

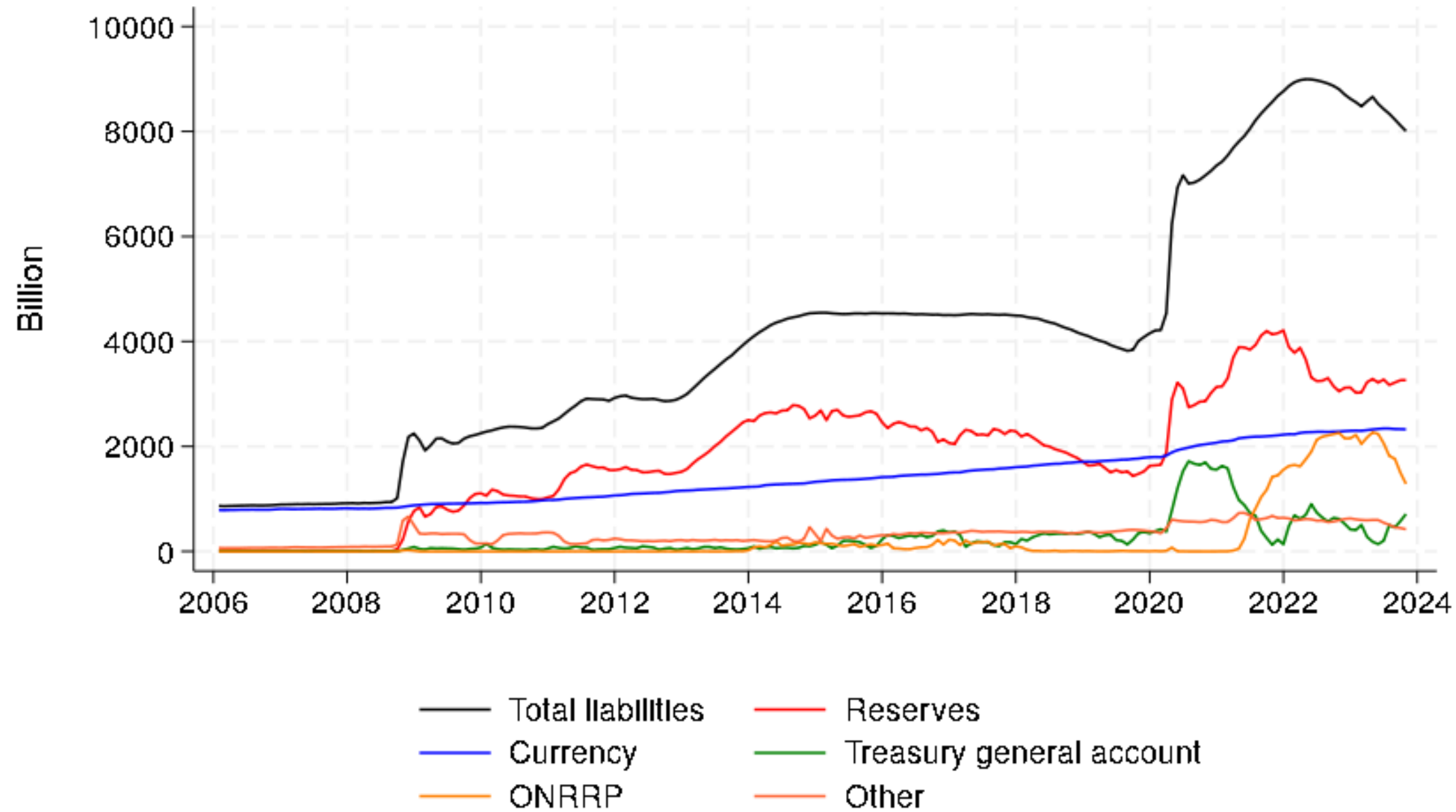
Balance Sheet Policy Above the Effective Lower Bound

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The views expressed here are those of the author; they do not represent those of the Federal Reserve Board or the Federal Reserve System.

Federal Reserve liabilities, 2006M1-2023M10



Federal Reserve balance sheet

Federal Reserve balance sheet, June 28, 2023

H.4 release, \$B

Assets		Liabilities	
Treasuries	5,145	Reserves	3,176
MBS	2,538	Overnight reverse repurchase agreements	1,945
Loans	282	Currency	2,344
Other	426	Treasury general account	409
		Other	517
	8,391		8,391

Question: What should central banks do with their balance sheets when $r > \text{ELB}$?

When the **policy rate is above the effective lower bound**:

- Monetary policy stance can be adjusted **up/down via interest rate on reserves**
- A particular balance sheet size is **not needed** to steer economy
- **Many combinations** of interest rate on reserves and balance sheet size give same policy tightness

→ How should a central bank choose **balance sheet size**?

This paper: **Convenience yields** are one useful input for guiding this choice

- Convenience yields: Benefits on an investment **over-and-above interest and principal payments**
 - From **liquidity**: Saved transactions/payment delay cost
 - From **safety**: Saved information costs due to low default risk
 - Both **interact with supervision and regulation** (can hold liquid and safe assets for LCR)
- Central bank reserves: Liquid and safe asset → Supplying **reserves adds value** (like cash does)

Question: What should central banks do with their balance sheets when $r > ELB$?

Derive “convenience-maximizing” reserve supply:

Depends on *how* a central bank supplies reserves – asset mix

(a) If reserves are supplied via central bank holdings of assets **without convenience yields**:

Convenience-maximizing reserve supply is **larger**

(b) If reserves are supplied via central bank holdings of assets **with convenience yields** (Treasuries or Bunds):

Convenience-maximizing reserve supply is **smaller**

Steps

1. **Reminder:** Too many tools above the ELB
2. **Relevant factors:** For choosing balance sheet size and composition above the ELB
3. **Political constraints on asset choice:** Federal Reserve versus ECB
4. **Framework:** Derive convenience-maximizing reserve supply as a fct of central bank asset choice
5. **Empirics:** Estimate convenience-maximizing reserves supply for US and euro area

1. Reminder: Too many tools above the ELB

Central bank can reach same equilibrium market rate with many different (IOR, Reserves) combinations

Lopez-Salido and Vissing-Jorgensen (2023): (But result is well-known back to at least Goodfriend (2002))

<i>Bank Assets</i>	<i>Bank Liabilities</i>
Reserves	Deposits
Securities, loans	Interbank and central bank borrowing
Interbank lending	Equity

1. Reserves pay interest, *IOR*
2. Reserves have **liquidity benefits**: Don't have to sell illiquid assets/cut lending/delay payments if deposits drop. Reserves are also useful for supervision & reg. purposes

