

# Quantitative Easing and Quantitative Tightening: The Money Channel

Michael Kumhof<sup>1</sup> and Mauricio Salgado-Moreno<sup>1</sup>

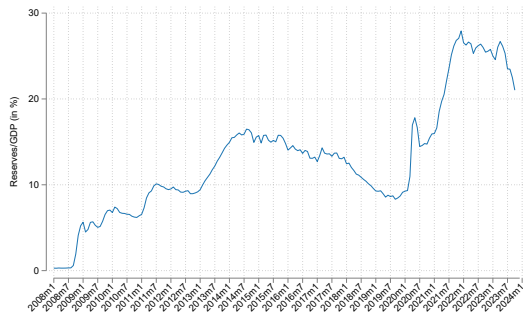
<sup>1</sup>Bank of England

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San Francisco, January 4th, 2025

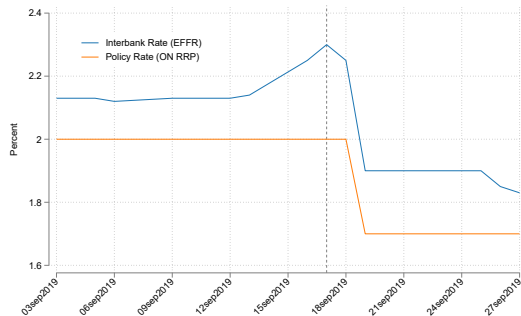
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# “Unconventional” B/S Policies and Financial (In)stability

- ⇒ 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

⇒ **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
- Financial stability considerations given banks' heterogeneous liquidity holdings
- Banks face capital, liquidity and interbank exposure frictions
- 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

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

- Heterogeneous effects across bank groups
- Reserves-scarce banks are affected far more severely
- Permanent QT has non-trivial negative effects on real activity
- Shape of Iso-market Rate Curve depends on distribution of reserves and on the interbank market structure
- **Non-linear effects** on equilibrium real rates

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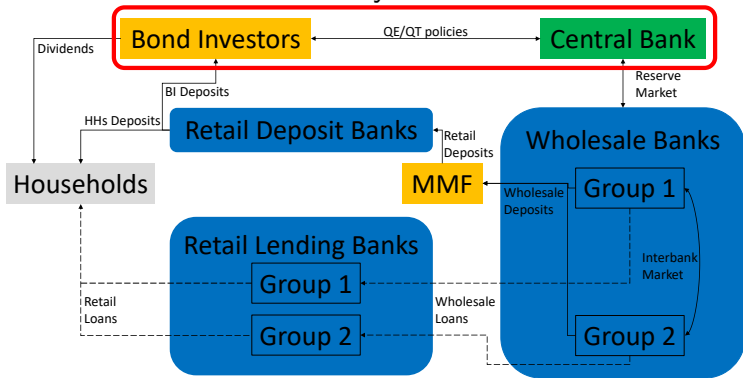
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## ⇒ **Dynamic effects:**

- **QT shock** decreases GDP as reserve scarcity increases lending rates, especially for scarce-reserves banks
- **Net deposit withdrawals** have highly asymmetric effects and thus, aggregate financial and real effects
- **Asymmetric lending booms** of same size have smaller effects, as banks retain the majority of their deposits
- **Countercyclical reserve rules**, responding to wider interbank spreads, can have sizable welfare benefits

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

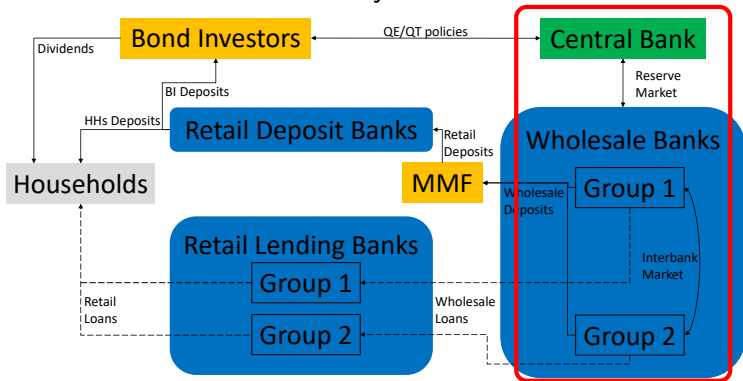
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- QT (QE) as central bank sales (purchases) of bonds to (from) Bond Investors
- Ex-ante heterogeneous banks interact with the CB through the reserves market, with each other through reserves and interbank markets
- Banks do not face financing risks,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

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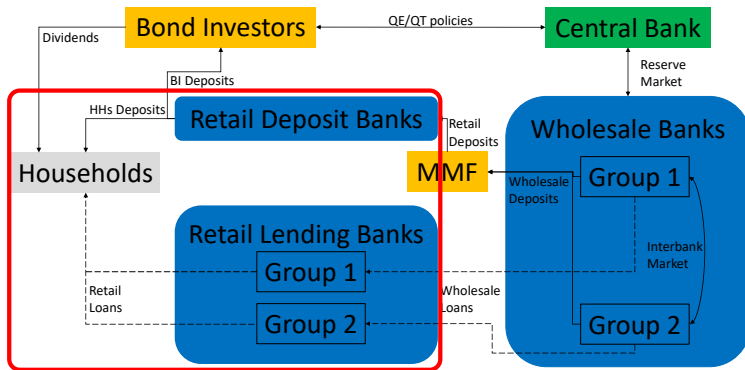
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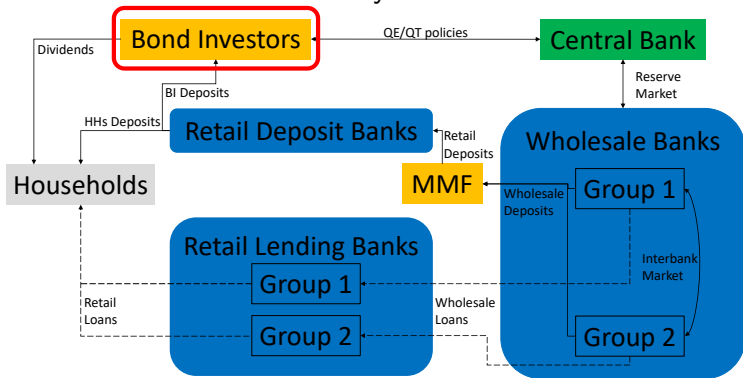


