Quantitative Easing and Quantitative Tightening: The Money Channel

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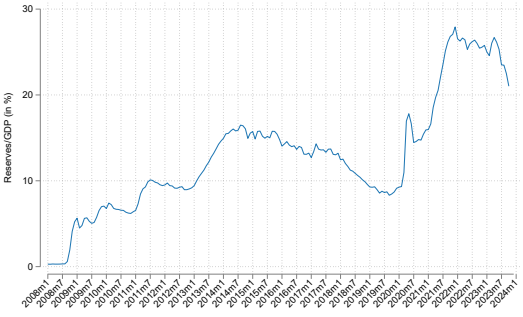
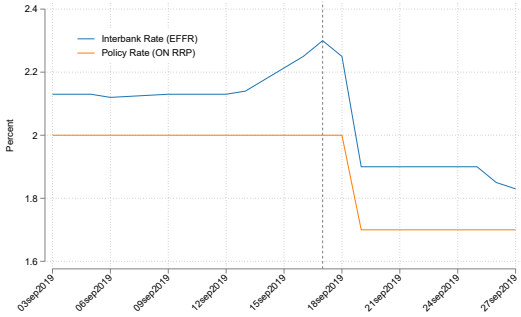
"Unconventional" B/S Policies and Financial (In)stability

⇒ Difficult to disentangle mechanisms of new tools and traditional rate tools.
⇒ Important once CBs start reducing their balance sheets.



(a) US reserves evolution since 2008



(b) September 2019 liquidity shortage

Theoretical Model as "Laboratory" for B/S Policies

$\Rightarrow$ We study how QE and QT policies transmit to the real economy via the financial system in an advanced economy with abundant liquidity.

We build a medium-scale dynamic structural NK model with a fully specified real sector and a very detailed financial sector:

- Emphasis on the liability side of CB balance sheet
- QE/QT policies transmission through the reserve and interbank markets

- On-balance sheet reserves are essential to buffer against liquidity shocks
- Reserves are not liquid assets held by HHs, but rather banks' settlement assets

Preview of Results

$\Rightarrow$ **Steady State effects of the quantity of reserves:**

- Heterogeneous effects across bank groups
- Permanent QT has non-trivial negative effects on real activity
- **Non-linear effects** on equilibrium real rates

Preview of Results

⇒ **Steady State effects of the quantity of reserves:**

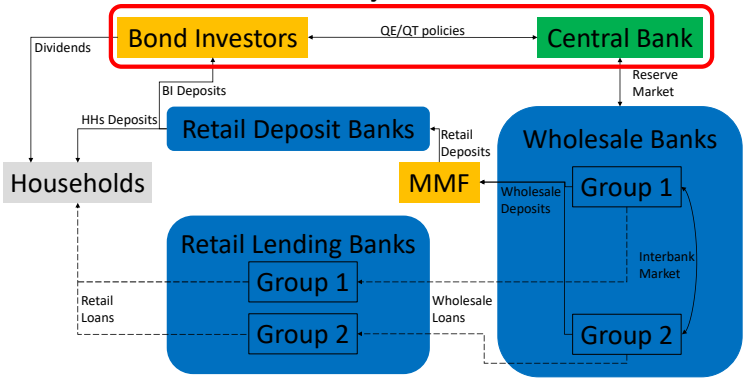
- Heterogeneous effects across bank groups
- Permanent QT has non-trivial negative effects on real activity
- **Non-linear effects** on equilibrium real rates

⇒ **Dynamic effects:**

- **Net deposit withdrawals** have highly asymmetric effects and thus, aggregate financial and real effects
- **Countercyclical reserve rules,** responding to wider interbank spreads, can have sizable welfare benefits

Bird's-Eye View of the Model's Financial System

We build a **medium-scale NK model** with a fully specified real sector and a very **detailed financial sector:**



- QT (QE) as central bank sales (purchases) of bonds to (from) Bond Investors
- Ex-ante heterogeneous banks interact with the CB through the reserves market, with each other through reserves and interbank markets
- Banks do not face financing risks, only refinancing risks
- HHs face a deposits-in-advance constraint for purchases of consumption and investment goods using deposits

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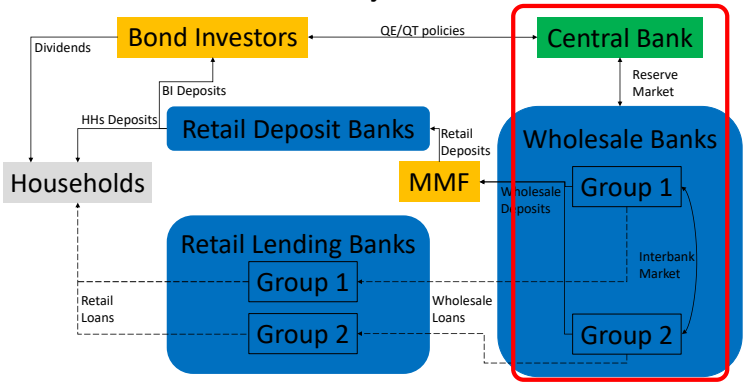

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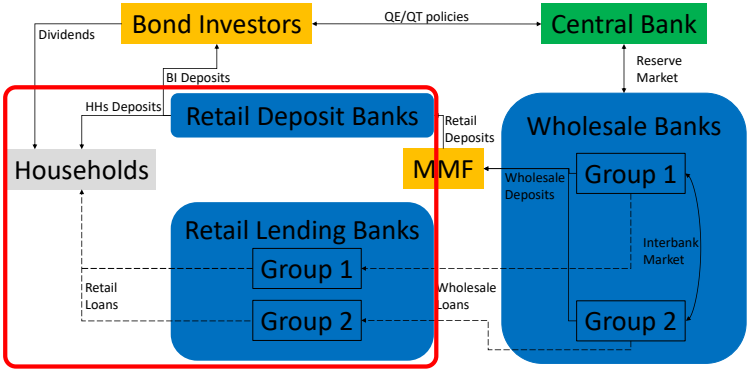

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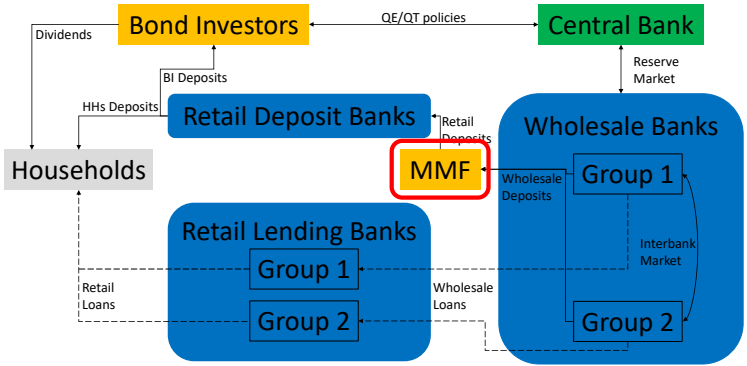


- Bond Investors (BIs) **hold and arbitrage a portfolio of government bonds and wholesale deposits**
- Bonds have a positive convenience yield relative to deposits

- Money Market Funds (MMFs) **buy wholesale deposit liabilities** from wholesale banks
- Their **customers are retail deposit banks**, who demand a CES aggregate

Wholesale Banks

Two groups that have identical st. st. net worth ($N^b_{bi,t}$) and loans ($L_{bi,t}$) but differ in their deposit ($D_{bi,t}$) and reserve ($M_{bi,t}$) holdings, with $i \in (1, 2)$.

