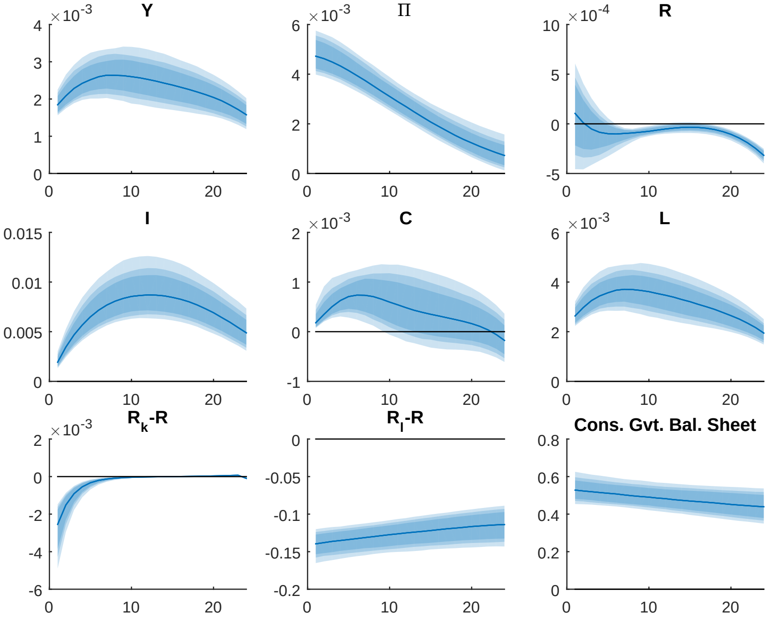
Main financial frictions

- bank loans to firms S_t: moral hazard in commercial banks restricts leverage and leads to interest rate spread $R_{k,t+1} - R_t$ (as in Gertler and Karadi, 2011)
- financial assets A_t: wholesale banks also subject to a moral-hazard constraint. They grant loans to firms, securitise them (harder to divert!) and sell them to commercial banks (see Meeks et al., 2014)
- long-term bonds B_t via preferred habitat channel: commercial banks invest household's deposits partially into government bonds and mix portfolio between long-term and short-term debt (Ellison and Tischbirek, 2014)

Data and model estimation

- monthly sample from 2008m12-2015m1 (74 obs.) based on:
  - quarterly national account data from ECB Area-Wide Model (Fagan et al., 2001);
  - monthly MFI data from ECB Stat. Warehouse Database (total bank assets, bank deposits, bank loans, return on loans);
  - aggregated daily data on APP holdings from ECB homepage
- does not include zero-lower bound yet (policy rate moves)
- estimation results are in line with those in the literature and most parameters are identified

Responses to government bond purchases B_t^g



An application to financial stability (1/2)

- use asset purchases for macroprudential policy (see Ellison and Tischbirek, 2014 and Janet Yellen, 2015)
- here: to **stabilise financial shock** as in Meeks et al. (2014):
  - commercial bank equity impaired
  - pledgeability of securitised assets diminished
  - collateral value of assets diminished
- central bank now uses the following reaction functions:

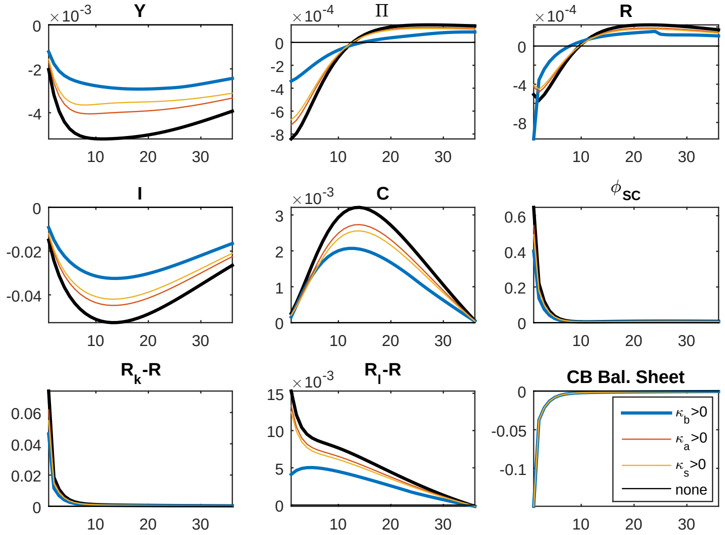
a) government debt $\quad B_t^g = \kappa_b \left[R_{k,t+1} - R_t - (R_k - R)\right]$

b) financial assets $\quad A_t^g = \kappa_a \left[R_{k,t+1} - R_t - (R_k - R)\right]$

c) firm loans (bonds) $\quad S_t^g = \kappa_s \left[R_{k,t+1} - R_t - (R_k - R)\right]$

An application to financial stability (2/2)

Responses to a financial shock with and without stabilisation by different APPs



Summary and outlook

Main results:

- APPs have expansionary effect on inflation, albeit small (roughly 50bp for PSPP)
- purchases of corporate debt and financial assets seem less effective
- APPs have potential to stabilise economy after financial shock

Next steps:

- zero lower bound
- allow for a more balanced "competition" between asset classes in estimation (use Gertler and Karadi, 2013, add long-term corporate bonds)
- LTROs as a stand-in for S_t^g (CSPP)?