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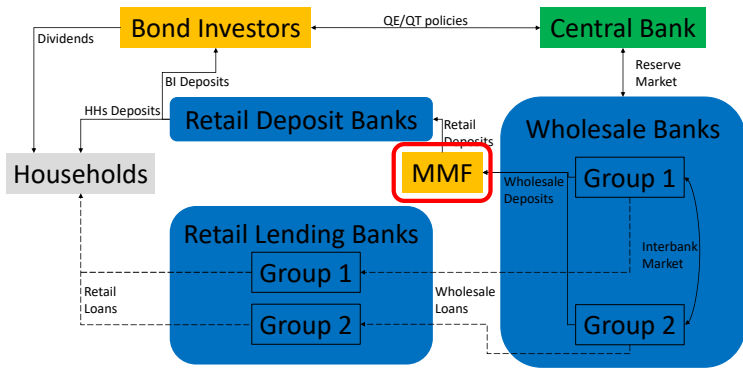
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- Bond Investors (BIs) **hold and arbitrage a portfolio of government bonds and wholesale deposits**
- Bonds have a positive convenience yield relative to deposits
- Money Market Funds (MMFs) **buy wholesale deposit liabilities** from wholesale banks
- Their **customers are retail deposit banks**, who demand a CES aggregate

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# Wholesale Banks

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

**Reserve scarcity cost (RSC):** increasing in the ratio of deposits to reserves.

**Minimum 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.

## Balance sheets:

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

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

# Wholesale Banks Group 1 FOCs

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

$$\mathbb{E}_t r_{w,b1,t+1} = \mathbb{E}_t (r_{t+1} + \textcolor{red}{RSC}_{b1,t}^m) \quad (1)$$

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

$$\begin{aligned} \mathbb{E}_t r_{o,t+1} = \mathbb{E}_t (&r_{w,b1,t+1} + \textcolor{red}{RSC}_{b1,t}^o + \textcolor{blue}{MCAR}_{b1,t}^o + \textcolor{brown}{LELC}_{b1,t}^o + \dots \\ &+ \textcolor{red}{RSC}_{b1,t}^o \textcolor{blue}{MCAR}_{b1,t}^o + \textcolor{blue}{MCAR}_{b1,t}^o \textcolor{brown}{LELC}_{b1,t}^o + \textcolor{red}{RSC}_{b1,t}^o \textcolor{blue}{MCAR}_{b1,t}^o \textcolor{brown}{LELC}_{b1,t}^o) \end{aligned} \quad (2)$$

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

$$\begin{aligned} \mathbb{E}_t r_{\ell,b1,t+1} = \mathbb{E}_t (&r_{w,b1,t+1} + \textcolor{red}{RSC}_{b1,t}^\ell + \textcolor{blue}{MCAR}_{b1,t}^\ell + \textcolor{brown}{LELC}_{b1,t}^\ell + \dots \\ &+ \textcolor{red}{RSC}_{b1,t}^\ell \textcolor{blue}{MCAR}_{b1,t}^\ell + \textcolor{blue}{MCAR}_{b1,t}^\ell \textcolor{brown}{LELC}_{b1,t}^\ell + \textcolor{red}{RSC}_{b1,t}^\ell \textcolor{blue}{MCAR}_{b1,t}^\ell \textcolor{brown}{LELC}_{b1,t}^\ell) \end{aligned} \quad (3)$$

# 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

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

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

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

To obtain deposits, HHs need to obtain bank loans subject to small nonzero real adjustment costs  $G_{L,i,t}(j) = \ell_{i,t}(j) \frac{\phi_\ell}{2} \left( \check{\ell}_{i,t}(j) - \check{\ell}_{i,t-1} \right)^2$ ,  $i \in (b1, b2)$

# Households' simplified nominal flow budget constraint

The representative HH's nominal flow budget constraint is

$$D_t^{hh}(j) - \sum_{i=b1}^{b2} L_{i,t}(j) = i_{d,t-1} D_{t-1}^{hh}(j) - \sum_{i=b1}^{b2} i_{\ell,i,t-1} L_{i,t-1}(j) + income_t - spending_t \quad (6)$$

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

# Central Bank and Government

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

$$i_t = (i_{t-1})^{i_i} \bar{i}^{(1-i_i)} \mathbb{E}_t(\pi_{t+1}^p / \bar{\pi})^{(1-i_i)i_\pi} S_t^{int}. \quad (7)$$

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

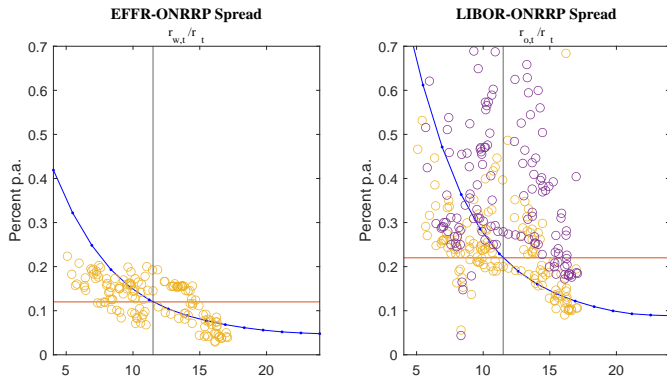
$$\check{m}_t^{rat} = \bar{m}^{rat} [(i_{o,t} / i_t) / (\bar{i}_{o,t} / \bar{i}_t)]^{-4m_o} S_t^r. \quad (8)$$