Balance sheets:

- Group 1: $L_{b1,t} + M_{b1,t} + O_{b1,t} = D_{b1,t} + N_{b1,t}$
- Group 2: $L_{b2,t} + M_{b2,t} = O_{b2,t} + D_{b2,t} + N_{b2,t}$

$\Rightarrow$ Banks optimize over gross, not net, asset and liability positions.

Frictions:

- Reserve scarcity cost (RSC): increasing in the ratio of deposits to reserves.
- Min. capital adequacy rules (MCAR): increasing in ratio of loans to net worth.
- Large exposure limit costs (LELC): increasing in the ratio of interbank loans ($O_{b1,t}$) to net worth.

Wholesale Banks Group 1 FOCs

Reserves FOC (st.st. spread equal to 12bps):

$$\mathbb{E}_t r_{w,b1,t+1} = \mathbb{E}_t(r_{t+1} + RSC^m_{b1,t}) \tag{1}$$

Interbank loans FOC (st.st. spread equal to 22bps):

$$\begin{aligned}\mathbb{E}_t r_{o,t+1} = \mathbb{E}_t(r_{w,b1,t+1} + RSC^o_{b1,t} + MCAR^o_{b1,t} + LELC^o_{b1,t} + \dots \\ + RSC^o_{b1,t} MCAR^o_{b1,t} + MCAR^o_{b1,t} LELC^o_{b1,t} + RSC^o_{b1,t} MCAR^o_{b1,t} LELC^o_{b1,t})\end{aligned} \tag{2}$$

Household loans FOC (st.st. spread equal to 46bps):

$$\begin{aligned}\mathbb{E}_t r_{\ell,b1,t+1} = \mathbb{E}_t(r_{w,b1,t+1} + RSC^\ell_{b1,t} + MCAR^\ell_{b1,t} + LELC^\ell_{b1,t} + \dots \\ + RSC^\ell_{b1,t} MCAR^\ell_{b1,t} + MCAR^\ell_{b1,t} LELC^\ell_{b1,t} + RSC^\ell_{b1,t} MCAR^\ell_{b1,t} LELC^\ell_{b1,t})\end{aligned} \tag{3}$$

Details

Households

HHs choose consumption $c_t(j)$, hours $h_t(j)$, investment $I_t(j)$, capital $k_t(j)$, retail loans $L_{b1,t}(j)$ and $L_{b2,t}(j)$, and retail deposits $D_t^{hh}(j)$ to maximize lifetime utility

$$Max \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{hh}^t \left\{ (1-\frac{\nu}{x}) S_t^c \log(c_t(j) - \nu c_{t-1}) - \psi \frac{h_t(j)^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \right\}, \tag{4}$$

s.t. sequences of intertemporal budget, bank participation, and deposits-in-advance constraints:

$$\varkappa D_t^{hh}(j) \geq 4 S_t^{mon} P_t(c_t(j) + I_t(j)) \,. \tag{5}$$

Households' simplified nominal flow budget constraint

Gross Deposits

Gross Loans

The representative HH's nominal flow budget constraint is

$$D_t^{hh}(j) - \sum_{i=b1}^{b2} L_{i,t}(j) = i_{d,t-1} D_{t-1}^{hh}(j) - \sum_{i=b1}^{b2} i_{\ell,i,t-1} L_{i,t-1}(j) + \text{income}_t - \text{spending}_t$$

Like banks, households optimize over gross, not net, asset and liability positions.

Gross positions are independent of net positions = saving

Central Bank and Government

$\Rightarrow$ **Conventional MP** captured by an interest rate rule on central bank reserves i_t:

$$i_t = \left(i_{t-1}\right)^{i_i \bar{i}^{(1-i_i)}} \mathbb{E}_t \left(\pi^p_{t+1} / \bar{\pi}\right)^{(1-i_i) i_\pi} S^{int}_t. \tag{6}$$

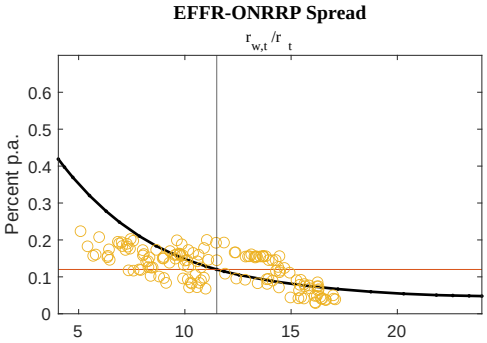
$\Rightarrow$ CB supplies reserves to banks $m^{rat}_t = \left(\check{m}_t / \left(4 * g\check{d}p_t\right)\right)$ and follows a **(countercyclical) reserve rule:**

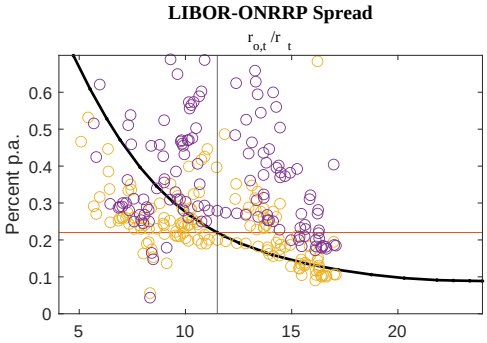
$$\check{m}^{rat}_t = \bar{m}^{rat} \left[\left(i_{o,t} / i_t\right) / \left(\bar{i}_{o,t} / \bar{i}_t\right)\right]^{-4 m_o} S^r_t. \tag{7}$$

$\Rightarrow$ **CB balance sheet:** $\check{b}^{cb}_t = \check{m}_t$.

Calibration

Calibrated to match US data averages between 2008-2019.
For example, financial sector parameters chosen to **match empirically observed demand functions for reserves** and interbank loans.