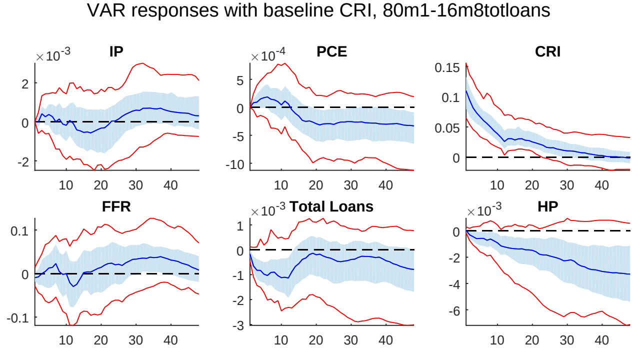
"Common Banking Regulation and the Business Cycle in a Monetary Union"

- two-country model (Germany and Spain)
  - both have bank leverage (Gerali et al., 2010) and firm leverage (Gertler and Karadi, 2011)
  - interact via goods trade and interbank market; common monetary policy
  - unification of banking regulation: differences in firm and bank leverage disappear/diminish
- results of estimation
  - financial shocks explain about one fifth of German and two fifth of Spanish GDP growth volatility
  - common regulation aligns business cycles across countries, increases welfare and would have reduced effect of Great Recession
- possible extensions:
  - RoW block
  - effects of new banking regulation (Basel IV?): EA core v periphery

“US Capital Requirement Changes and the Macroeconomy” (1/2)

- with Sandra Eickmeier and Esteban Prieto Fernández (Deutsche Bundesbank Forschungszentrum)
- many micro-studies assess the effect of capital requirement (CR) changes, but few take into account repercussions on business cycle
- we develop an indicator of CR changes for the US, 1980m1-2016m9 to examine its effect on macro and aggregate banking variables
- similar results from single-equation regressions, local projections and Qualitative VAR (Dueker, 2005, 2006)

"US Capital Requirement Changes and the Macroeconomy" (2/2)



Note: Monthly data from 1980m1 to 2016m8, recursive identification with ordering as plotted; cumulated 12 lags, const., lin. & quadr. trend; 6000 draws from Gibbs sampler, 95% (red) and 84% (blue) confidence bands

"The Causes of Low Inflation in the Euro Area"

- with Johan Grip (Uppsala University), Andresa Lagerborg (EUI) and Carlos Montes Galdon (ECB)
- Which are the dominant causes of the current low inflation in the Euro Area?
  - labour and product market reforms ⇒ downwardly rigid nominal wages (Abbritti and Fahr, 2013), time-varying price and wage adjustment costs
  - shocks from abroad ⇒ imperfect pass-through of import prices (Justiniano and Preston, 2010), with time-varying adjustment costs
  - "bad luck" ⇒ stochastic volatility of shocks
- estimate open-econ DSGE model at second order, using a recently developed modified Kalman filter (Kollmann, 2015)

That's it...

Thank you for your attention!

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Meeks, Roland, Benjamin Nelson, and Piergiorgio Alessandri, “Shadow banks and macroeconomic instability,” Bank of England working papers 487, Bank of England March 2014.

Households

Homogeneous households solve

$$\max_{C_t, D_t, L_t(i)} \sum_{t=0}^{\infty} \beta^t \left(x_{d,t} \frac{(C_t - H_t)^{1-\sigma}}{1-\sigma} - \chi \frac{L_t(i)^{1+\varphi}}{1+\varphi} \right)$$

$$\text{s.t. } C_t + D_t + T_t = R_{t-1} D_{t-1} + w_t(i) L_t(i) - \Gamma_{w,t} w_t L_t$$
$$+ \Pi_{r,t} + \Pi_{I,t} + \Pi_{cb,t} + \Pi_{wb,t},$$

$$\text{where } L_t(i) = \left(\frac{w_t(i)}{w_t} \right)^{-\epsilon_{w,t}} L_t$$

$$\text{and } \Gamma_{w,t} = \frac{\chi_w}{2} \left(\frac{w_t(i)}{w_{t-1}(i)} \pi_t - \pi \right)^2$$

Firms, capital producers and retailers

Productive firms solve

$$\max_{K_{t-1},L_t} P_{p,t}Y_t - r_{pk,t}K_{t-1} - w_tL_t \text{ s.t. } Y_t = x_{a,t}K_{t-1}^{\alpha}L_t^{1-\alpha}$$

Capital producers solve

$$\max_{I_t} E_t\left\{\sum_{t=0}^{\infty}\beta^t\frac{\lambda_t}{\lambda_0}\left(Q_t - 1 - \Gamma_{I,t}\right)I_t\right\}$$

$$\text{where } \Gamma_{I,t} = \frac{\chi_I}{2}x_t^i\left(\frac{I_t}{I_{t-1}} - 1\right)^2$$

Retailer z solves

$$\max_{P_t(z)} E_0\sum_{t=0}^{\infty}\beta^t\frac{\lambda_t}{\lambda_0}\left\{\left[\frac{P_t(z)}{P_t} - P_{p,t}\right]\left(\frac{P_t(z)}{P_t}\right)^{-\epsilon_{p,t}}Y_t - \Gamma_{p,t}Y_t\right\}$$

$$\text{where } \Gamma_{p,t} = \frac{\chi_p}{2}\left(\frac{P_t(z)}{P_{t-1}(z)} - \pi\right)^2$$