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

# 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. Blue line = model fit, circles = monthly data (orange: 1-month; violet: 3-month LIBOR)



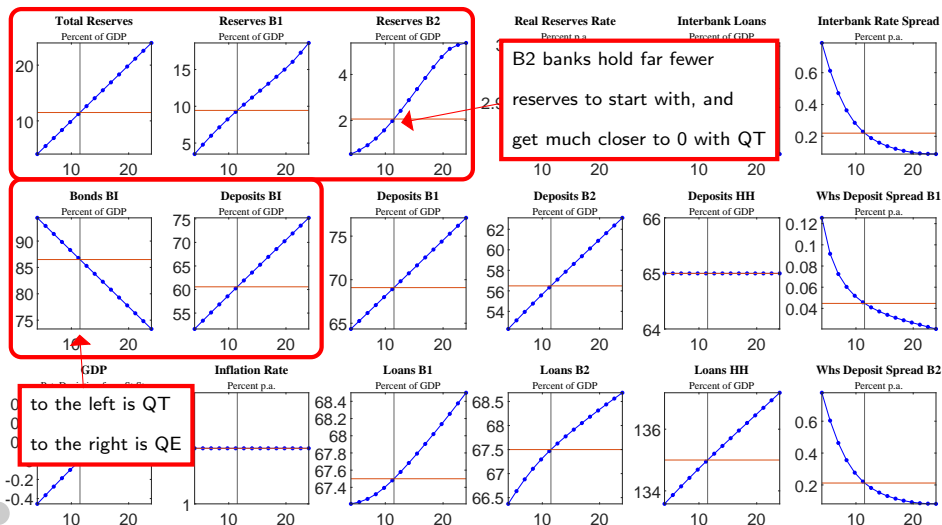
# QT Transmission Mechanism

Central Bank	
Assets	Liabilities
Bonds	Reserves
(- Bonds)	(- Reserves)

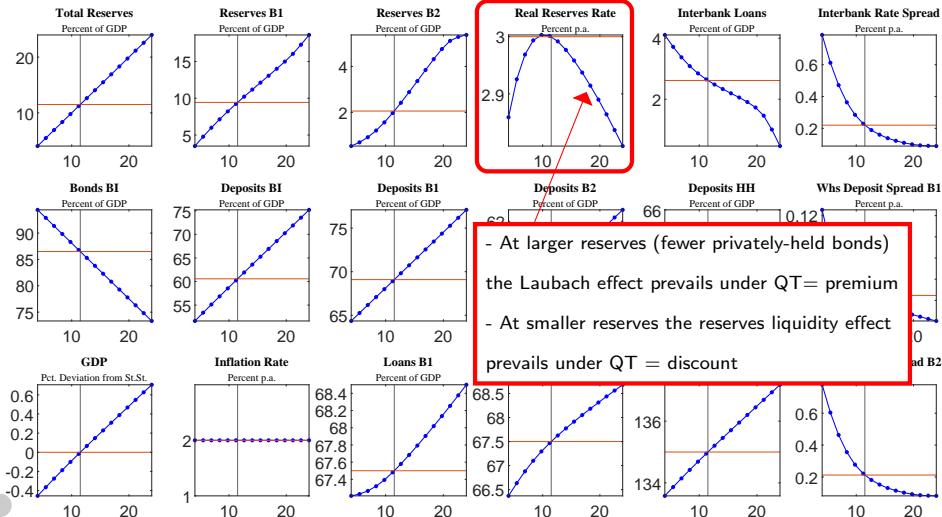
Bond Investors	
Assets	Liabilities
Bonds	Equity
+ Bonds (- Deposits)	
Deposits	

Wholesale Banks	
Assets	Liabilities
Loans	Equity
	Deposits
Reserves	
(- Reserves)	(- Deposits)

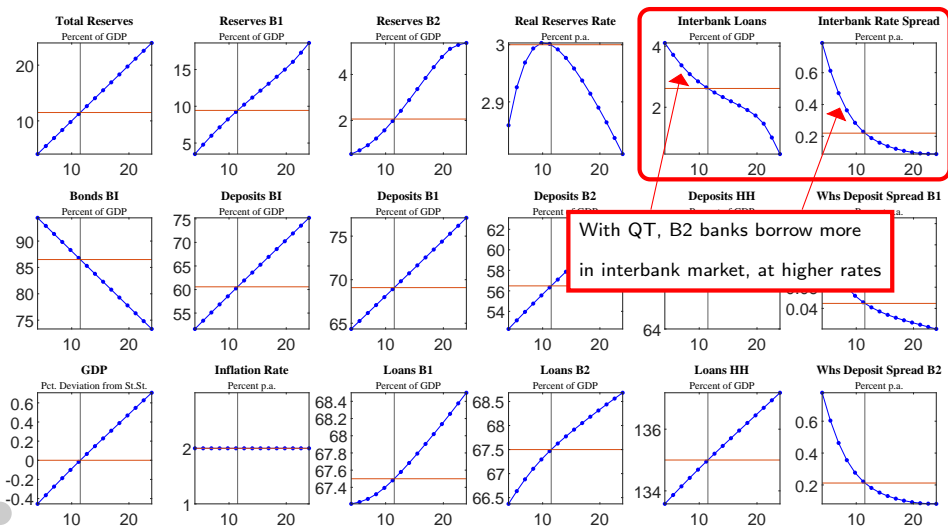
# Steady State Effects of QT (and QE)