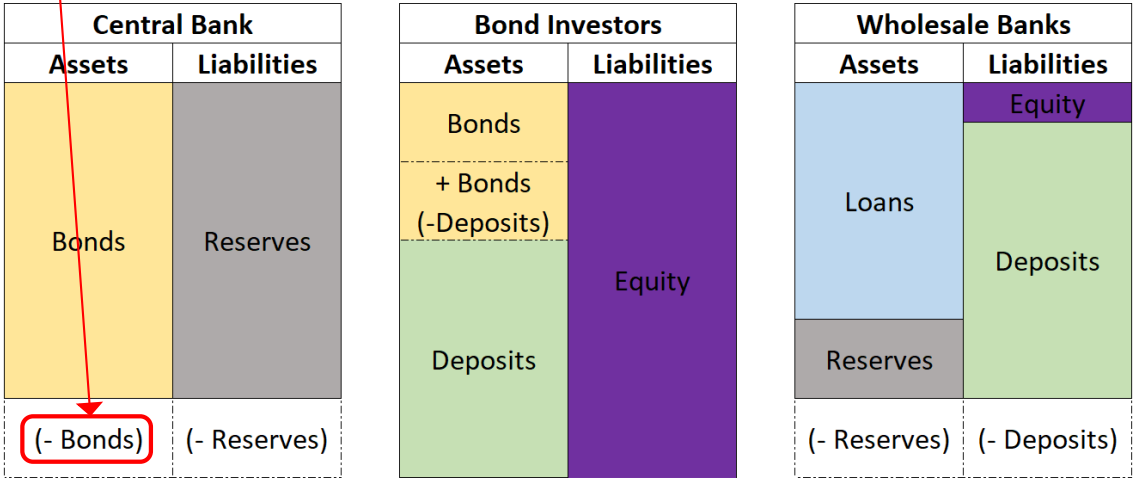




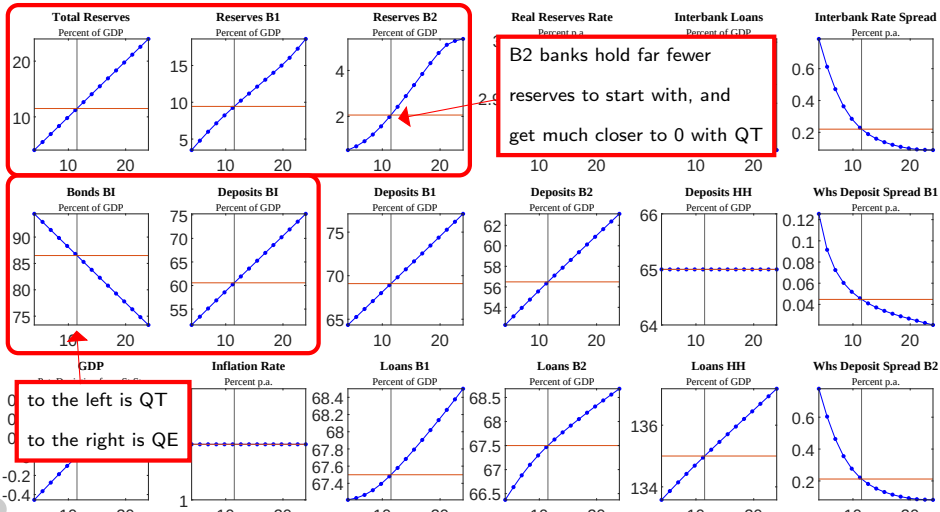
X-axis: Reserves/GDP in percent. Black line = model fit, circles = monthly data (orange: 1-month; violet: 3-month LIBOR)

QT Transmission Mechanism

Bonds are exchanged against deposits, which are then cleared against reserves



Steady State Effects of QT (and QE)



B | B&M | B fix M

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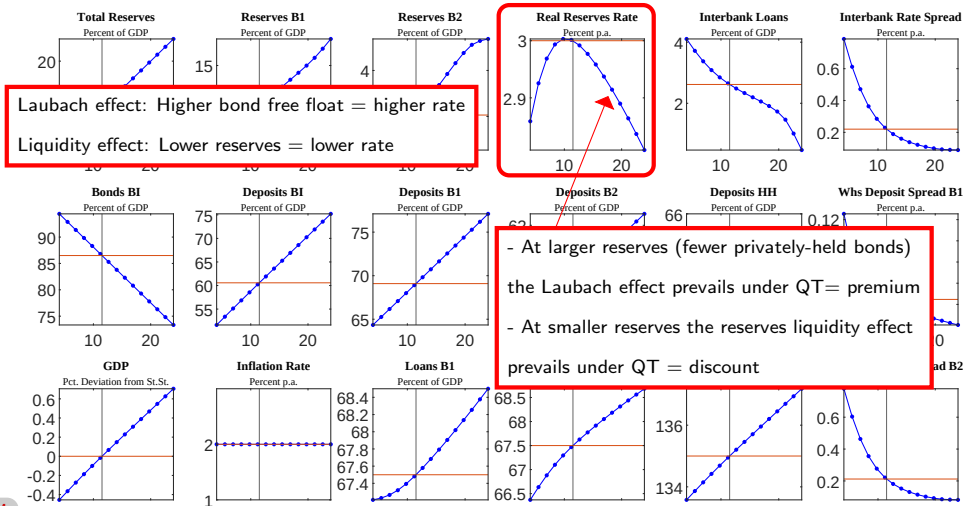

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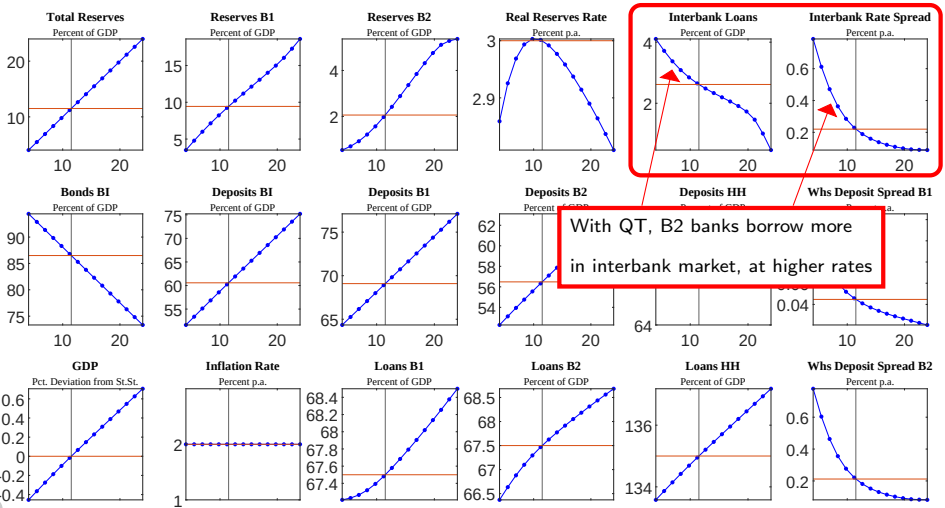

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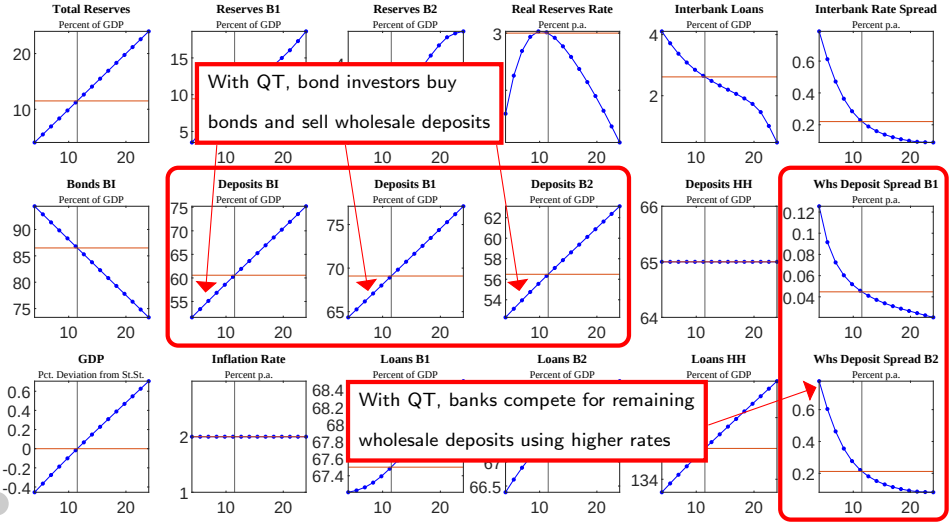