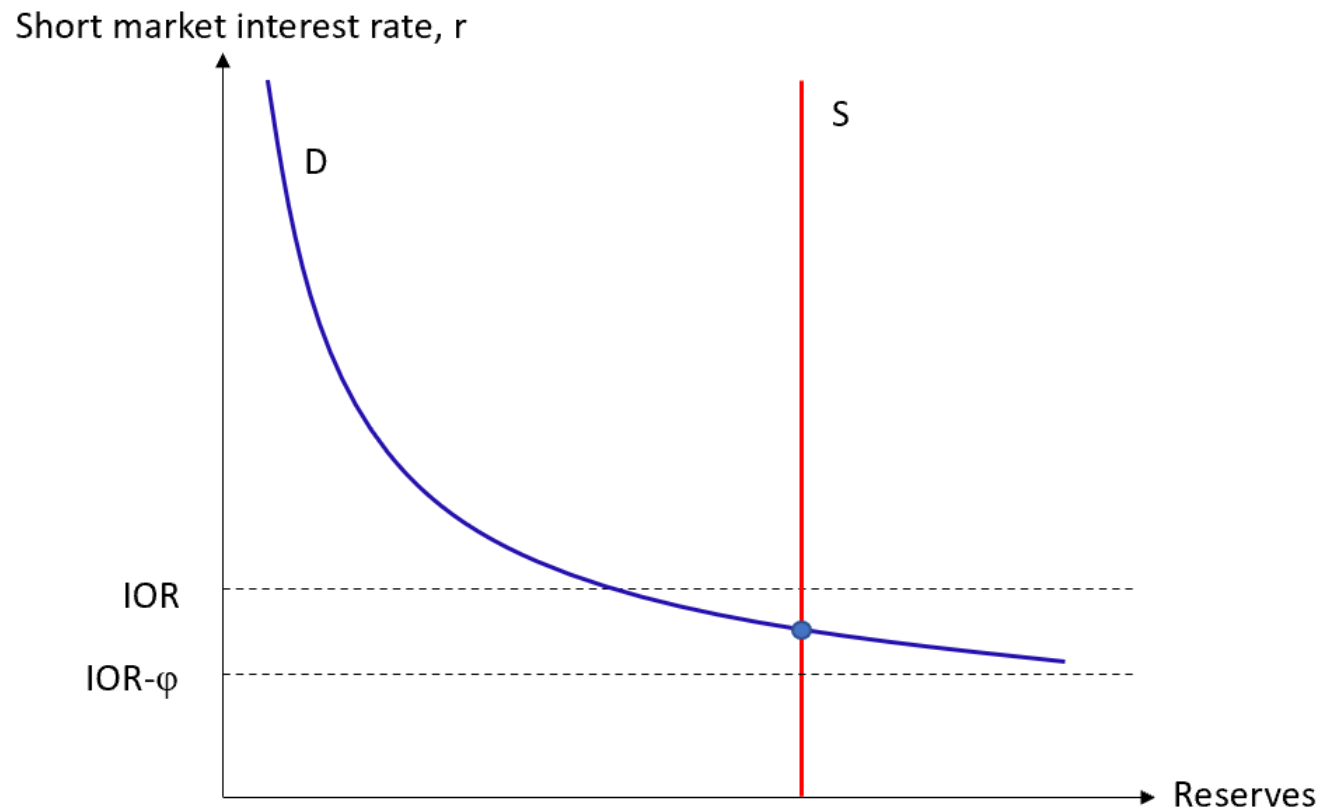
$v(\text{Reserves}, \text{Deposits})$	Convenience value – saved transactions/other costs
$v'_R(\text{Reserves}, \text{Deposits})$	Convenience yield: Marginal value of more reserves Decreasing in reserves, increasing in deposits

3. **Bank balance sheet cost φ** per dollar of assets (capital requirements, e.g., SLR)

1. Reminder: Too many tools above the ELB

→ Banks' first-order condition for borrowing at market rate r and investing in reserves:

$$\underbrace{r}_{\substack{\text{Highest interest rate} \\ \text{bank is willing to pay} \\ \text{to borrow to invest in reserves}}} = \underbrace{IOR + v'_R(\text{Reserves}, \text{Deposits}) - \varphi}_{\text{Net benefit of reserves}} \quad \text{Reserve demand curve}$$



Reserve demand:

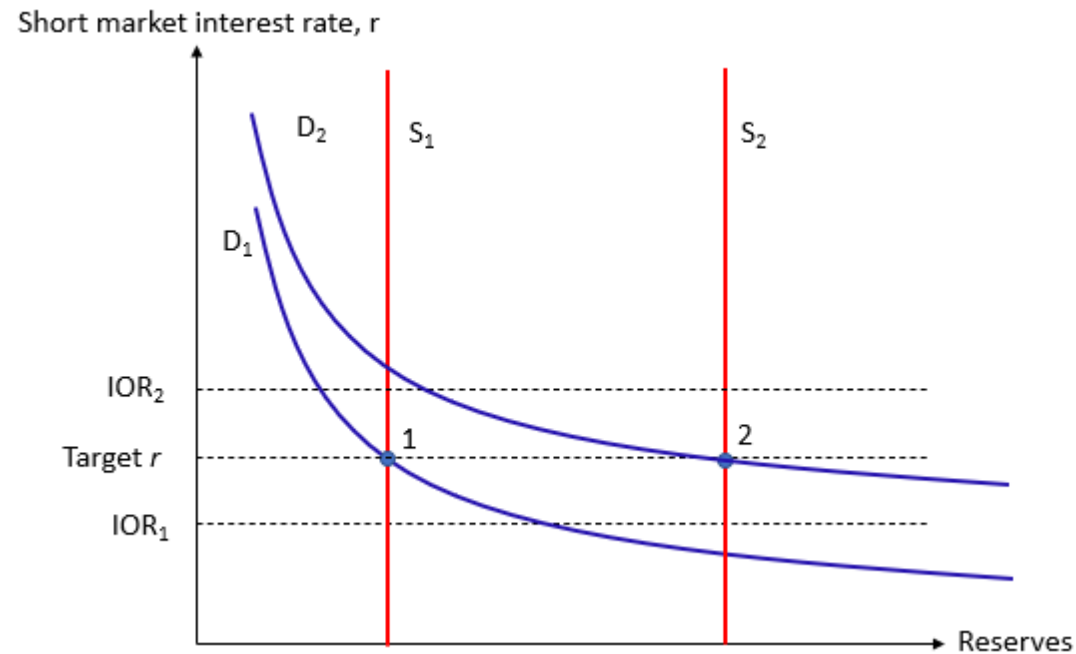
- **Slope:** Comes from $v'_R(\cdot)$
- **Level:** Shifts up with IOR , down with φ
- **Asymptotes** to $IOR - \varphi$ if $v'_R(\cdot) \rightarrow 0$

Equilibrium: Can involve $r < IOR$ if:

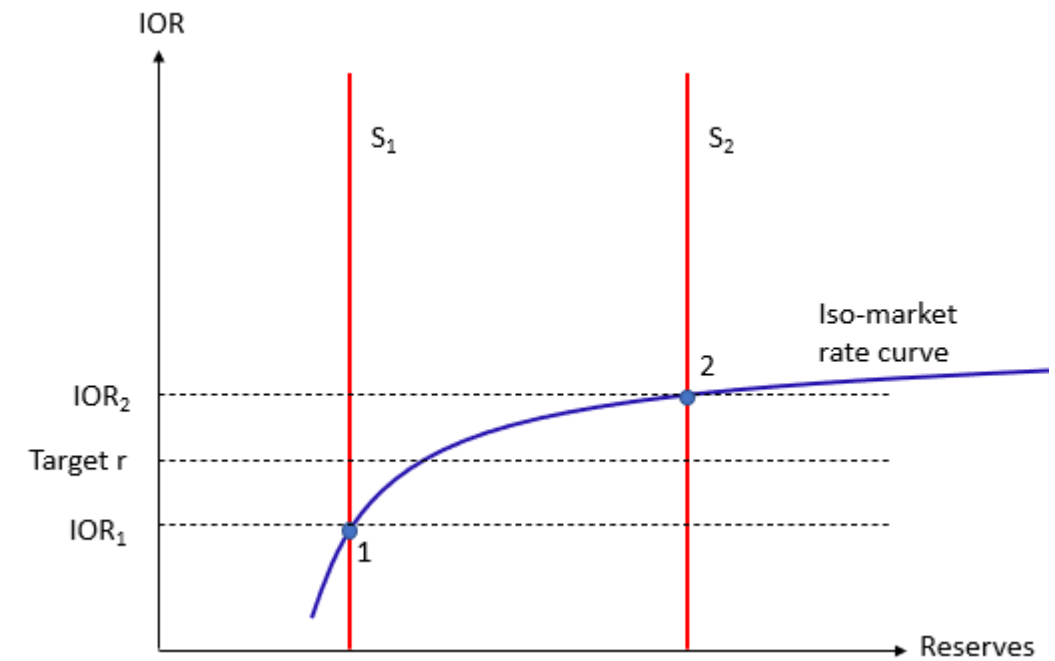
- Reserve supply is high so $v'_R(\cdot) - \varphi < 0$
- Banks can earn IOR but others cannot (e.g., GS MMFs)

1. Reminder: Too many tools above the ELB

Reserve market



Iso-market rate curve for short rate



Reserve demand: $r = IOR + v'_R(\text{Reserves}, \text{Deposits}) - \varphi$

- 1: Low IOR, IOR_1 , $v'_R(\cdot) - \varphi > 0$ due to low reserve supply, S_1
- 2: High IOR, IOR_2 , $v'_R(\cdot) - \varphi < 0$ due to high reserve supply, S_2

“Iso-market rate” curve: $(IOR, \text{Reserves})$ comb's that achieve same target. $IOR = r^{Target} - [v'_R(\cdot) - \varphi]$

- How to set IOR given balance sheet size, or conversely

2. Factors relevant for choosing balance sheet size and composition above the ELB

(a) Interest rate volatility:

- **Reserve demand flatter at higher quantities** → **Less interest rate volatility** from volatility in reserve supply due to fluctuating **autonomous factors** (currency, government deposits)

<i>Central bank assets</i>	<i>Central bank liabilities</i>
Securities	Currency, government deposits: Autonomous factors
Loans	Reserves

(b) Central bank's liquidity/safety supply: My focus here.