Commercial Banks (CB): general setup

- some household members become commercial bankers every period, retire with probability θ_c
- investment in government and firm debt are strictly separated and yield same return R_t:

$$R_t D_t = R_t D_t^b + R_t D_t^k$$

- both D_t^b and D_t^k will be considered in turn

Comm. Banks: Investment in gvt. debt

The CB branch investing in government debt perceives households as heterogeneous as regards their preferred investment horizon. It solves

$$\max_{B_t^s, B_t^l} V\left(R_{Bs,t} B_t^s, R_{Bl,t} B_t^l\right) \text{ s.t. } D_t^b = B_t^s + B_t^l$$

I use the indirect utility function to get closed form solution for ST and LT bond demand (see Ellison and Tischbirek, 2014):

$$B_t^s = g^s + R_{Bs,t}\left(\frac{D_t^b}{R_t \pi_{t+1}} - \frac{g^s}{R_{Bs,t}} - \frac{g^l}{R_{Bl,t}}\right)\left[a_1 + a_2 \log\left(\frac{R_{Bl,t}}{R_{Bs,t}}\right)\right]$$

$$B_t^l = g^l + R_{Bl,t}\left(\frac{D_t^b}{R_t \pi_{t+1}} - \frac{g^s}{R_{Bs,t}} - \frac{g^l}{R_{Bl,t}}\right)\left[1 - a_1 - a_2 \log\left(\frac{R_{Bl,t}}{R_{Bs,t}}\right)\right]$$

Comm. Banks: Investment in firm debt

- bankers start with some net worth N_t^c, sole objective is maximising it:

$$\mathcal{V}_t^c = \max_{S_t^c, A_t^c, D_t^k} E_t \left\{ \sum_{t=0}^{\infty} (1-\theta_c)\theta_c^t \beta^t \frac{\lambda_{t+1}}{\lambda_t} N_{t+1}^c \right\}$$

- balance sheet is given by $Q_t S_t^c + q_t A_t^c = D_t^k + N_t^c$
- **agency problem**: bankers can divert (=steal) share μ_c of loans or $\mu_c(1-\omega)$ of assets. Depositors will lend to bankers only up to the incentive constraint

$$\mathcal{V}_t^c \geq \mu_c \left[Q_t S_t^c + (1-\omega) q_t A_t^c \right]$$

- this implies **restricted leverage**

$$\frac{Q_t S_t^c + (1-\omega) q_t A_t^c}{N_t^c} \leq f(R_{k,t}, R_{a,t}, R_t, ...; \mu_c, ...)$$

Wholesale Banks (WB)

- analogous to CB: maximise net worth N_t^w via retained earnings

$$\mathcal{V}_t^w = \max E_t \left\{ \sum_{t=0}^{\infty} (1-\theta_w)\theta_w^t \beta^t \frac{\lambda_{t+1}}{\lambda_t} N_{t+1}^w \right\}$$

- their balance sheet is

$$Q_t S_t^w = q_t A_t^w + N_t^w$$

- leverage limited by incentive constraint

$$\mathcal{V}_t^w \geq \mu_w Q_t S_t^w$$

Monetary policy

- Conventional MP via Taylor rule:

$$R_{Bs,t}\pi_{t+1} = (R_{Bs,t-1}\pi_t)^{\rho_r}\left[R_{Bs}\pi\cdot\left(\frac{\pi_t}{\pi}\right)^{\kappa_\pi}\right]^{1-\rho_r} x_{r,t}$$

- Unconventional MP via APPs: intermediate

$$\text{government debt } B_t^g = \left[1-\left(\frac{\pi_t}{\pi}\right)^{\kappa_b}\right] + x_{b,t}$$

$$\text{financial assets } A_t^g = \left[1-\left(\frac{\pi_t}{\pi}\right)^{\kappa_a}\right] + x_{a,t}$$

$$\text{firm debt directly, } S_t^g = \left[1-\left(\frac{\pi_t}{\pi}\right)^{\kappa_s}\right] + x_{s,t}$$

- Consolidated government BC:

$$\begin{aligned} G_t + (1+\tau_p)(Q_t S_t^g + q_t A_t^g + B_t^g) \\ + R_{BS,t-1}B_{s,t-1} = T_t + B_{s,t} + B_{t-q}^g \\ + R_{k,t}S_{t-1}^g + R_{a,t}A_{t-1}^g. \end{aligned}$$

Market clearing

- Asset purchases reduce the overall amount of the respective asset in the market:

$$
\begin{aligned}
f \cdot Y &= B_t^l + B_t^g \\
A_t^w &= A_t^c + A_t^g \\
K_t &= S_t^c + S_t^w + S_t^g
\end{aligned}
$$

- Goods markets clear:

$$
\begin{aligned}
Y_t = C_t + G_t + I_t \left[1 + \frac{\chi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] + Y_t \cdot \frac{\chi_p}{2}\left(\pi_t - \pi\right)^2 \\
+ w_t L_t \cdot \frac{\chi_w}{2}\left(\frac{w_t}{w_{t-1}}\pi_t - \pi\right)^2 + \tau_p(S_t^g + A_t^g + B_t^g)
\end{aligned}
$$

Low Inflation in the Euro Area (1/2)