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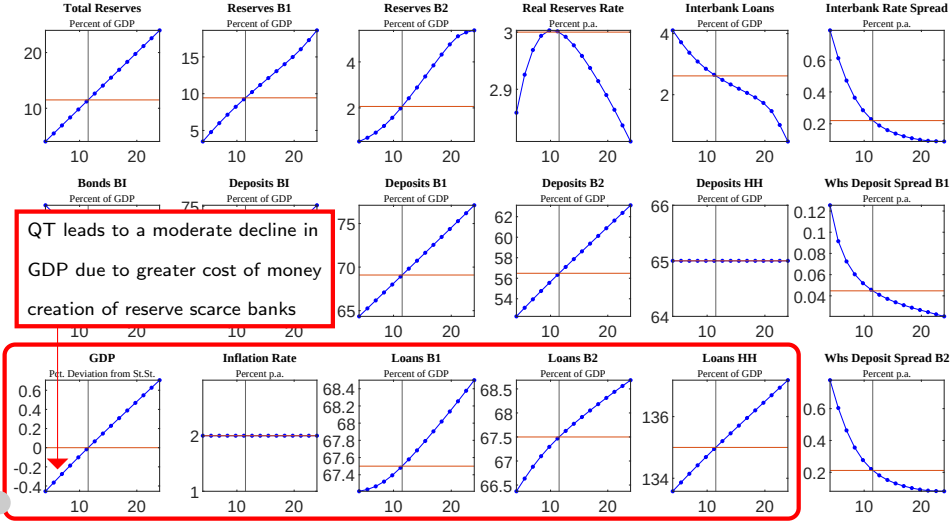
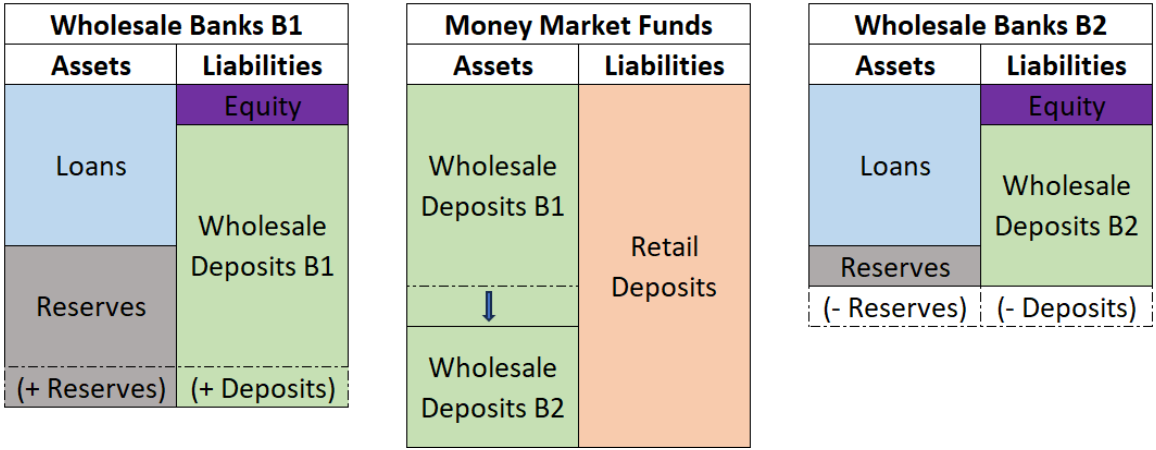


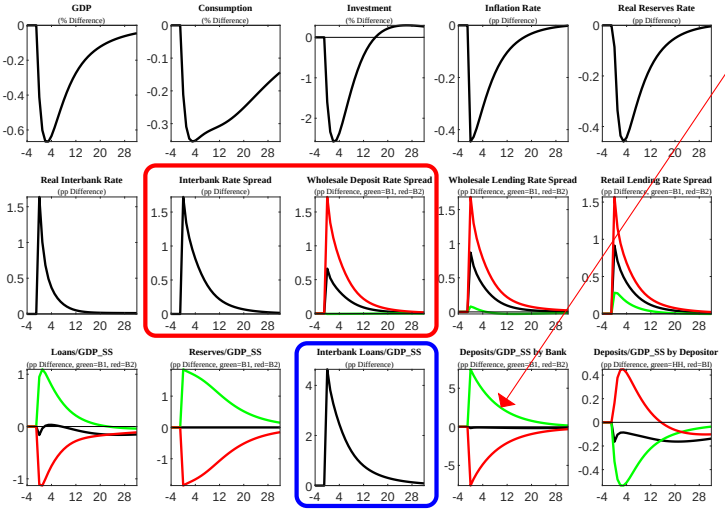
QT leads to a moderate decline in GDP due to greater cost of money creation of reserve scarce banks

B | B&M | B fix M

Net Deposit Withdrawals Transmission Mechanism

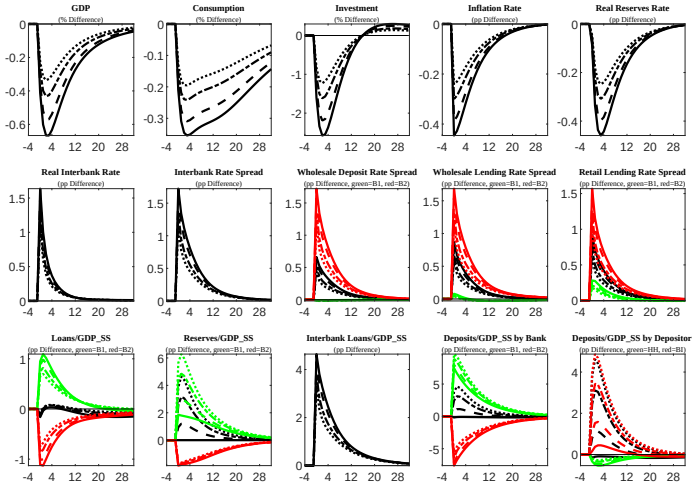


Dynamic Responses to a Net Deposit Withdrawal Shock



- Large deposit withdrawal shock from B2 to B1 banks
- While B1 rates are almost unaffected, B2 banks increase their deposit and interbank rates by 170bps
- B2 banks are able to refinance deposit losses of 4.5% of GDP in the interbank market
- Deposit rate increases are passed on to retail lending rates
- B2 banks lend significantly less
- As a result of much costlier liquidity creation, GDP drops by 0.65% and inflation by 45 bps