- **Convenient asset scarcity.** Convenience yields imply that Ricardian equivalence fails
Krishnamurthy and Vissing-Jorgensen (2012)
Arrata, Nguyen, Rahmouni-Rousseau and Vari (2020), Schnabel (2023a), Hauser (2022)

2. Factors relevant for choosing balance sheet size and composition above the ELB

(c) *Side effects of large central bank balance sheets:* Banks need to **fund their reserve holdings**

- **Crowding-out** of bank securities holdings/loans: Can lead to a welfare loss (Empirical evidence: Diamond, Jiang and Ma (2022) and Chakraborty, Goldstein and MacKinley (2020))
- **Crowding-in** of deposits/other liabilities: Adds liquidity/safety benefits but also financial stability risk

(d) *Central bank profits:*

- CB losses may pose a **threat to central bank independence** → Large current balance sheet may **limit headroom for future QE** if needed (e.g., Hauser (2022))

3. Political constraints on asset choices: Federal Reserve versus ECB

Federal Reserve: Has announced plans to primarily hold **Treasuries** in the longer run “**thereby minimizing the effect of Federal Reserve holdings** on the **allocation of credit across sectors** of the economy”

- Federal Reserve Act: Fed can hold assets that are **direct obligations of, or guaranteed by, the US**
 - Corporate bond purchases during COVID crisis: Emergency lending program under Section 13-3
 - Discount window priced to be used mainly in crisis
- Broadus and Goodfriend (2001): Express common sentiment in US that Fed should mainly hold Treasuries

*“...the Fed’s asset acquisition policy ought to give priority to **preserving public support for the Fed’s independence** by insulating the central bank as much as possible from potentially damaging **disputes regarding credit allocation**”*

*“When the Fed purchases Treasury securities, it extends Federal Reserve credit to the Treasury. Doing so, however, **leaves all the fiscal decisions to Congress and the Treasury**”*

3. Political constraints on asset choices: Federal Reserve versus ECB

ECB: Could likely hold only assets without convenience yields in the longer run (and without requiring convenient assets as collateral for lending)

- Historically supplied reserves via **collateralized lending to banks**
- **Government bond purchases: Politically sensitive.** Challenged in court
- Schnabel (2023a) states:

*“In the **euro area**, however, there are [...] additional considerations relevant for the assessment of **whether a large bond portfolio is desirable** or not. One is that the **lack of a consolidated public sector balance sheet** raises more **fundamental concerns about monetary and fiscal interactions in a currency union** with sovereign member states. These concerns may potentially **undermine the credibility and independence** of the central bank.”*

3. Political constraints on asset choices: Federal Reserve versus ECB

Across the Atlantic: **What is politically sensitive differs**

- Government bonds:
 - Politically safe choice in US
 - Politically risky choice in euro area
- From the perspective of **convenience-maximization**:
 - ECB is at an advantage: Fits case (a) better
 - Fed is at a disadvantage: Fits case (b) better, given the convenience yield on Treasuries

4. Framework: Convenience-maximizing reserve supply and asset choice

Friedman rule for **optimal supply of money** (non-interest bearing):

- Maximize welfare from money: Set convenience yield **on money to zero**

Translated to **optimal supply of reserves** (interest bearing):

- Maximize welfare from reserves: Set convenience yield **on reserves (net of φ) to zero**

Fed: “Lowest Comfortable Level of Reserves” (LCLoR)

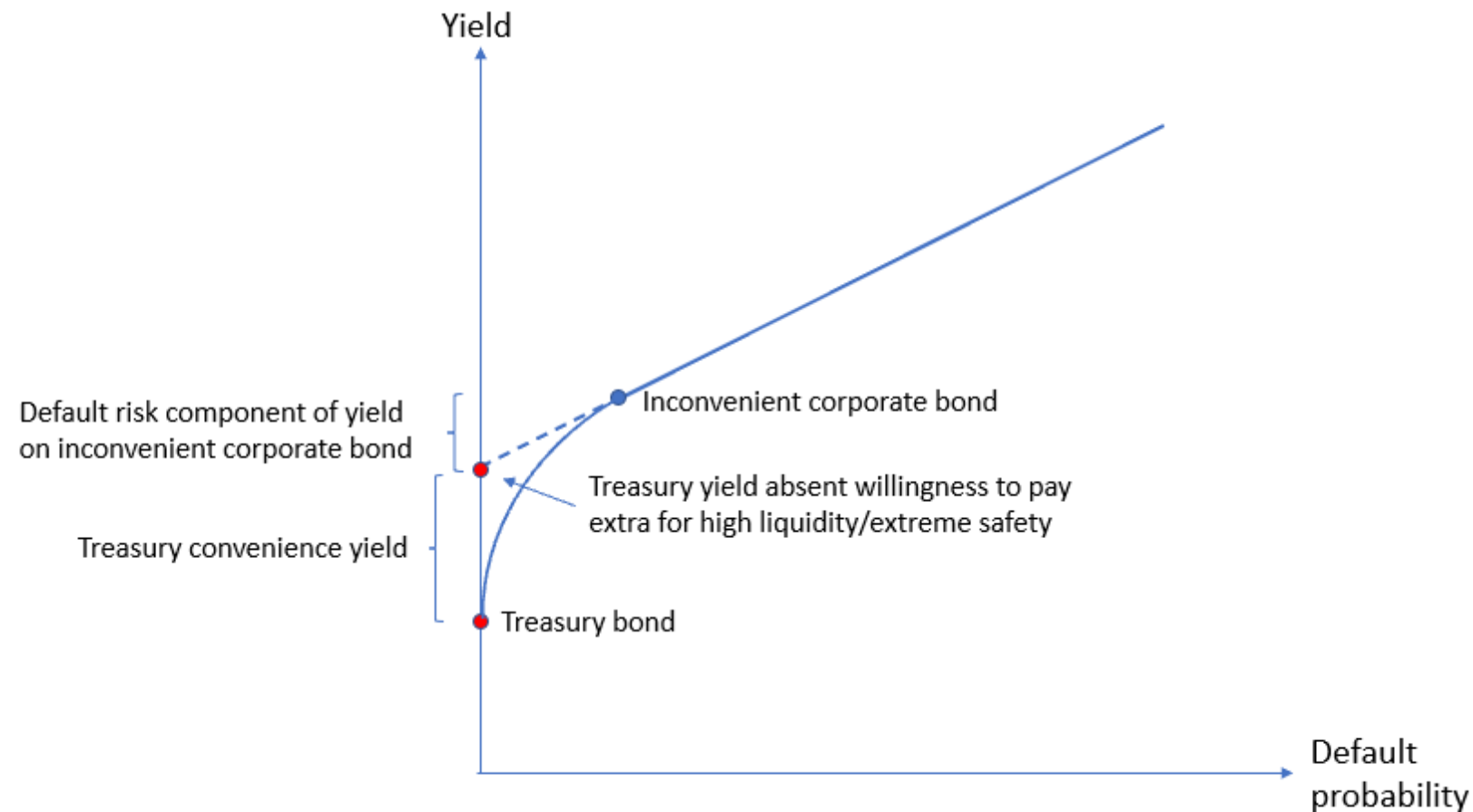
ECB: “Floor Required Excess Liquidity” (FREL)