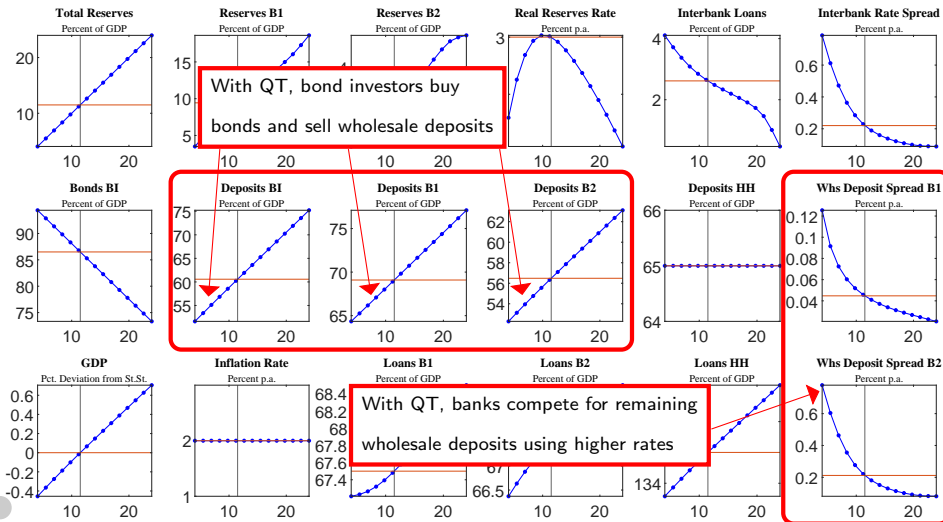
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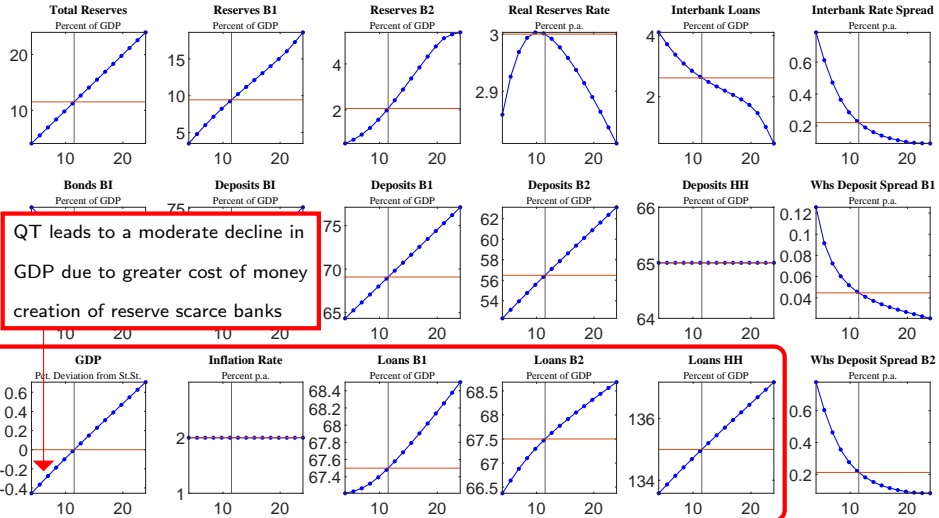
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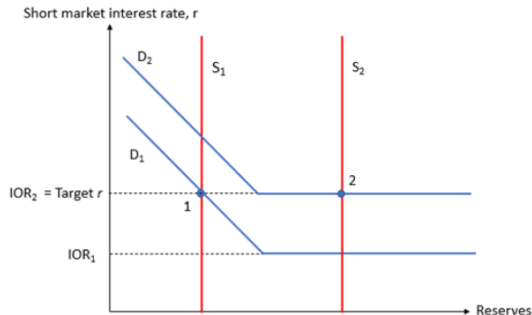
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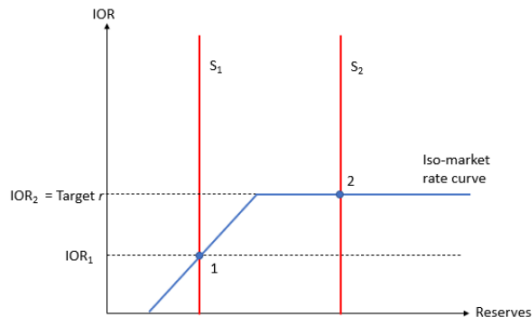
# Iso-Market Rate Curve a la Vissing-Jorgensen (2023)

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

## Reserve demand and supply



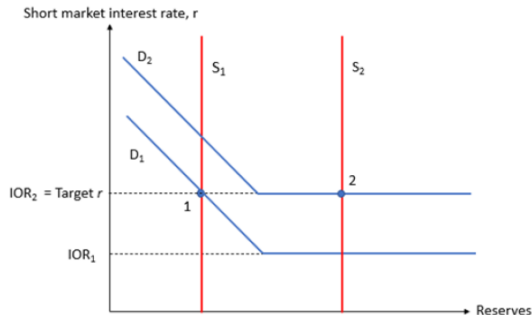
## Iso-market rate curve for short rate



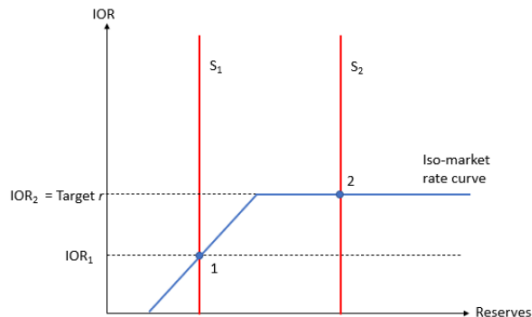
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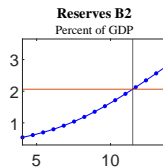
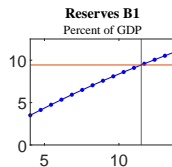
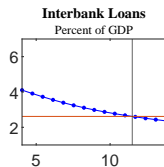
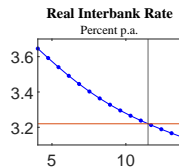
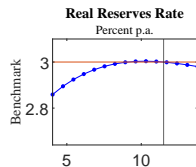
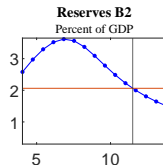
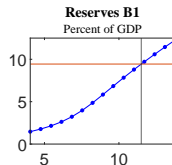
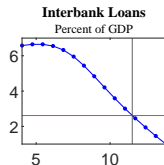
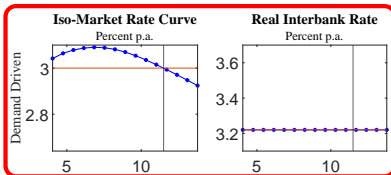