Countercyclical Reserve Rules Provide Welfare Gains

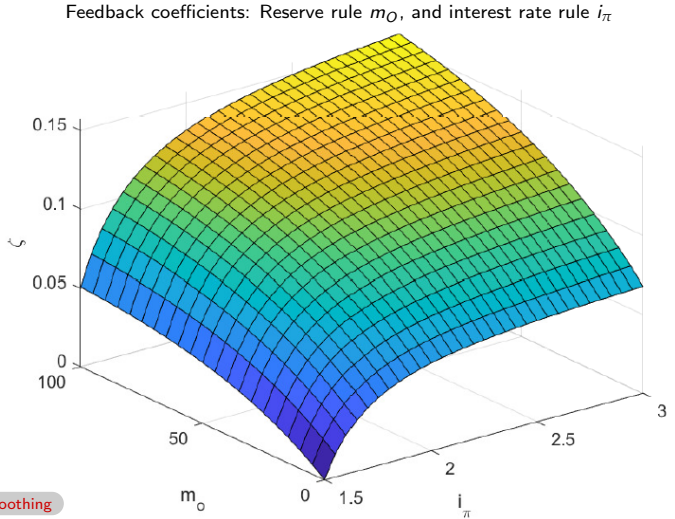


Solid line: m0 = 0, Dashed/Dash-dotted/Dotted lines: m0 = 10/30/50

- So far the overall level of reserves is kept constant
- Now the **central bank injects additional reserves when the interbank spread increases**
- The drops in GDP and inflation are halved in size

⇒ A CB policy that prevents shortages of reserves during banking sector distress can therefore have significant real economic benefits as helps to smooth wholesale deposit rates, and thereby lending rates, credit creation, and money creation

Welfare Gains from Countercyclical Reserve Rule



- Second-order approximation of both welfare and the equilibrium equations of the model over a grid of policy rule parameterizations
- Overall welfare gain, relative to the baseline, equals a 0.16% compensating consumption variation

Conclusion

⇒ Model characterization:

- Model embeds full financial sector with role for reserves in a General Equilibrium New-Keynesian model
- Reserves are used for settlement among banks, not for payment among households

⇒ Model results:

- Sizeable QT increases interbank spreads and lending rates and reduces output
- Equilibrium policy rates are lower with QT because of liquidity discount
- Deposit withdrawal shocks are highly asymmetric and cause reserve scarce banks to contract lending
- Asymmetric lending shock of same size has smaller effects as banks keep many of their new deposits
- Countercyclical reserve injections have sizable welfare benefits

Comments welcome!

Appendix

Wholesale banks FOCs in detail

Back

Reserves FOC:

$$\mathbb{E}_t r_{w,b1,t+1} = \mathbb{E}_t \left(r_{t+1} + v\left(\frac{\check{d}_{b1,t}}{\check{m}_{b1,t}}\right)^{\eth} \frac{\check{\ell}_{b1,t}\check{n}_{b1,t} + \check{o}_{b1,t}\check{n}_{b1,t} - \check{n}^2_{b1,t}}{\check{m}^2_{b1,t}} \right). \tag{8}$$

Household loans FOC:

$$\mathbb{E}_t r_{\ell,b1,t+1} = \mathbb{E}_t \left[r_{w,b1,t+1} + v\left(\frac{\check{d}_{b1,t}}{\check{m}_{b1,t}}\right)^{\eth} \frac{\check{n}_{b1,t}}{\check{m}_{b1,t}} \left(1 + \frac{\chi_{b1,\ell} f^b_{b1,t+1}}{(1-\gamma_\ell) r_{\ell,b1,t+1}} \left(1 + \mathfrak{r} \frac{\check{o}_{b1,t}}{\check{\ell}_{b1,t}} \right) \right) \right] \tag{9}$$

$$+ \mathbb{E}_t \chi_{b1,\ell} \left(F^b_{b1,t+1} + f^b_{b1,t+1} \left(1 + \mathfrak{r} \frac{\check{o}_{b1,t}}{\check{\ell}_{b1,t}} \right) \left(\frac{r_{a,b1,t+1}\check{n}_{b1,t}}{(1-\gamma_\ell) r_{\ell,b1,t+1}\check{\ell}_{b1,t}} \right) \right),$$

with

$$r_{a,b1,t+1}\check{n}_{b1,t} = r_{w,b1,t+1}\check{n}_{b1,t} + \check{\Pi}^R_{b1,t+1} x + (r_{t+1} - r_{w,b1,t+1})\check{m}_{b1,t} + (r_{o,t+1}(1-\gamma_\ell \mathfrak{r}) - r_{w,b1,t+1})\check{o}_{b1,t} - \check{G}_{M,b1,t}.$$

Wholesale banks FOCs in detail (cont.) Back

Interbank loans FOC:

$$\mathbb{E}_t r_{o,t+1} = \mathbb{E}_t \left(r_{w,b1,t+1} + \upsilon \left(\frac{\check{d}_{b1,t}}{\check{m}_{b1,t}} \right)^{\eth} \left(\frac{\check{n}_{b1,t}}{\check{m}_{b1,t}} \right) \right) / \left(1 - \gamma_\ell \mathfrak{r} + \frac{\gamma_\ell \mathfrak{r}}{\mathfrak{f}_t} \right) \tag{10}$$

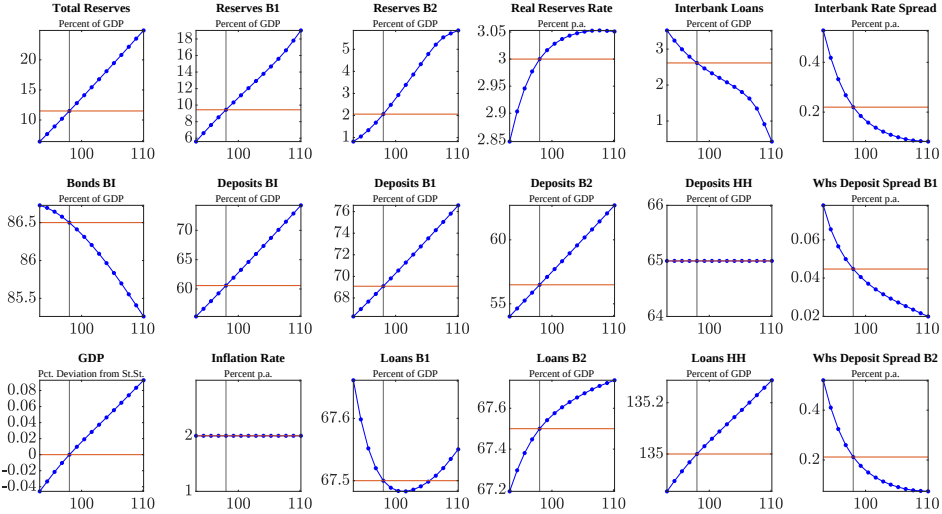
$$+\mathbb{E}_t \left(\chi_{b1,\ell} \mathfrak{r} F^b_{t+1} + \chi_o \left(\frac{\check{o}_{b1,t}}{\check{n}_{b1,t}} \right)^{\varpi} \left(F^o_{t+1} + f^o_{t+1} \frac{1}{(1+\varpi)\gamma_o} \frac{\check{o}_{b1,t}}{\check{n}_{b1,t}} \right) \right) / \left(\left(1 - \gamma_\ell \mathfrak{r} + \frac{\gamma_\ell \mathfrak{r}}{\mathfrak{f}_t} \right) \mathfrak{f}_t \right),$$

with

$$\mathfrak{f}_t = \left(1 + \frac{\chi_{b1,\ell} f^b_{b1,t+1}}{(1-\gamma_\ell) r_{\ell,b1,t+1}} \left(1 + \mathfrak{r} \frac{\check{o}_{b1,t}}{\check{\ell}_{b1,t}} \right) \right).$$