BoE: “Preferred Minimum Range of Reserves” (PMRR)

- Useful, but what if the CB’s **assets** have a convenience yield too? (From liquidity/safety, will not matter)

4. Framework: Convenience-maximizing reserve supply and asset choice

Convenience yields on bonds – illustration for Treasuries (works the same for Bunds)



- Yields on **very safe** assets, which also tend to be **very liquid**:
Below “normal” yield-risk relation

- $y^{Inconv. corp. bonds} - y^{Treasury}$
 $= \underbrace{v'_T(T)}_{\text{Treasury conv. yield}} + \underbrace{\text{Default component}}_{\text{Spread for large Treasury supply}}$

- Krishnamurthy and Vissing-Jorgensen (2012): Avg. (long) Treasury conv. yield, 1919-2008
 - **46 bps** relative to Aaa corporate bonds
 - **73 bps** relative to Baa corporate bonds

4. Framework: Convenience-maximizing reserve supply and asset choice

Private (non-central bank) sector's convenience from reserves and bonds with conv. yield:

$$[v_R(R) - \varphi R] + v_B(B - B^{cb})$$

- **Is bank balance sheet cost φ a social cost? Yes**
 - Banks' perspective: φ is due to capital requirements
 - Society's perspective: Capital req's imposed due to ST debt externality, Stein (2012)
 - If capital req. set optimally: We should subtract φ in convenience-maximization

4. Framework: Convenience-maximizing reserve supply and asset choice

$$[v_R(R) - \varphi R] + v_B(B - B^{cb})$$

Result (Convenience-maximizing reserve supply)

(A) If a central bank holds assets *without convenience yields*, $B^{cb} = 0$:

$$\text{Max}_R v_R(R) - \varphi R \quad \rightarrow R^A, \text{ solves} \quad v'_R(R) - \varphi = 0$$

(B) If a central bank holds bonds (B) *with convenience yields*, $B^{cb} = R + A$:

$$\text{Max}_R [v_R(R) - \varphi R] + v_B(B - R - A) \quad \rightarrow R^B \text{ solves:} \quad v'_R(R) - \varphi = v'_B(B - R - A)$$

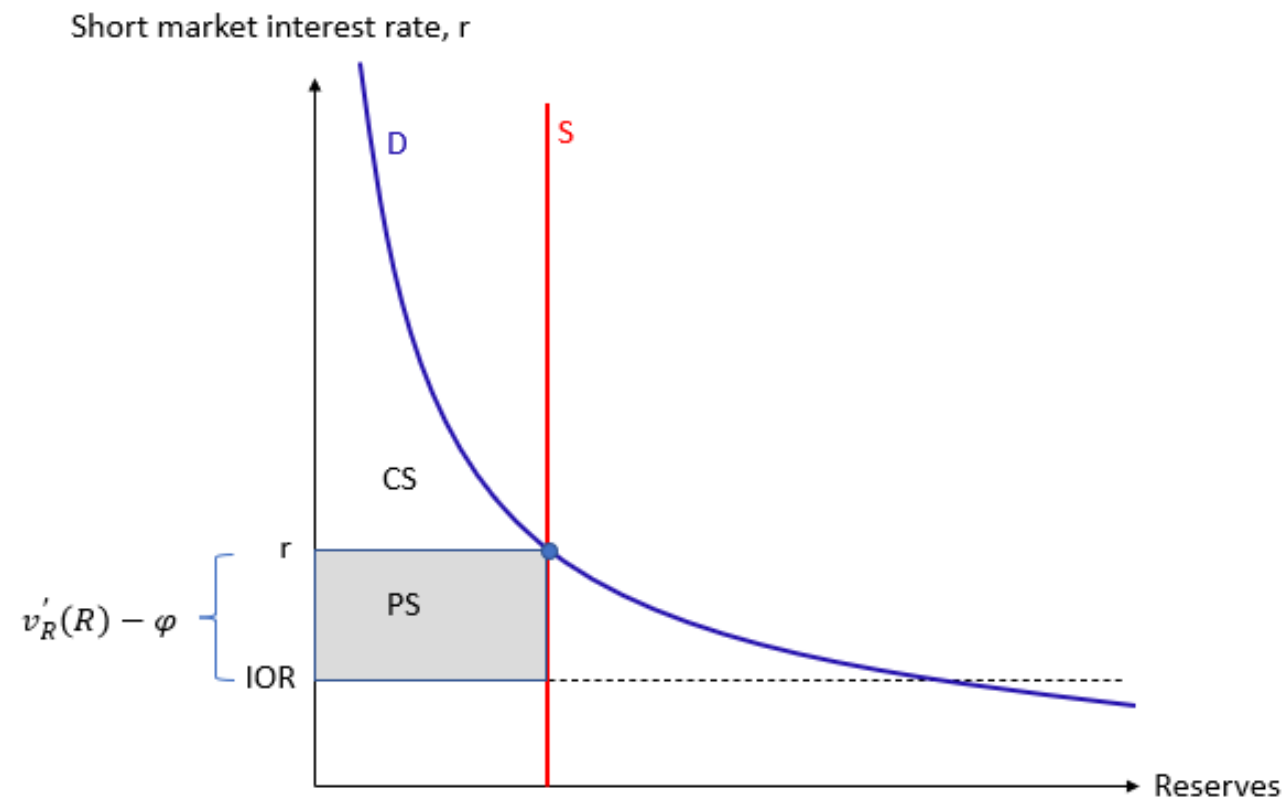
Holds regardless of the exact mix of crowding out/crowding in that banks use to fund reserves

- At the margin, cost from crowding out & crowding in has to be equally costly
→ Marginal welfare loss from funding reserve holdings is always equal to φ

4. Framework: Convenience-maximizing reserve supply in Case A

Reserve market

$$D: r = IOR + v'_R(R) - \varphi$$



Total convenience value of reserves:

- Area between reserve demand curve and IOR , integral of $v'_R(R) - \varphi$

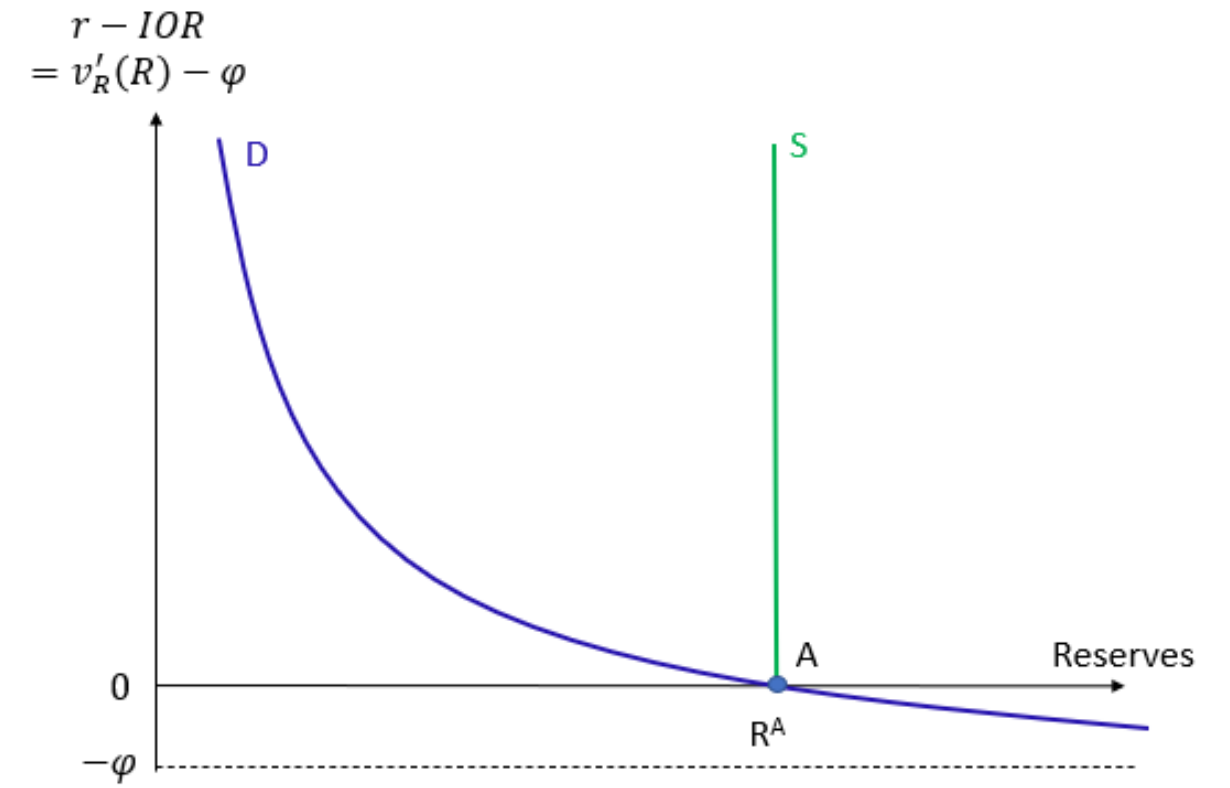
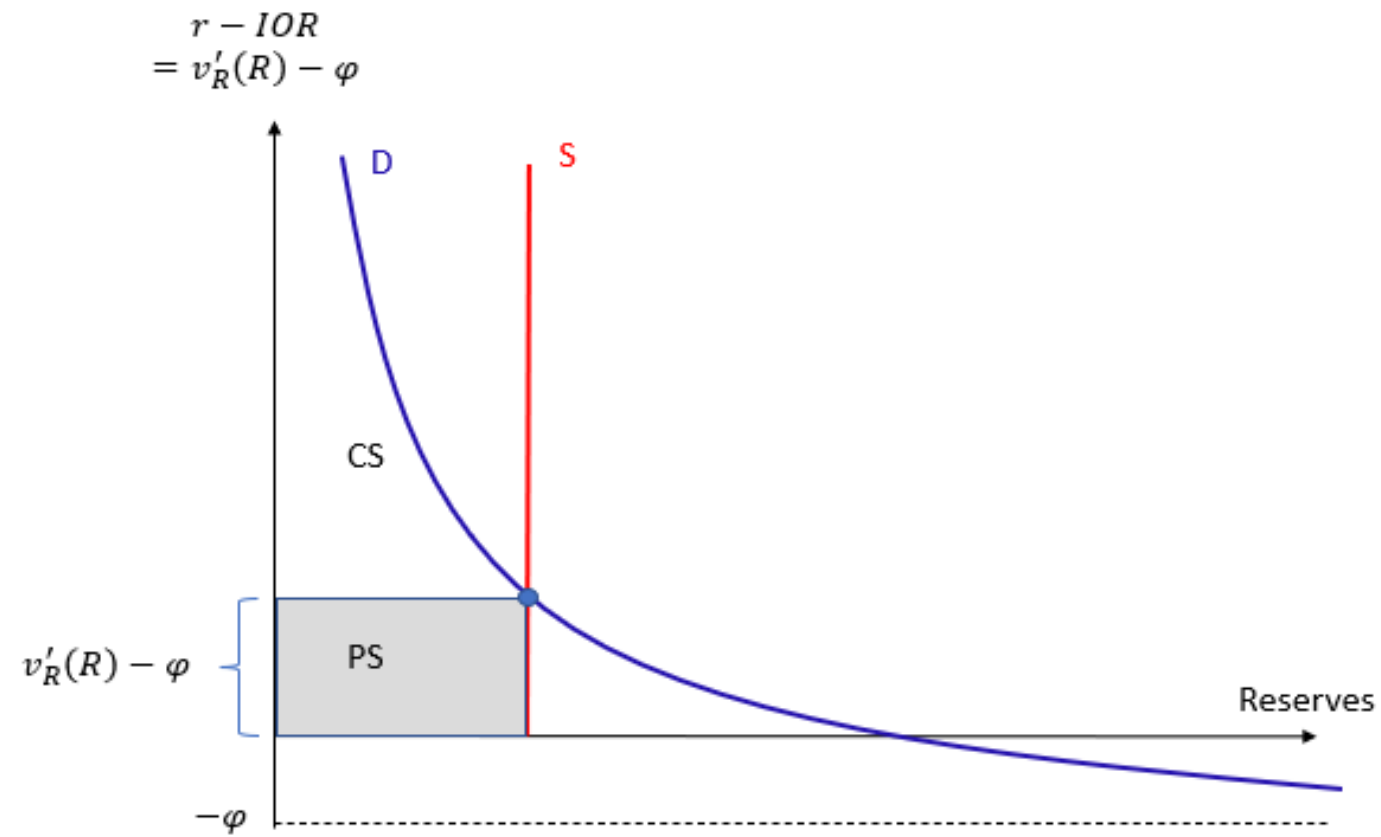
- For given unit of reserves