⇒ Same policy stance with different combinations of IOR and B/S size

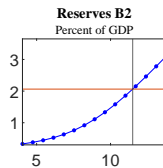
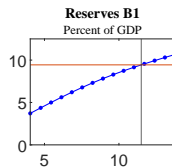
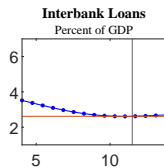
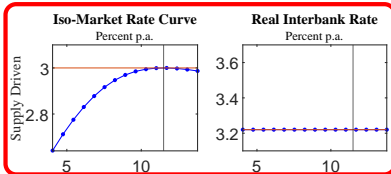


# Steady State Iso-Market Rate Curve

Demand-  
Driven  
Interbank  
Market

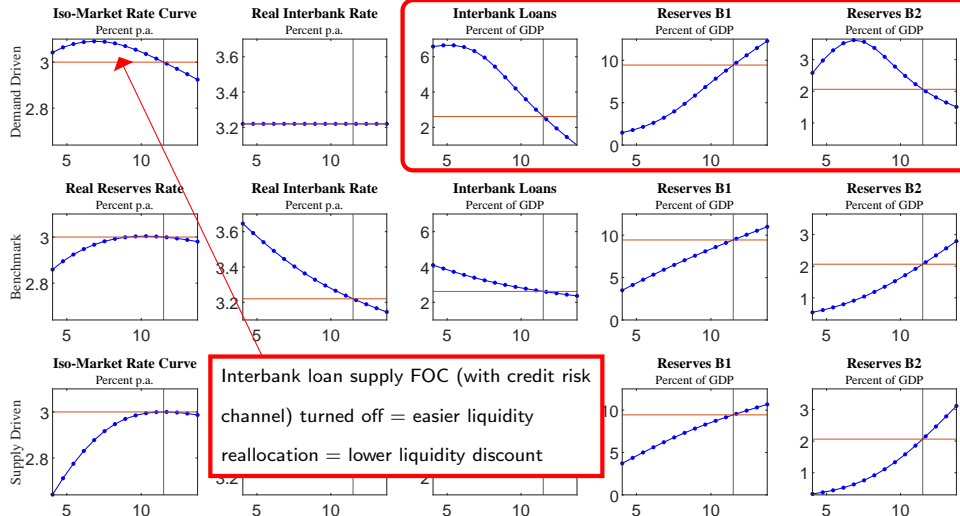


Supply-  
Driven  
Interbank  
Market

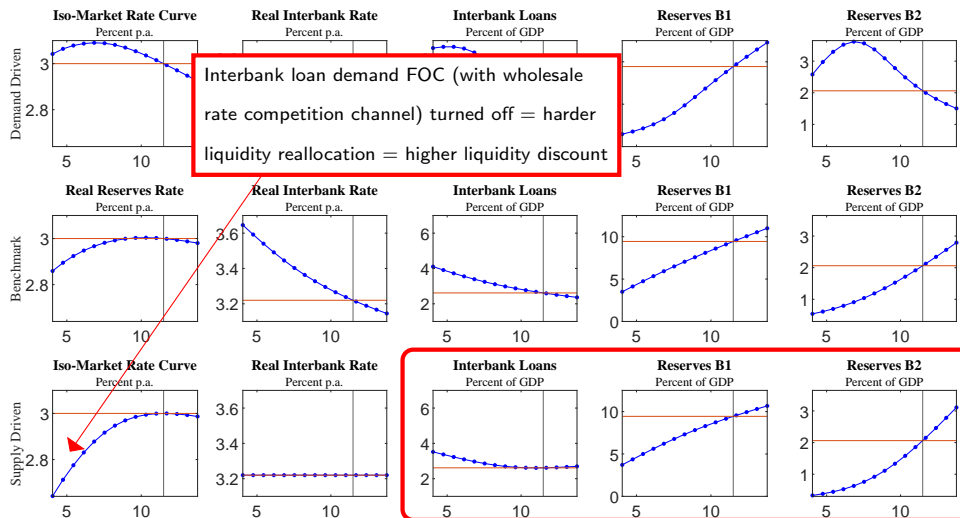


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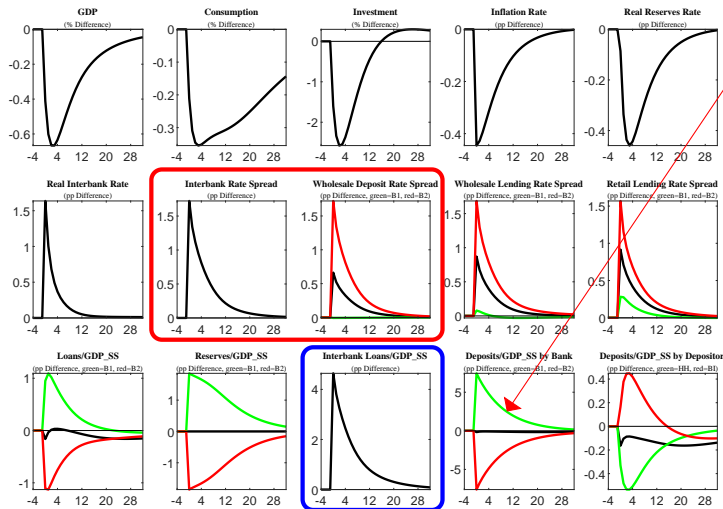
# Net Deposit Withdrawals Transmission Mechanism