- 2nd-order estimation to account for changes in downward wage rigidity, stochastic volatility etc.
- use recent advances in DSGE model estimation at 2nd order: deterministic filter à la Kollmann (2015). Pruned solution at 2nd order (w/ observable equation):

$$x_{t+1}^f = h_x x_t^f + \sigma\eta\epsilon_{t+1}$$

$$x_{t+1}^s = h_x x_t^s + \frac{1}{2}H_{xx}(x_t^f \otimes x_t^f) + \frac{1}{2}h_{\sigma\sigma}\sigma^2$$

$$y_t^s = g_x(x_t^f + x_t^s) + \frac{1}{2}G_{xx}(x_t^f \otimes x_t^f) + \frac{1}{2}g_{\sigma\sigma}\sigma^2 + u_{t+1}$$

- instead, use augmented state vector $z_t = [x_{t+1}^f, x_{t+1}^s, (x_{t+1}^f \otimes x_{t+1}^f)]$ and rewrite as

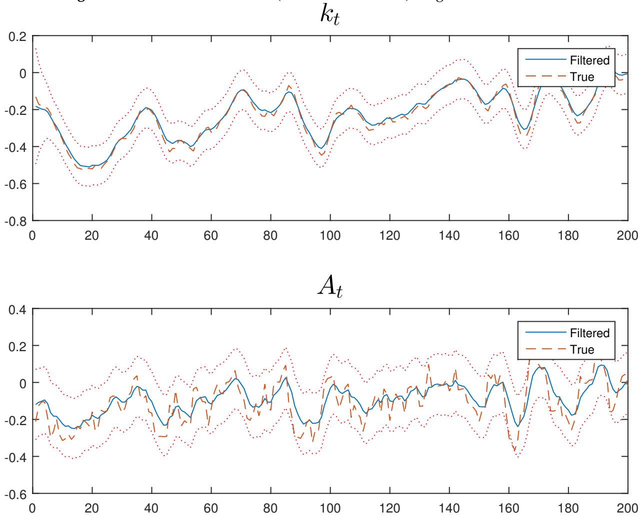
$$y_t = d + Gz_t + u_{t+1}$$

$$z_{t+1} = c + Az_t + \xi_{t+1}$$

- more efficient and much faster than bootstrap particle-filter

Low Inflation in the Euro Area (2/2)

Figure 2: True vs. Filtered States (Neoclassical Model) - Big Measurement Error



Note: States obtained by deterministic filter for 2nd order (neoclassical model)

Model eqs. household and firm FOCs

$$
\begin{aligned}
\lambda_t &= x_{p,t}(C_t - hC_{t-1})^{-\sigma} \\
\lambda_t &= \beta\lambda_{t+1}R_t \\
1 &= \epsilon_w x_{w,t}\left(1 - \frac{\chi L_t^{\varphi}}{\lambda_t w_t}\right) + \chi_w\left(\frac{w_t}{w_{t-1}}\pi_t - \pi^*\right)\frac{w_t}{w_{t-1}}\pi_t \\
&\quad - E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{L_{t+1}}{L_t}\chi_w\left(\frac{w_{t+1}}{w_t}\pi_{t+1} - \pi^*\right)\left(\frac{w_{t+1}}{w_t}\right)^2\pi_{t+1}\right\}
\end{aligned}
$$

$$
\begin{aligned}
Y_t &= x_{a,t}K_{t-1}^{\alpha}L_t^{1-\alpha} \\
r_{pk,t} &= \alpha P_{p,t}Y_t/K_{t-1} \\
w_t &= (1-\alpha)P_{p,t}Y_t/L_t \\
R_{k,t} &= \frac{(1-\delta)Q_t + r_{pk,t}}{Q_{t-1}}
\end{aligned}
$$

Model eqs. capital producer and retailer

Capital producer.

$$
\begin{aligned}
K_t &= x_{i,t} I_t + (1-\delta) K_{t-1} \\
Q_t &= 1 + \frac{\chi_I}{2} x_{i,t} (I_t / I_{t-1} - 1)^2 + \chi_I x_{i,t} (I_t / I_{t-1} - 1) I_t / I_{t-1} \\
&\quad - E_t \left\{ \frac{\beta \lambda_{t+1}}{\lambda_t} \chi_I x_{i,t+1} (I_{t+1}/I_t - 1)(I_{t+1}/I_t)^2 \right\}
\end{aligned}
$$

Retailer.

$$
\begin{aligned}
1 &= \epsilon_{p,t}(1 - P_{p,t}) + \chi_p \left(\pi_t - \pi\right) \pi_t \\
&\quad - E_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{Y_{t+1}}{Y_t} \chi_p \left(\pi_{t+1} - \pi\right) \pi_{t+1} \right\}
\end{aligned}
$$

Model eqs. investment in gov. debt

$$R_{Bs,t}B_t^s = R_t\pi_{t+1}D_t^b - \frac{1}{\tau}\left(R_{Bl,t}B_t^l + \sum_{i=1}^{\tau-1}\frac{R_{Bl,t-i}B_{t-i}^l}{\prod_{j=0}^{i-1}\pi_{t-j}}\right)$$

$$B_t^s = g^s + R_{Bs,t}\left(\frac{D_t^b}{R_t\pi_{t+1}} - \frac{g^s}{R_{Bs,t}} - \frac{g^l}{R_{Bl,t}}\right)\left[a_1 + a_2\log\left(\frac{R_{Bl,t}}{R_{Bs,t}}\right)\right]$$

$$B_t^l = g^l + R_{Bl,t}\left(\frac{D_t^b}{R_t\pi_{t+1}} - \frac{g^s}{R_{Bs,t}} - \frac{g^l}{R_{Bl,t}}\right)\left[1 - a_1 - a_2\log\left(\frac{R_{Bl,t}}{R_{Bs,t}}\right)\right]$$