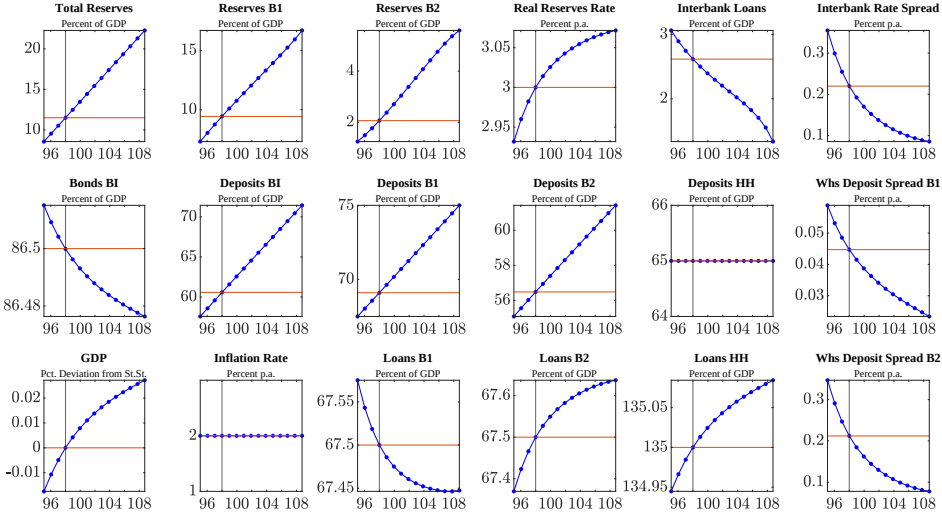
Steady State effects of Bonds

back



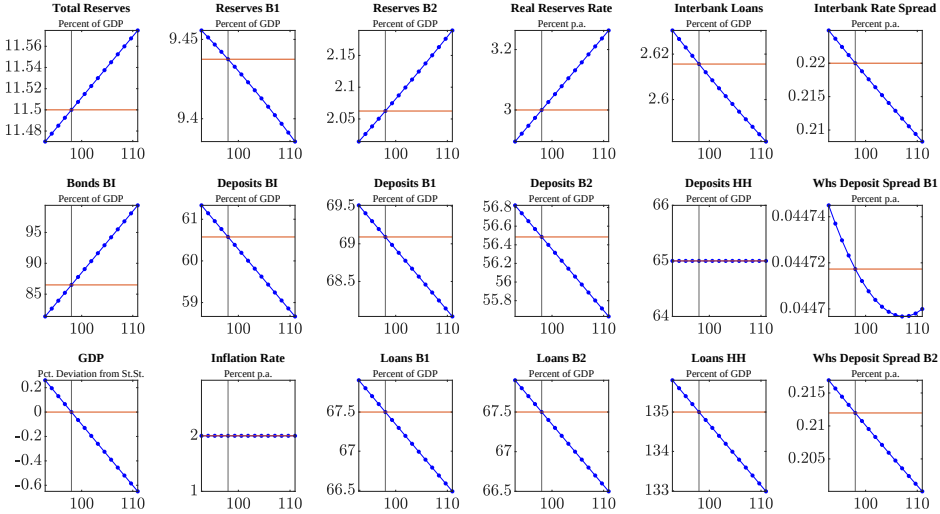
Steady State effects of Bonds (fix BI bonds)

back



Steady State effects of Bonds (fix M)

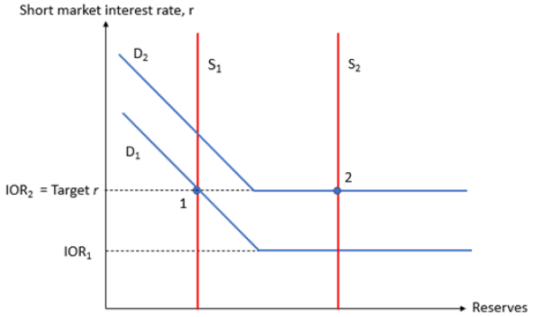
back



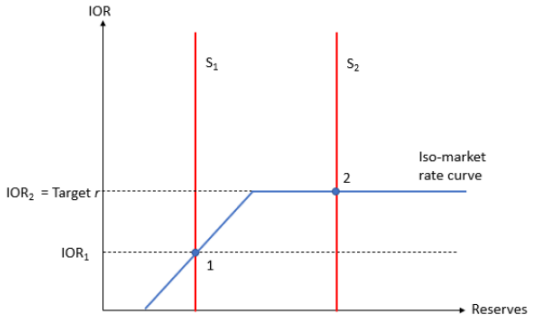
Iso-Market Rate Curve a la Vissing-Jorgensen (2023)

Schedule with "all possible combinations of reserve supply and the interest rate on reserves which achieve the same [interbank] target."

Reserve demand and supply



Iso-market rate curve for short rate



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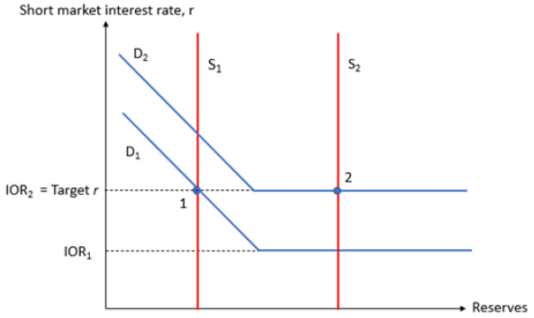
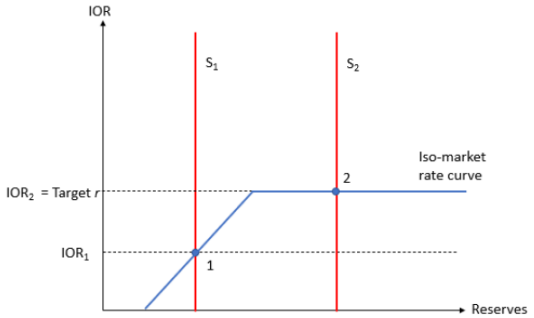
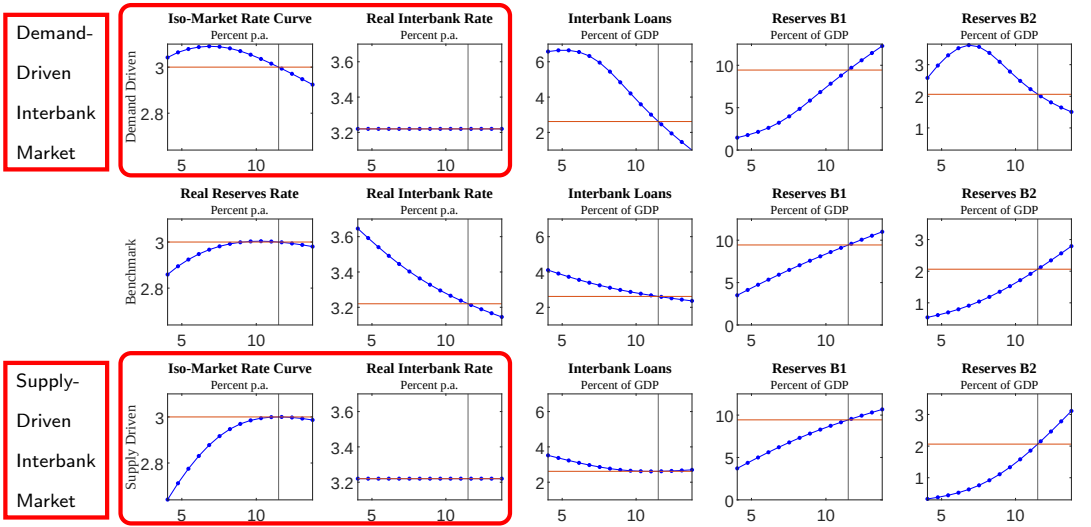