Wholesale Banks B1	
Assets	Liabilities
Loans	Equity
	Wholesale Deposits B1
Reserves	
(+ Reserves)	(+ Deposits)

Money Market Funds	
Assets	Liabilities
Wholesale Deposits B1	Retail Deposits
↓	
Wholesale Deposits B2	

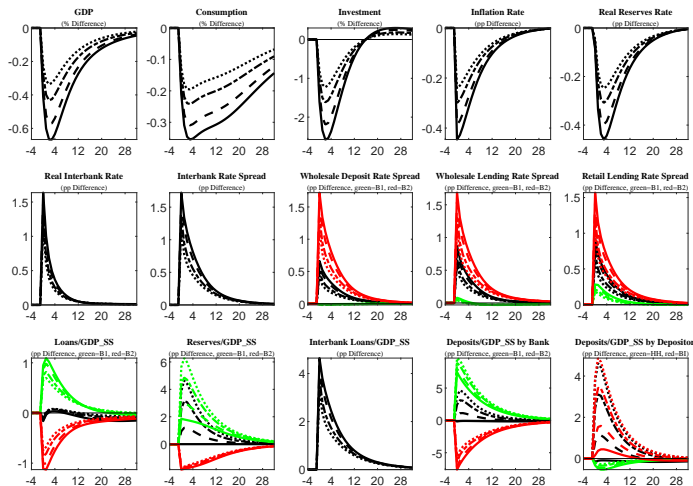
Wholesale Banks B2	
Assets	Liabilities
Loans	Equity
	Wholesale Deposits B2
Reserves	
(- Reserves)	(- Deposits)

# 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:  $m_0 = 0$ , Dashed/Dash-dotted/Dotted lines:  $m_0 = 10/30/50$

- 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

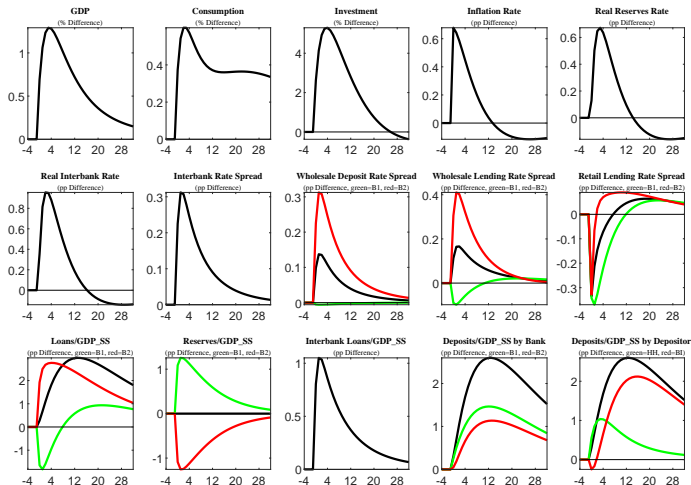
# Asymmetric Lending Boom Mechanism

Wholesale Banks B1	
Assets	Liabilities
Loans	Equity
	Wholesale Deposits B1
Reserves	
(+ Reserves)	(+ Deposits)

Households	
Assets	Liabilities
Retail Deposits	Loans B1
	Loans B2
(+Deposits)	(+Loans)

Wholesale Banks B2	
Assets	Liabilities
Loans	Equity
	Wholesale Deposits B2
(+Loans) (- Reserves)	
Reserves	(+Deposits)

# Dynamic Responses to an Asymmetric Lending Boom Shock

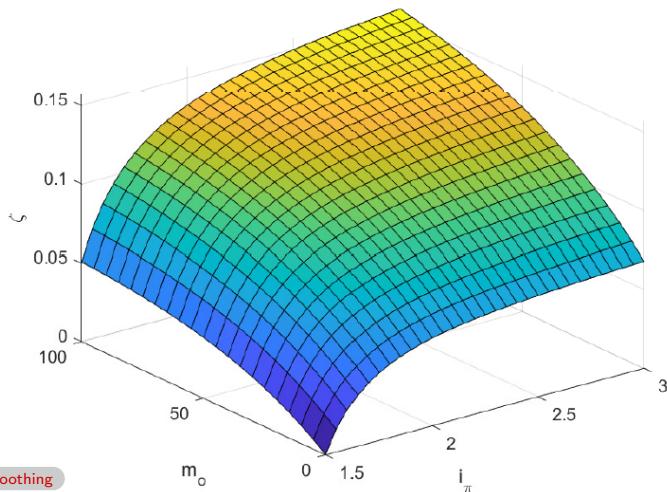


- Reserve-scarce B2 banks significantly increase their willingness to lend while B1 banks do not.
- The increase in funding costs in the interbank and wholesale deposit markets partly offsets B2 greater willingness to lend.
- Overall this shock is however expansionary, with GDP increasing by 1.25% and inflation by 70 basis points.
- B2 banks retain less than half of the deposits that they create by lending.