Consumers' surplus (CS): $[IOR + v'_R(R) - \varphi] - r$

Producers' surplus (PS): $r - IOR$

Sum: $v'_R(R) - \varphi$

4. Framework: Convenience-maximizing reserve supply in Case A

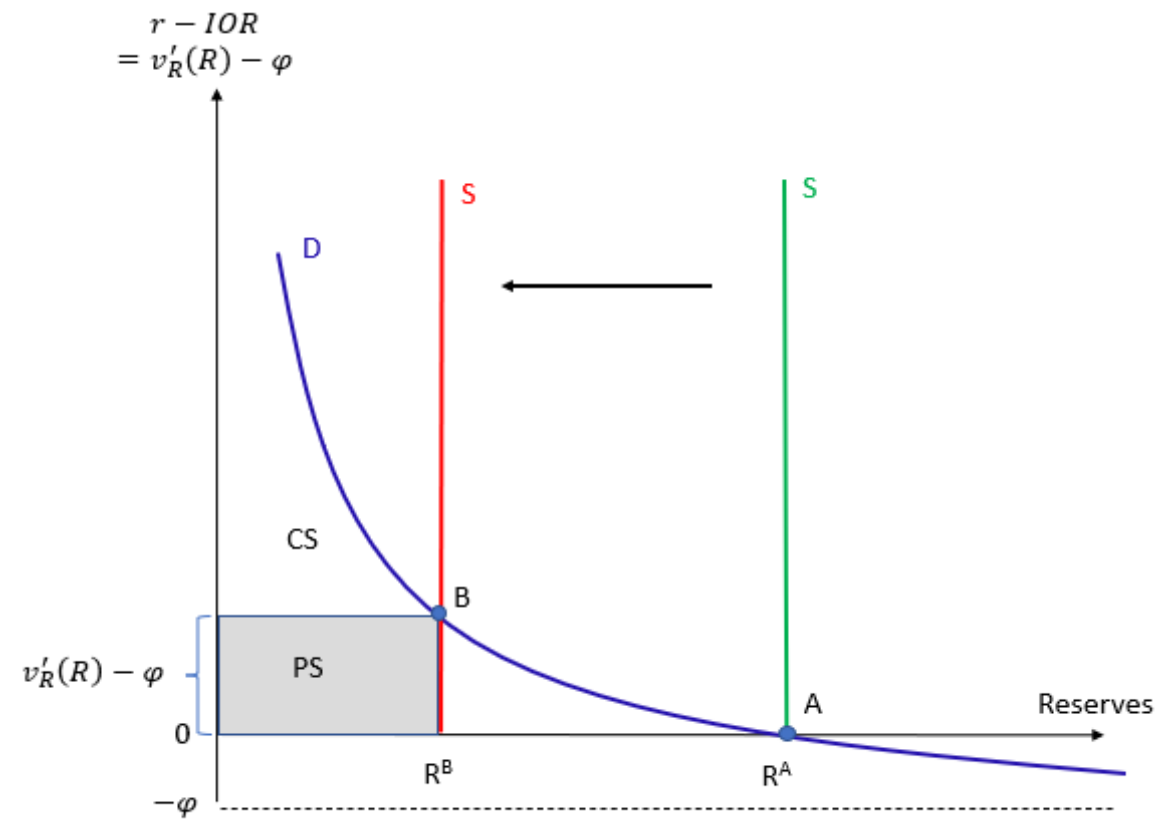


- R^A maximizes CS+PS from reserves by setting $v'_R(R) - \varphi = 0$

4. Framework: Convenience-maximizing reserve supply in Case B

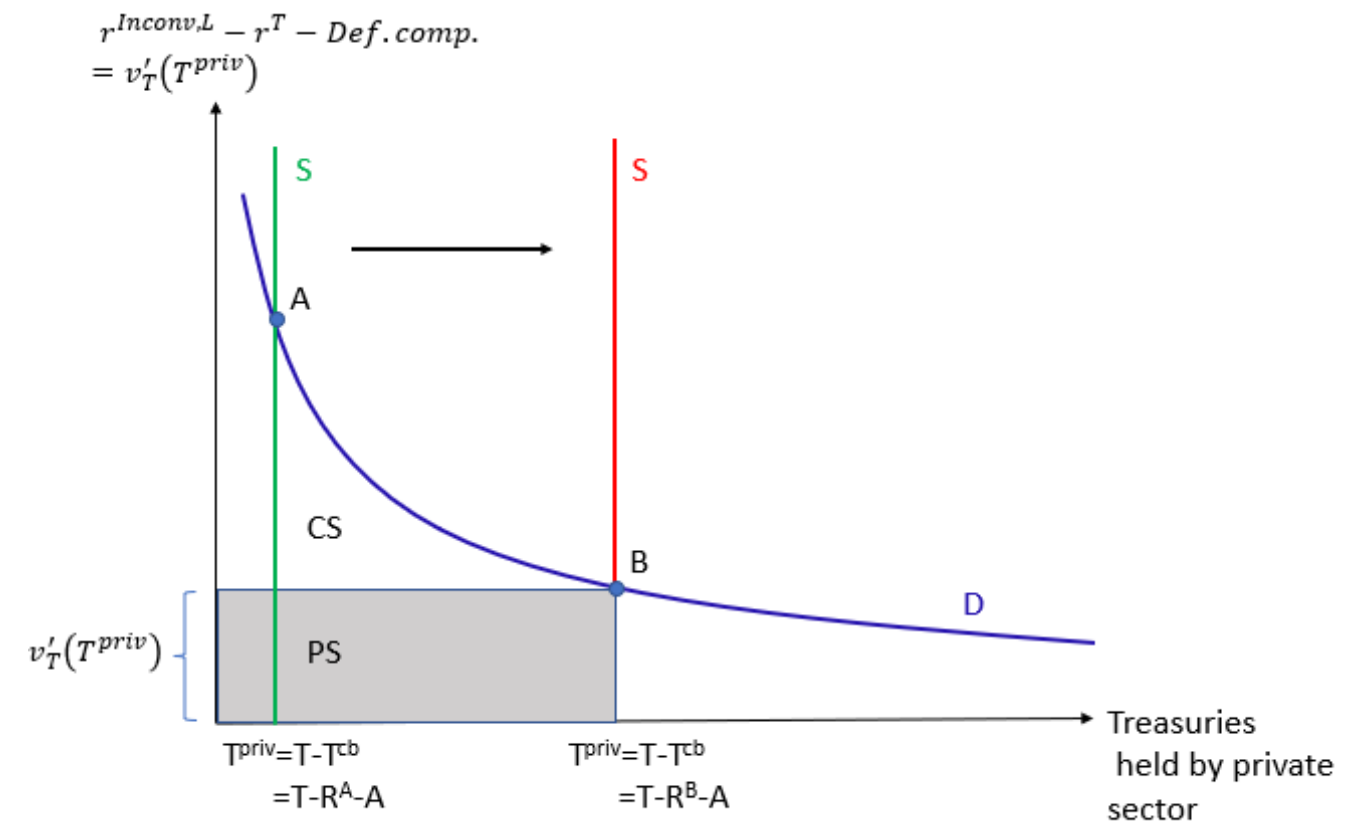
Reserve market

$$D: r - IOR = v'_R(R) - \varphi$$



Bond market (e.g., Treasuries)

$$D: r^{Inconv,L} - r^T - Def.comp. = v'_T(T^{priv})$$



- R^B maximizes total conv. value (CS+PS) from both reserves and bonds: Set $v'_R(R) - \varphi = v'_T(T^{priv})$

4. Framework: Convenience-maximizing reserve supply and asset choice

COMMENT. What if the ECB decided to supply reserves with a mix of bank lending (inconvenient) and government bonds (some of which convenient)?

- Set $v'_R(R) - \varphi = \text{Average convenience yield on ECB assets}$
- Suppose only German bunds have convenience yield

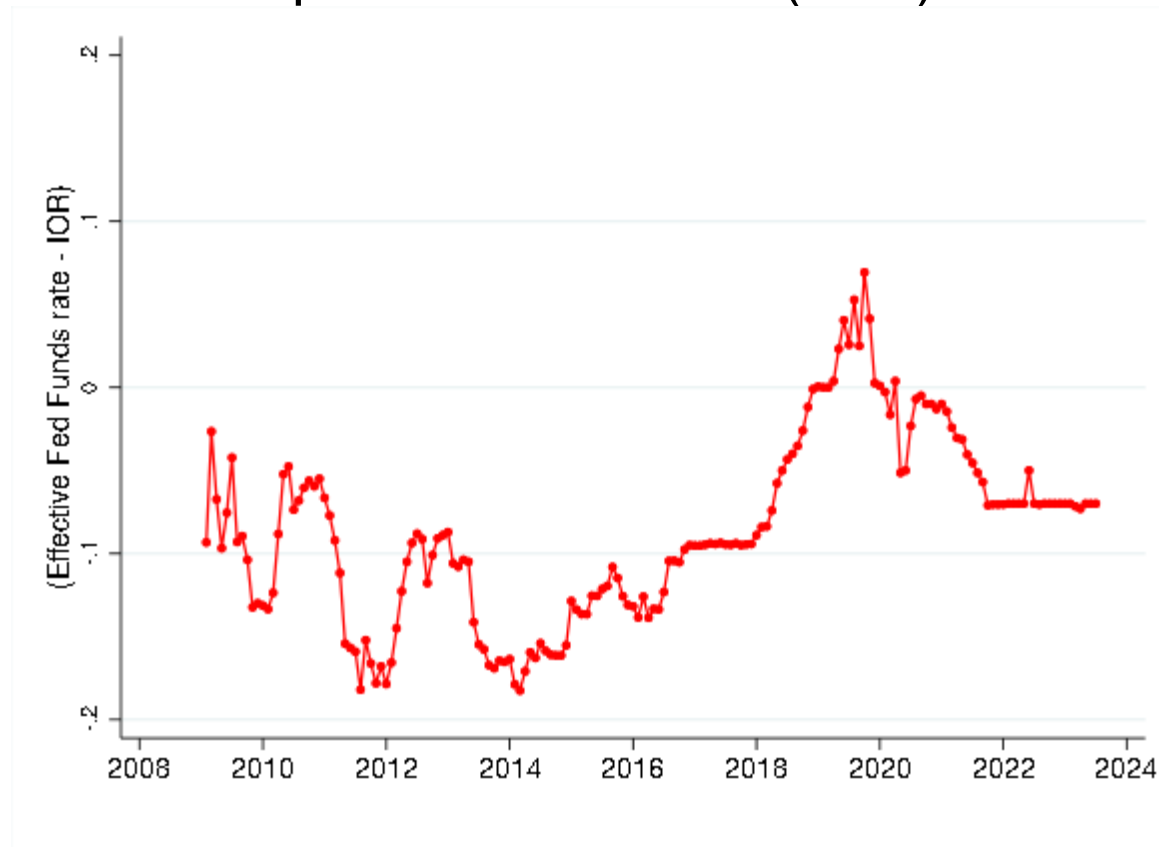
$$v'_R(R) - \varphi = \underbrace{v'_B(B_1^{priv})}_{\text{Convenience yield on bunds}} * \underbrace{\omega}_{\text{ECB portfolio weight on bunds}} * \underbrace{\alpha_1}_{\text{Weight of bunds in ECB's government bond portfolio}}$$