Model eqs. investment in firm capital I

$$
\begin{aligned}
\phi^c_{s,t} &= \frac{Q_t S^c_t}{N^c_t} \\
\phi^c_{a,t} &= \frac{A_t}{N^c_t} \\
z_t &= (R_{k,t} - R_{t-1})\phi^c_{s,t-1} + (R_{a,t-1} - R_{t-1})\phi^c_{a,t-1} + R_{t-1} \\
\nu^c_t &= E_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1-\theta_c)(R_{k,t+1} - R_t) + \theta_c \frac{\phi^c_{s,t+1}}{\phi^c_{s,t}} z_{t+1} \nu^c_{t+1} \right] \right\} \\
\gamma^c_t &= E_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1-\theta_c)(R_{a,t} - R_t) + \theta_c \frac{\phi^c_{a,t+1}}{\phi^c_{a,t}} z_{t+1} \gamma^c_{t+1} \right] \right\} \\
\eta^c_t &= E_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1-\theta_c) R_t + \theta_c z_{t+1} \eta^c_{t+1} \right] \right\}
\end{aligned}
$$

Model eqs. investment in firm capital II

$$
\begin{aligned}
R_{a,t} &= R_t + (1-\omega)(R_{k,t+1} - R_t) \\
&\quad + \frac{\theta_c}{1-\theta_c}\left(\frac{\phi^c_{s,t+1}}{\phi^c_{s,t}} - \frac{\phi^c_{a,t+1}}{\phi^c_{a,t}}\right) z_{t+1}\gamma^c_{t+1} \\
\frac{\eta^c_t}{\mu_c - \nu^c_t} &= \phi^c_{s,t} + (1-\omega)\phi^c_{a,t} \\
N^c_t &= \theta_c z_t N^c_{t-1} + \tau_c(Q_t S^c_{t-1} + q_t A^c_{t-1}) \\
D^k_t &= Q_t S^c_t + q_t A^c_t - N^c_t \\
q_t &= (1-\eta) + \eta \frac{\left[(1-\eta)R^{rt}_{a,t-1} + \eta R^{rs}_{a,t}\right] q_{t-1} - r_{pk,t}}{1-\delta}
\end{aligned}
$$

Model eqs. wholesale bank

$$
\begin{aligned}
\nu_t^w &= E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}\Big[(1-\theta_w)(R_{k,t+1}-R_{a,t+1})\right.\\
&\qquad\left.+\,\theta_w\frac{\phi_{t+1}^w}{\phi_t^w}\left((R_{k,t+1}-R_{a,t+1})\phi_t^w+R_{a,t+1}\right)\nu_{t+1}^w\Big]\right\}\\
\eta_t^w &= E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}\Big[(1-\theta_w)R_{a,t+1}\right.\\
&\qquad\left.+\,\theta_w\left((R_{k,t+1}-R_{a,t+1})\phi_t^w+R_{a,t+1}\right)\eta_{t+1}^w\Big]\right\}\\
\phi_t^w &= \frac{Q_tS_t^w}{N_t^w}\\
\phi_t^w &= \frac{\eta_t^w}{\mu_w-\nu_t^w}\\
N_t^w &= \theta_w[(R_{k,t}-R_{a,t})\phi_{t-1}^w+R_{a,t}]N_{t-1}^w+\tau_wQ_tS_{t-1}^w
\end{aligned}
$$

Monetary policy

$$R_{Bs,t} = R_{Bs,t-1}^{\rho_r}\left[R_{Bs}\left(\frac{\pi_t}{\pi}\right)^{\kappa_\pi}\right]^{1-\rho_r} x_{r,t}$$

$$B_t^g = \left[1-\left(\frac{\pi_t}{\pi}\right)^{\kappa_b}\right] + x_{b,t}$$

$$A_t^g = \left[1-\left(\frac{\pi_t}{\pi}\right)^{\kappa_a}\right] + x_{a,t}$$

$$S_t^g = \left[1-\left(\frac{\pi_t}{\pi}\right)^{\kappa_s}\right] + x_{s,t}$$

$$BS_t = Q_t S_t^g + A_t^g + G_t$$

Market clearing

$$
\begin{aligned}
Y_t &= C_t + G_t + I_t\left[1 + \frac{\chi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] + Y_t \cdot \frac{\chi_p}{2}\left(\pi_t - \pi\right)^2 \\
&\quad + w_t L_t \cdot \frac{\chi_w}{2}\left(\frac{w_t}{w_{t-1}}\pi_t - \pi\right)^2 + \tau_p(S_t^g + A_t^g + B_t^g) \\
C_t &= R_{t-1}(D_{t-1}^b + D_{t-1}^k) + w_t L_t\left[1 - \frac{\chi_w}{2}\left(\frac{w_t}{w_{t-1}}\pi_t - \pi\right)^2\right] \\
&\quad + Y_t\left[1 - P_{p,t} - \frac{\chi_p}{2}\left(\pi_t - \pi\right)^2\right] + I_t\left[Q_t - 1 - \frac{\chi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] \\
&\quad + \left(1 - \theta_w\left[(R_{k,t} - R_{a,t})\phi_t^w + R_{a,t}\right]\right) N_{t-1}^w - \tau_w Q_t S_{t-1}^w \\
&\quad + \left(1 - \theta_c z_t\right) N_{t-1}^c - \tau_c(Q_t S_{t-1}^c + q_t A_{t-1}^c) - (D_t^b + D_t^k) - G_t \\
f \cdot Y &= B_t^l + B_t^g \\
A_t^w &= A_t^c + A_t^g \\
K_t &= S_t^c + S_t^w + S_t^g
\end{aligned}
$$