# Welfare Gains from Countercyclical Reserve Rule

Feedback coefficients: Reserve rule  $m_O$ , and interest rate rule  $i_\pi$



Smoothing

- 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:

$$\mathbb{E}_t r_{w,b1,t+1} = \mathbb{E}_t \left( r_{t+1} + v \left( \frac{\check{d}_{b1,t}}{\check{m}_{b1,t}} \right)^{\check{\theta}} \frac{\check{\ell}_{b1,t} \check{n}_{b1,t} + \check{o}_{b1,t} \check{n}_{b1,t} - \check{n}_{b1,t}^2}{\check{m}_{b1,t}^2} \right). \quad (9)$$

## Household loans FOC:

$$\begin{aligned} \mathbb{E}_t r_{\ell,b1,t+1} = \mathbb{E}_t \left[ r_{w,b1,t+1} + v \left( \frac{\check{d}_{b1,t}}{\check{m}_{b1,t}} \right)^{\check{\theta}} \frac{\check{n}_{b1,t}}{\check{m}_{b1,t}} \left( 1 + \frac{\chi_{b1,\ell} f_{b1,t+1}^b}{(1 - \gamma_\ell) r_{\ell,b1,t+1}} \left( 1 + \tau \frac{\check{o}_{b1,t}}{\check{\ell}_{b1,t}} \right) \right) \right] \quad (10) \\ + \mathbb{E}_t \chi_{b1,\ell} \left( F_{b1,t+1}^b + f_{b1,t+1}^b \left( 1 + \tau \frac{\check{o}_{b1,t}}{\check{\ell}_{b1,t}} \right) \left( \frac{r_{a,b1,t+1} \check{n}_{b1,t}}{(1 - \gamma_\ell) r_{\ell,b1,t+1} \check{\ell}_{b1,t}} \right) \right), \end{aligned}$$

with

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

# Wholesale banks FOCs in detail (cont.)

Back

## Interbank loans FOC:

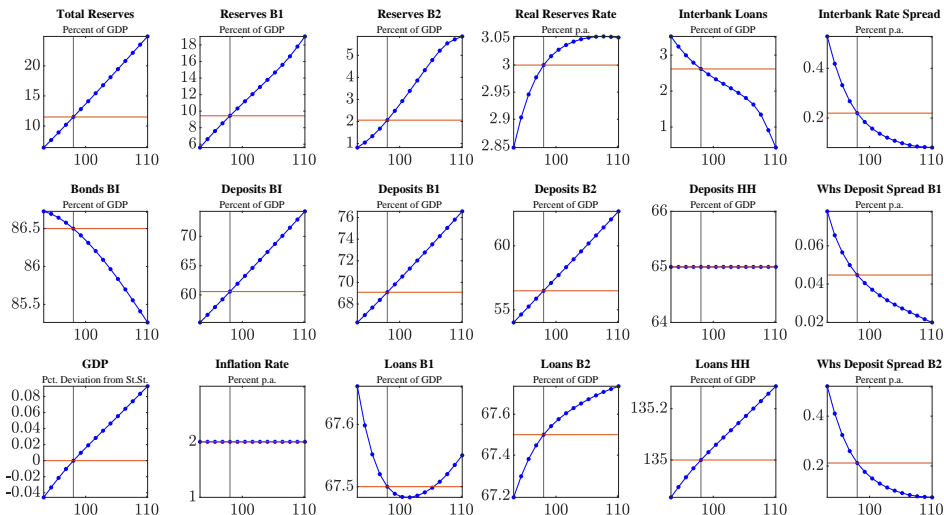
$$\mathbb{E}_t r_{o,t+1} = \mathbb{E}_t \left( r_{w,b1,t+1} + v \left( \frac{\check{d}_{b1,t}}{\check{m}_{b1,t}} \right)^{\check{\theta}} \left( \frac{\check{n}_{b1,t}}{\check{m}_{b1,t}} \right) \right) / \left( 1 - \gamma_\ell \mathbf{r} + \frac{\gamma_\ell \mathbf{r}}{f_t} \right) \quad (11)$$

$$+ \mathbb{E}_t \left( \chi_{b1,\ell} \mathbf{r} F_{t+1}^b + \chi_o \left( \frac{\check{o}_{b1,t}}{\check{n}_{b1,t}} \right)^\omega \left( F_{t+1}^o + f_{t+1}^o \frac{1}{(1+\omega)\gamma_o} \frac{\check{o}_{b1,t}}{\check{n}_{b1,t}} \right) \right) / \left( \left( 1 - \gamma_\ell \mathbf{r} + \frac{\gamma_\ell \mathbf{r}}{f_t} \right) f_t \right),$$

with

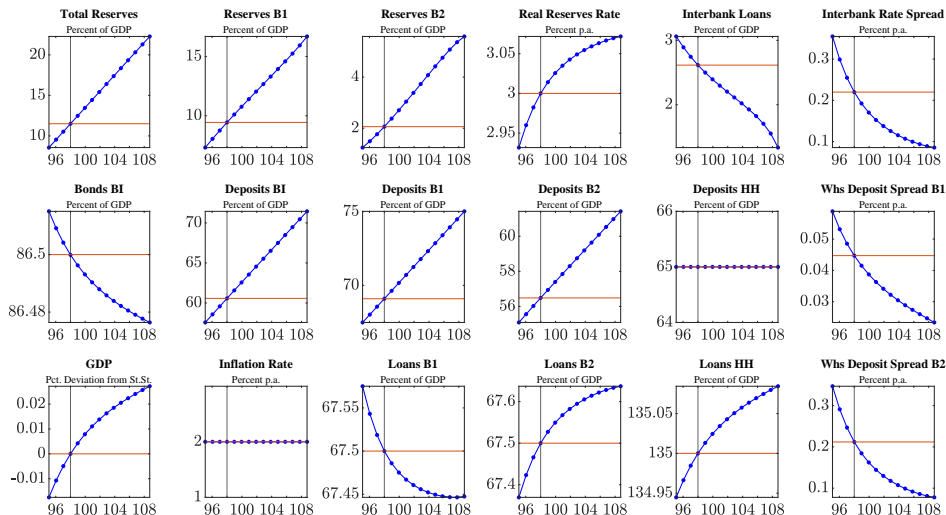
$$f_t = \left( 1 + \frac{\chi_{b1,\ell} f_{b1,t+1}^b}{(1-\gamma_\ell) r_{\ell,b1,t+1}} \left( 1 + \mathbf{r} \frac{\check{o}_{b1,t}}{\check{\ell}_{b1,t}} \right) \right).$$