5. Estimating the convenience-maximizing reserve supply for the US

Yield spreads on reserves (relative to inconvenient assets)

Monthly data, 2009M1-2023M4

Spread on reserves (in %)



- Use effective federal funds rate for short market rate r

$$EFFR - IOR = v'_R(R) - \varphi$$

April 2023: $v'_R(\cdot) - \varphi$ around -7 bps

5. Estimating the convenience-maximizing reserve supply for the US

Estimating reserve demand: Lopez-Salido and Vissing-Jorgensen (2023)

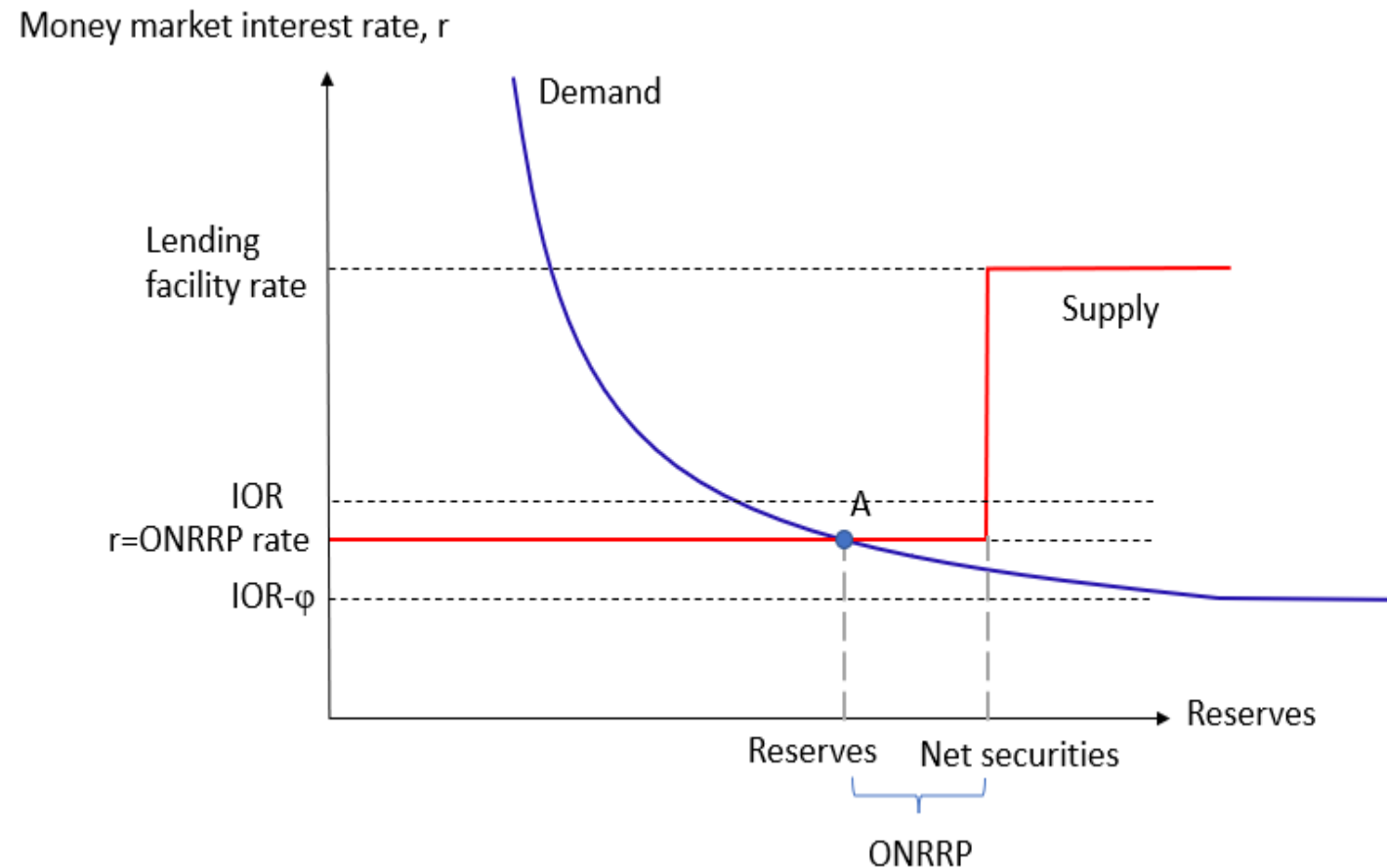
- $v'_R(\cdot) - \varphi$ **log-linear** in (excess) reserves and deposits. Demand shock, u

$$\begin{aligned} v'_R(\text{Reserves}, \text{Deposits}) - \varphi &= a + b * \ln(\text{Excess Reserves}) + c * \ln(\text{Deposits}) + u \\ \text{EFFR} - \text{IOR} &= a + b * \ln(\text{Excess Reserves}) + c * \ln(\text{Deposits}) + u \end{aligned}$$

- Monthly data, 2009M1-2023M4
- **Both excess reserves and deposits are nominal** so account for prices changes
- Instrument excess reserves with **reserves+ONRRP**
- Instrumenting for deposits has little effect. **Controlling for deposits is crucial.**
- Using **liquid deposits** gives similar results

5. Estimating the convenience-maximizing reserve supply for the US

<i>Fed Assets</i>	<i>Fed Liabilities</i>
Securities	Currency, government deposits: Autonomous factors
Loans to banks	Reserves
	ONRRP



$$\text{Reserves} = \underbrace{[\text{Securities} - \text{Autonomous factors}]}_{\text{Net securities}} + \underbrace{\text{Loans to banks}}_{\substack{\text{Reserves borrowed} \\ \text{from the central bank} \\ \text{by banks}}} - \underbrace{\text{ONRRP}}_{\substack{\text{Reserves lent} \\ \text{to the central bank} \\ \text{by non-banks}}}$$

- Along a horizontal part of the supply curve: Reserve demand shocks affect reserves
- Instrument excess reserves with Reserves+ONRRP (=Net sec's when loans to banks are small)