Quarterly data sources

	AWM series
YER	GDP (Real)
YED	GDP deflator
STN	Short-Term Interest Rate (Nominal)
ITR	Gross Investment
ITD	Gross Investment Deflator
PCR	Private Consumption
PCD	Consumption Deflator
GCR	Government Consumption
GCD	Government Consumption Deflator

Note: The source for all quarterly time series is the AWM database, see Fagan et al. (2001) and http://www.eabcn.org/page/area-wide-model.

Quarterly data treatment

	Observables	stands for...
gdp	$d(\ln(\text{YER}))$	production/demand
pcd	$d(\ln(\text{PCD}))$	personal consumption deflator
nir	$\ln(1+\text{STN}/400)$	nominal interest rate
riv	$d(\ln(\text{ITR}*\text{ITD}/\text{YED}))$	investment
con	$d(\ln(\text{PCR}*\text{PCD}/\text{YED}))$	consumption
gvc	$d(\ln(\text{GCR}*\text{GCD}/\text{YED}))$	government consumption

Note: "*d*" denotes the difference operator.

Monthly data sources

	SDW series	SDW code / source
TBA	Total bank assets	BSI.M.U2.N.A.T00.A.1.Z5.0000.Z01.E
DEP	Bank deposits	BSI.M.U2.N.A.L20.A.1.U2.0000.Z01.E
LOA	Bank loans	BSI.M.U2.N.A.A20.A.1.U2.0000.Z01.E
RSC	Return on loans	MIR.M.U2.B.A2A.F.R.0.2240.EUR.N
BGY	APPs: SMP + PSPP	ECB homepage
AGY	APPs: CBPP1-3, ABSPP	ECB homepage
SGY	APPs: CSPP	ECB homepage

Note: The source for all quarterly time series is the AWM database, see Fagan et al. (2001) and http://www.eabcn.org/page/area-wide-model.

Monthly data treatment

	Observables	stands for...
bal	$d(\ln(\mathrm{TBA}))$	bank balance sheet
dep	$d(\ln(\mathrm{DEP}))$	bank deposits
loa	$d(\ln(\mathrm{LOA}))$	bank loans
rsc	$\ln(1+[\mathrm{RSC}-\mathrm{mean}(\mathrm{RSC})]/1200)$	return on loans
bgy	$\mathrm{BGY}/\mathrm{mean}(\mathrm{YIN})$	APPs: gvt. bond purchases
agy	$\mathrm{AGY}/\mathrm{mean}(\mathrm{YIN})$	APPs: asset purchases
sgy	$\mathrm{SGY}/\mathrm{mean}(\mathrm{YIN})$	APPs: direct intermediation

Note: "*d*" denotes the difference operator.

Model observables

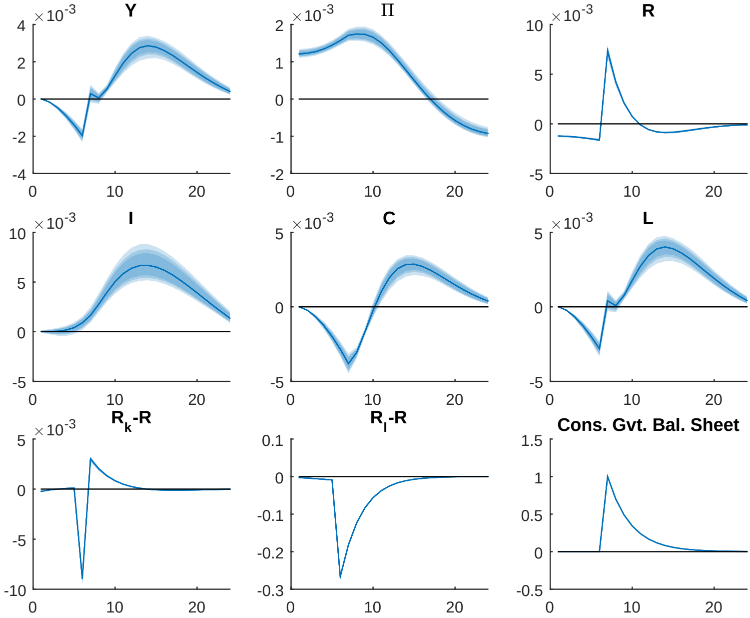
$$
\begin{aligned}
\text{gdp}_t &= \log(Y_t) - \log(Y_{t-1}) + \sigma_{ME} \cdot me_t^{\text{gdp}} \\
\text{pcd}_t &= \log(\pi_t) - \log(\pi) + \sigma_{ME} \cdot me_t^{\text{cpi}} \\
\text{nir}_t &= \log(R_t) - \log(1/\beta) + \sigma_{ME} \cdot me_t^{\text{nir}} \\
\text{riv}_t &= \log(I_t) - \log(I_{t-1}) + \sigma_{ME} \cdot me_t^{\text{riv}} \\
\text{con}_t &= \log(C_t) - \log(C_{t-1}) + \sigma_{ME} \cdot me_t^{\text{con}} \\
\text{gvc}_t &= \log(G_t) - \log(G_{t-1}) + \sigma_{ME} \cdot me_t^{\text{gvc}} \\
\text{bal}_t &= \log(D_t^k + D_t^b + N_t^c) - \log(D_{t01}^k + D_{t-1}^b + N_{t-1}^c) + \sigma_{ME} \cdot me_t^{\text{bal}} \\
\text{dep}_t &= \log(D_t^b + D_t^k) - \log(D_{t-1}^b + D_{t-1}^k) + \sigma_{ME} \cdot me_t^{\text{dep}} \\
\text{loa}_t &= \log(K_t) - \log(K_{t-1}) + \sigma_{ME} \cdot me_t^{\text{loa}} \\
\text{rsc}_t &= \log(R_{k,t}) - \log(R_k) + \sigma_{ME} \cdot me_t^{\text{rsc}} \\
\text{bgy}_t &= B_t^g / Y + \sigma_{ME} \cdot me_t^{\text{bgy}} \\
\text{agy}_t &= A_t^g / Y + \sigma_{ME} \cdot me_t^{\text{agy}}
\end{aligned}
$$