# Steady State effects of Bonds

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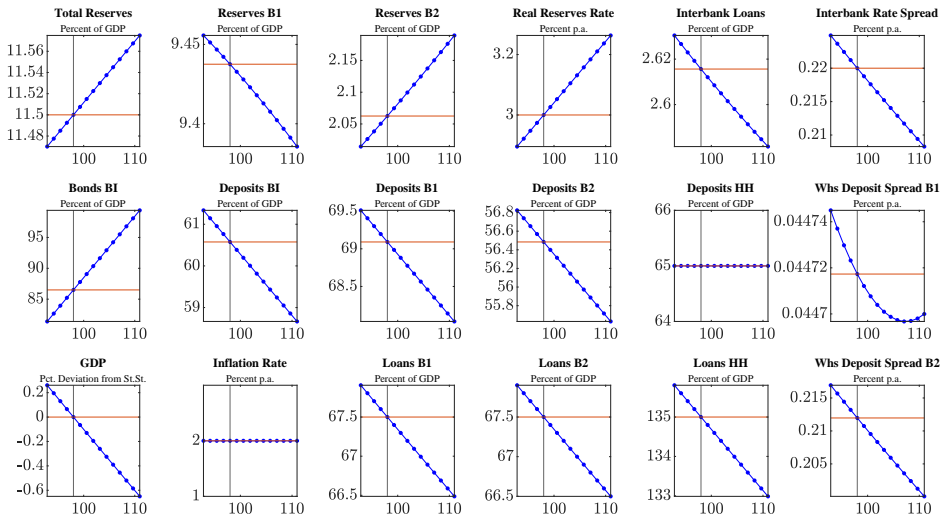
# Steady State effects of Bonds (fix BI bonds)

[back](#)

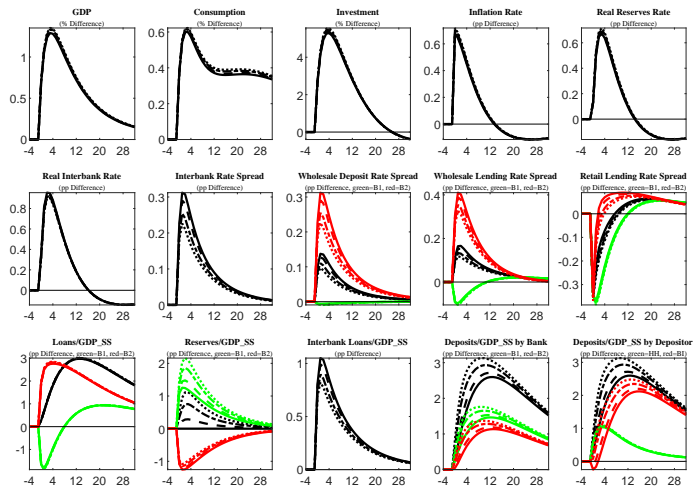




# Steady State effects of Bonds (fix M) back



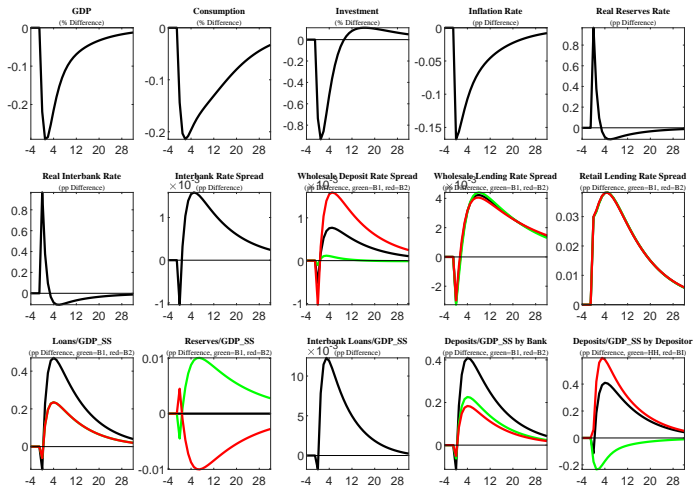
# Countercyclical Reserve Rules Provide Minor Welfare Gains



Solid line:  $m_0 = 0$ , Dashed/Dash-dotted/Dotted lines:  $m_0 = 10/30/50$

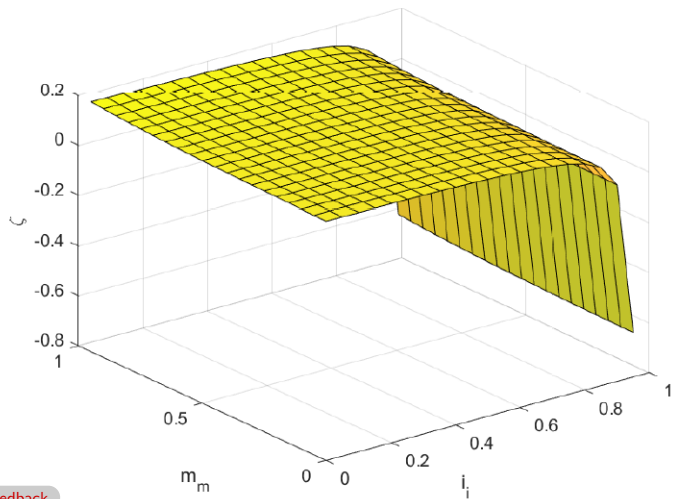
- The effects are qualitatively similar to, but quantitatively smaller than for net withdrawal shocks because the increase in the interbank rate spread is much smaller, and therefore triggers a more modest reserve injection.

# 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