Iso-market rate curve for short rate



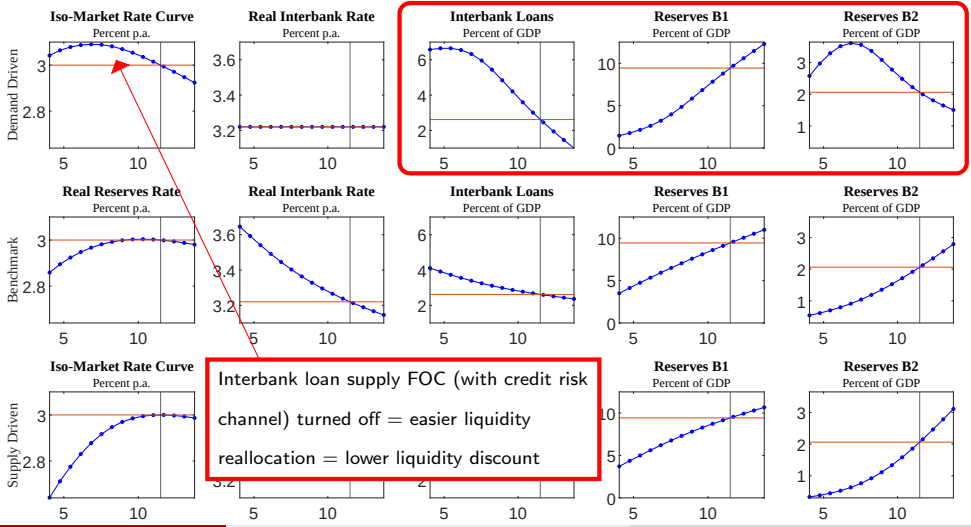
⇒ **Same policy stance with different combinations of IOR and B/S size**

Steady State Iso-Market Rate Curve

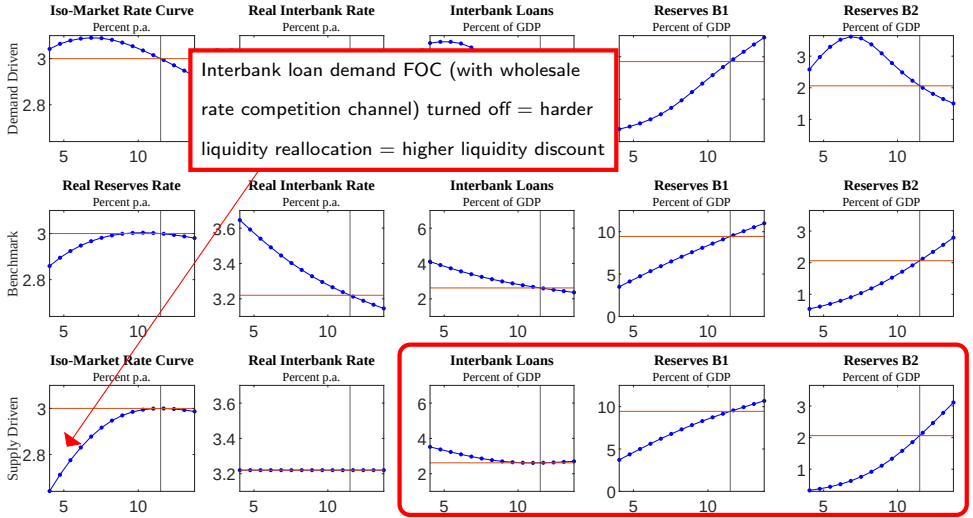


Steady State Iso-Market Rate Curve

Demand-Driven Interbank Market

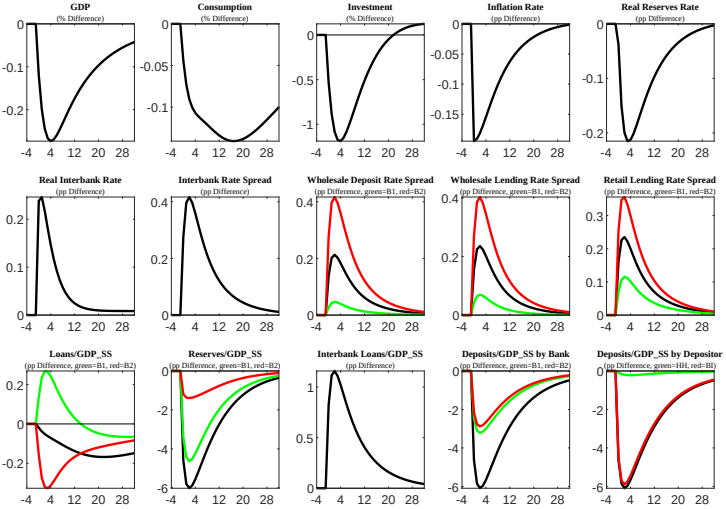


Steady State Iso-Market Rate Curve



Supply-Driven Interbank Market

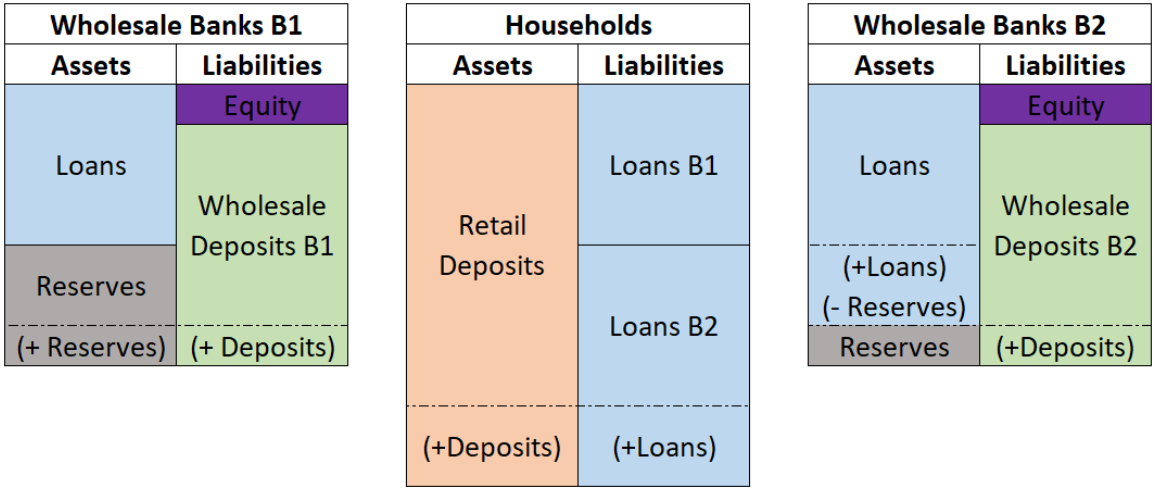
Dynamic Responses to a Transitory QT Shock