Estimation Results

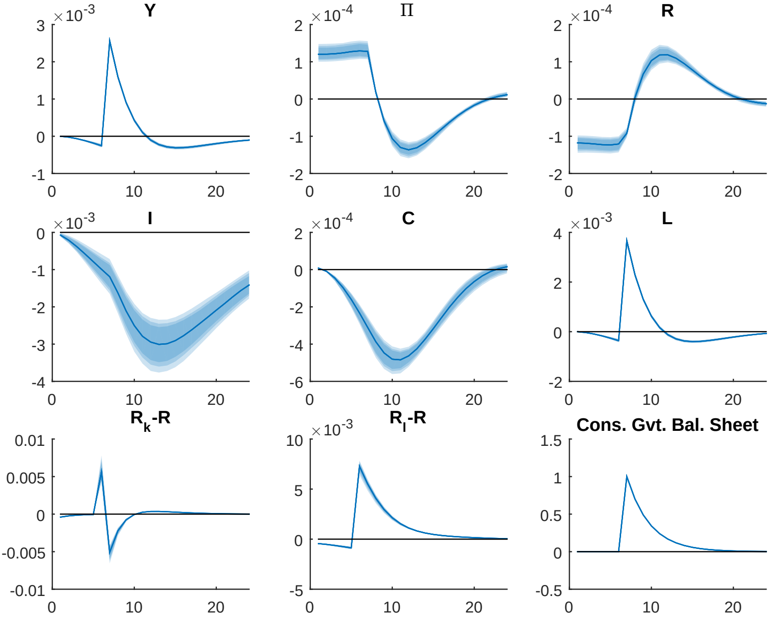
Coefficient	Prior Distr.	Moments				Post. 5 & 95 %-iles	
		Mean		Std. Dev.			
		Prior	Posterior	Prior	Posterior		
β	beta	0.998	0.9983	0.0001	0	0.9982	0.9984
σ	gamma	1.4	1.2033	0.1	0.0256	1.1045	1.3189
h	beta	0.6	0.7596	0.1	0.0145	0.6964	0.8291
γ_π	gamma	1.05	1.0498	1	0.0003	1.0489	1.0506
γ_r	beta	0.85	0.9907	0.1	0.0046	0.9824	0.9993
δ	beta	0.0083	0.0046	1	0.0003	0.0041	0.0051
χ_I	gamma	300	22.6996	50	6.271	15.3882	30.206
ϵ_p	gamma	11	18.0415	3	0.8429	15.6269	21.1517
χ_p	gamma	300	207.9347	50	14.4191	174.2384	241.5763
φ	gamma	2.5	2.2421	0.5	0.1569	1.7655	2.8144
τ_p	beta	0.0033	0.0034	0.0001	0	0.0032	0.0035
f	gamma	1	1.0456	1	0.0347	0.9701	1.1417
$R_k - R$	beta	0.005	0.0088	1	0.0002	0.0083	0.0093
$R_a - R$	beta	0.0025	0.0018	0.0005	0.0001	0.0013	0.0024
ϕ^w	gamma	10	10.0064	1	0.2868	8.8911	11.305

Coefficient	Prior Distr.	Moments				Post. 5 & 95 %-iles	
		Mean		Variance			
		Prior	Posterior	Prior	Posterior		
ρ_a	Beta	0.9	0.965	0.05	0.0067	0.9556	0.9749
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

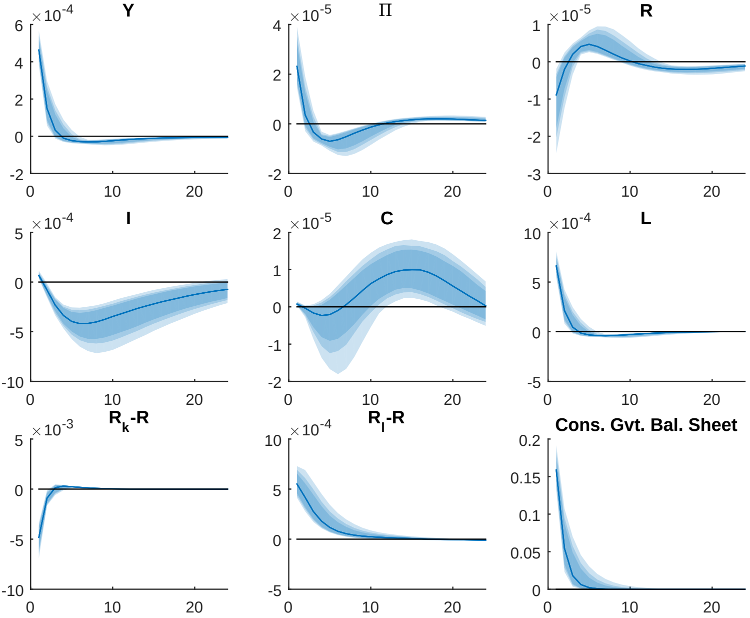
Responses to announced gvt. bond purchases B_t^{ag}