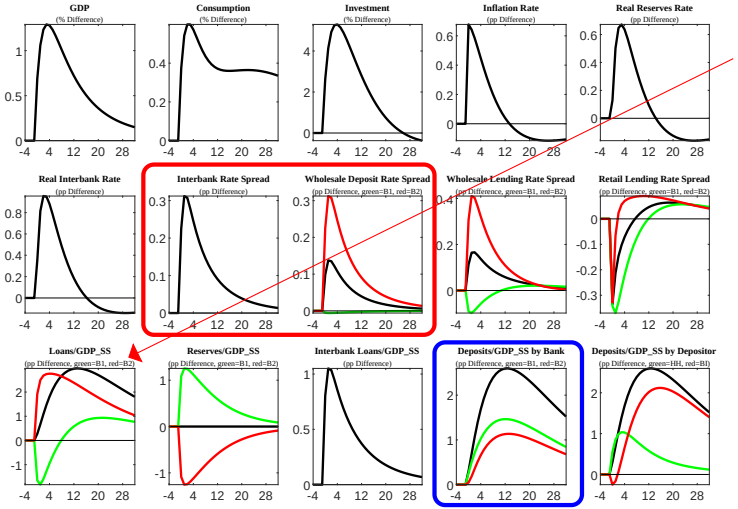
- Temporary QT shock reducing the quantity of reserves from 11.5% of GDP to 5.5%
- B1 banks absorb most of the reserve loss, but B2 banks experience the strongest effects
- Interbank activity increases with a rise in interbank rate and spread
- The effect of the rise in funding costs is a 0.30% drop in GDP and 20bps drop in inflation

$\Rightarrow$ QT affects real activity, and affect banks that have weak deposit bases disproportionately

Asymmetric Lending Boom Mechanism



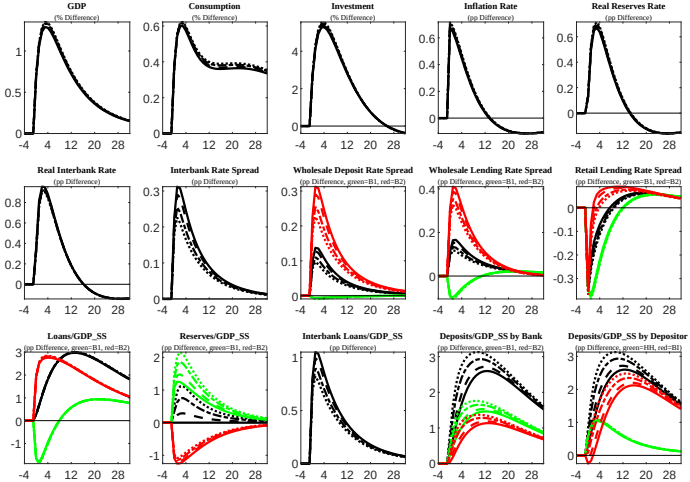
Dynamic Responses to an Asymmetric Lending Boom Shock



- Reserve-scarce B2 banks significantly increase their willingness to lend while B1 banks do not.
- B2 banks retain less than half of the deposits that they create by lending.
- The increase in funding costs in the interbank and wholesale deposit markets partly offsets B2 greater willingness to lend.

$\Rightarrow$ Overall this shock is however expansionary, with GDP increasing by 1.25% and inflation by 70 basis points.

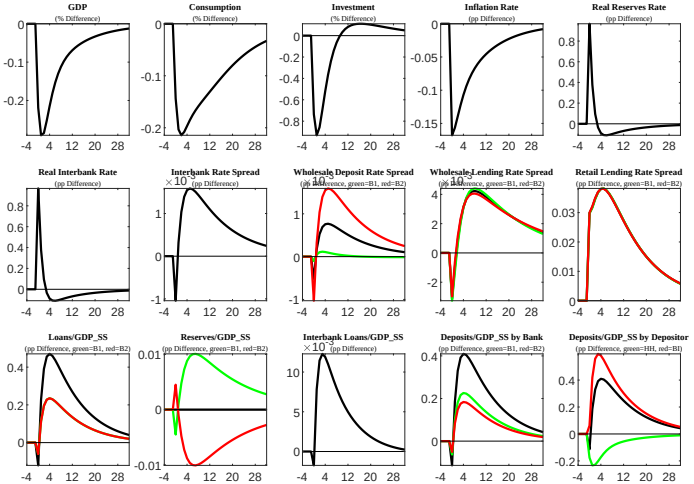
Countercyclical Reserve Rules Provide Minor Welfare Gains



Solid line: m0 = 0, Dashed/Dash-dotted/Dotted lines: m0 = 10/30/50

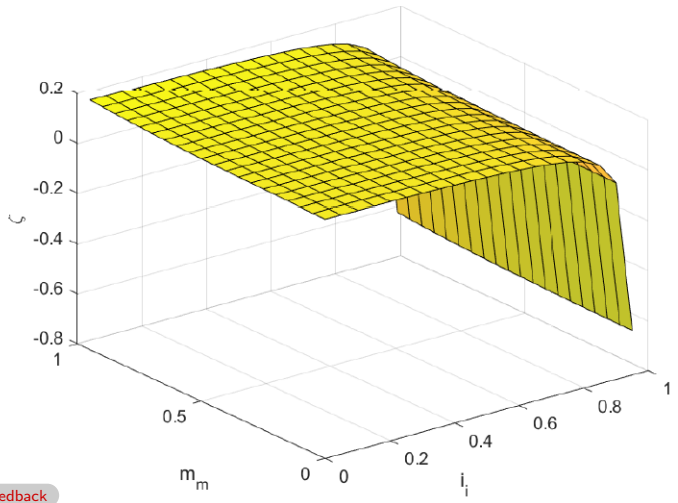
- The effects are qualitatively similar to, but quantitatively smaller than for net withdrawal shocks because the increase in the interbank rate spread is much smaller, and therefore triggers a more modest reserve injection.

Dynamic responses to a transitory MP shock



- IRFs to a 100 basis points shock to the interest rate reaction function.
- There are almost no significant effects through the interbank market, while the effects on inflation and real variables are standard.

Welfare gains from countercyclical reserve rule



Feedback