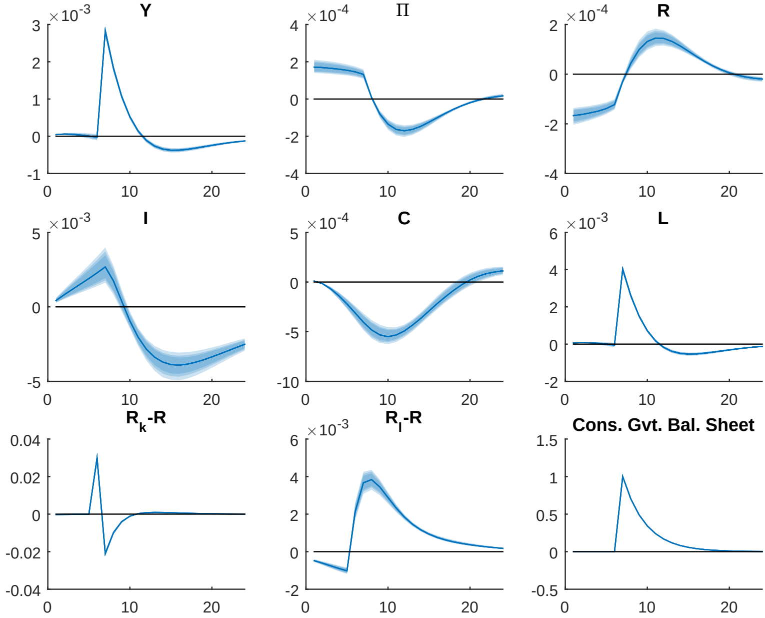
Responses to announced fin. asset purch.s A_t^{ag}



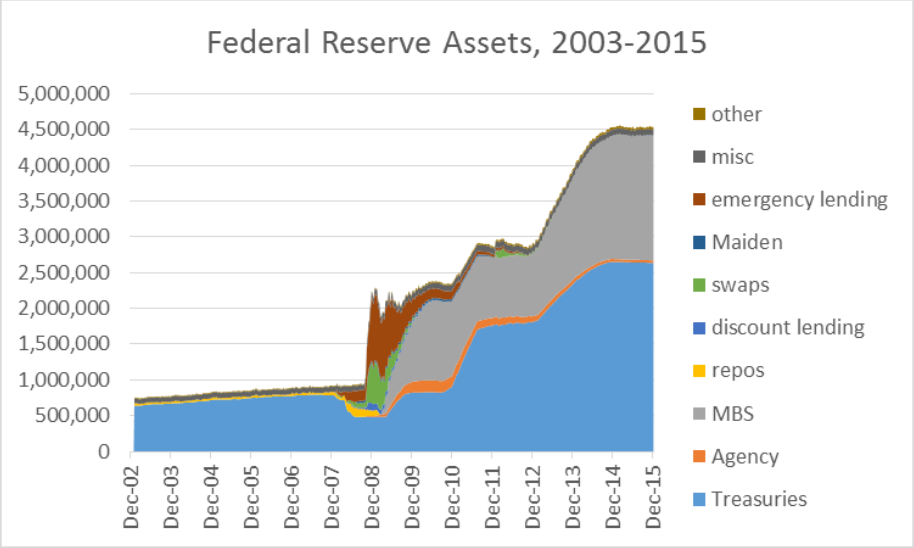
Responses to direct intermediation S_t^g



Responses to announced direct intermed. S_t^{ag}



US: Fed Balance Sheet



ECB Asset purchasing programmes I

- Covered Bond Purchase Programmes (1 to 3):
  From 2009-10, ECB bought 60 billion Euro worth of covered bonds over one year. From 2011-12, ECB bought 40 billion Euro worth of covered bonds in second CBPP. Since Oct. 2014, third programme, scheduled for two years. Covered bonds are very safe, as they have preferential rights in case issuer becomes insolvent. Stated goal: to bring inflation closer to 2%.
- Securities Markets Programme:
  From May 2010 to Sept. 2012, ECB undertook interventions in the public and private debt securities markets to ensure depth and liquidity in those markets

ECB Asset purchasing programmes II

- Asset-Backed Securities Purchase Programme:
  Since November 2014, ECB buys ABSs on primary and secondary markets, to bring inflation closer to 2%.
- Public Sector Purchase Programme:
  Established in January 2015, ECB buys 60 billion Euro worth of bonds issued by EA central governments, agencies and European institutions.
- Expanded Asset Purchase Programme:
  Common denomination for CBPP3, ABSPP and PSPP. Initiated to address the risks of a too prolonged period of low inflation. Purchases of €80 billion (from March 2015 to March 2016: €60 billion).

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