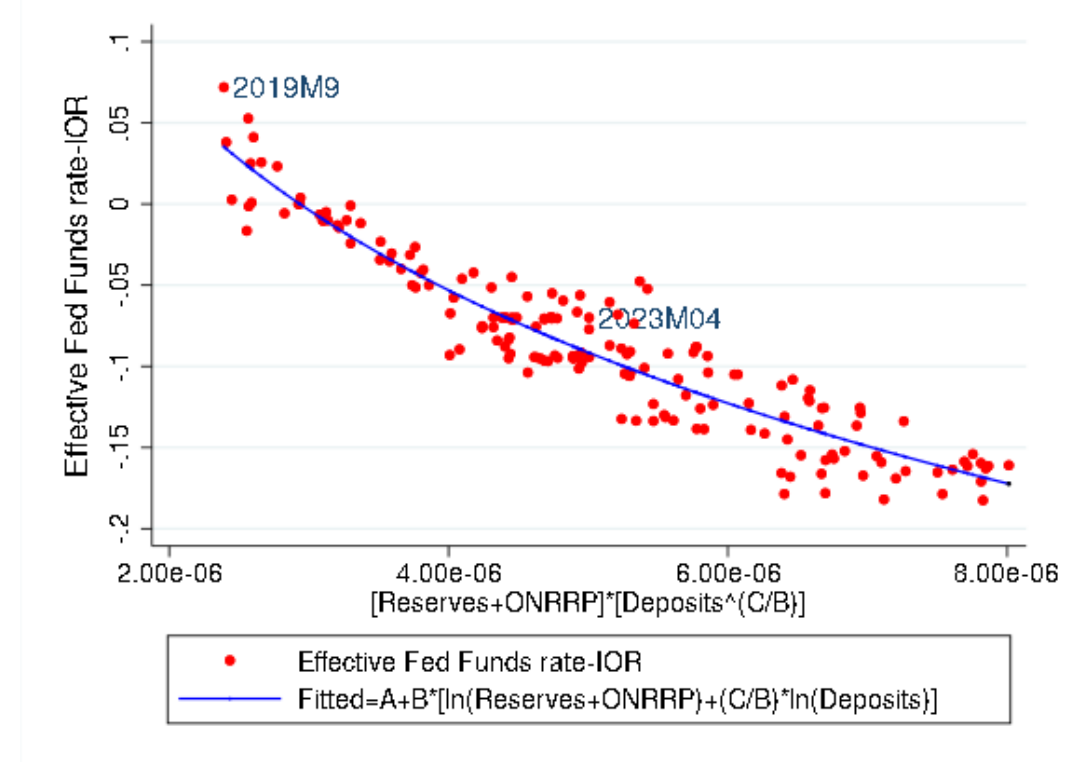
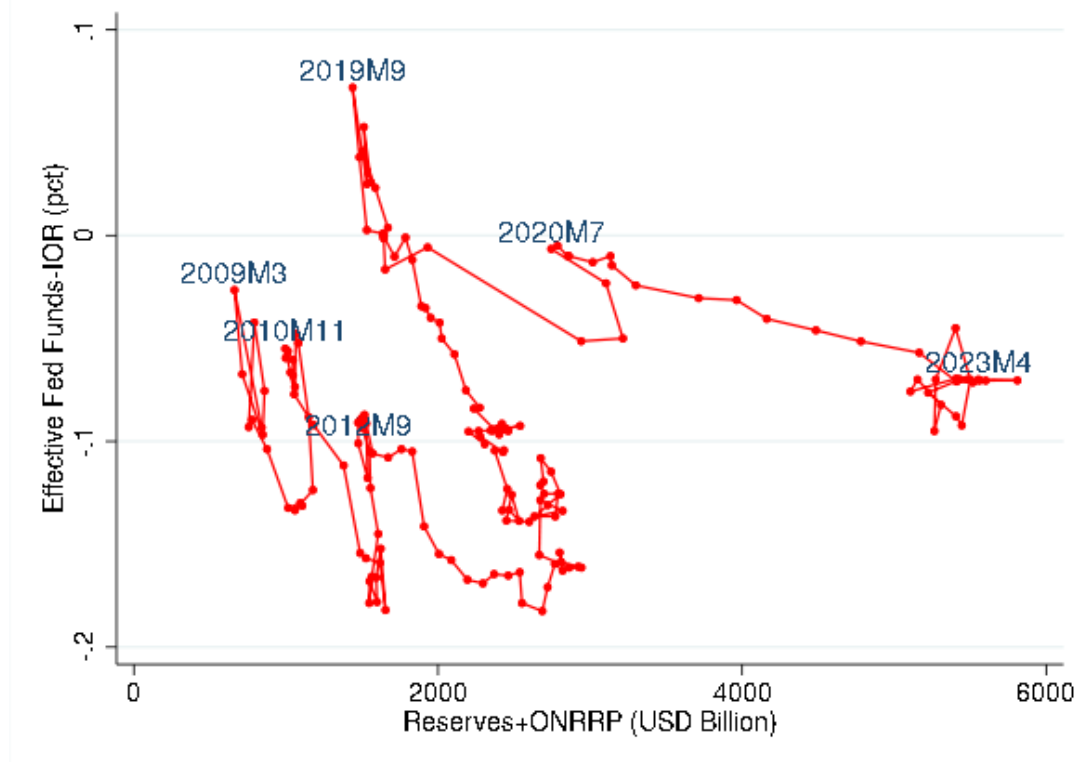
5. Estimating the convenience-maximizing reserve supply for the US

- Reduced form of IV:

$$EFFR - IOR = A_R + B_R * \ln(Reserves + ONRRP) + C_R * \ln(Deposits) + U$$

$$= A_R + B_R * \ln \left[\underbrace{(Reserves + ONRRP) * (Deposits)^{\frac{C_R}{B_R}}}_{\text{Deposit-adjusted Reserves+ONRRP supply}} \right] + U$$

$\widehat{A}_R = -2.186, \widehat{B}_R = -0.172, \widehat{C}_R = 0.367$, all sign. at 1% level (w/autocorr. up to 12 monthly lags). $R^2 = 0.89$

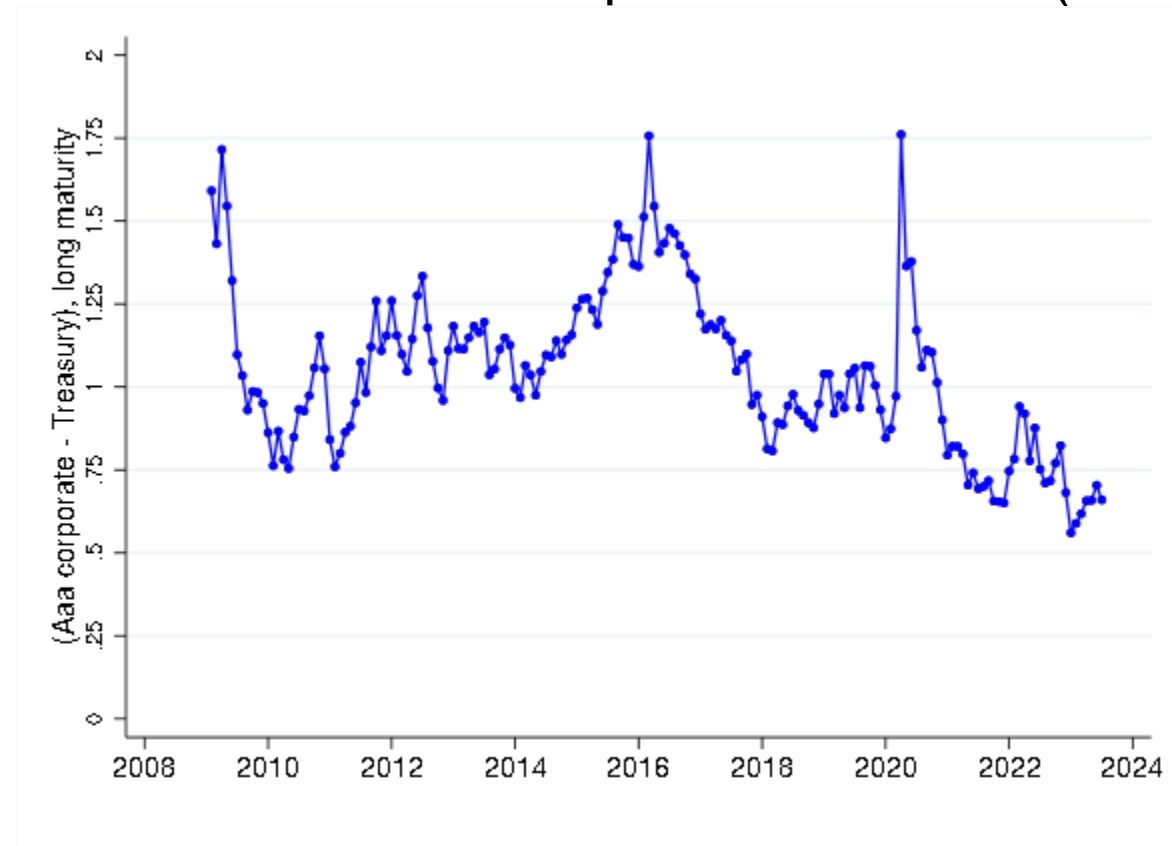


5. Estimating the convenience-maximizing reserve supply for the US

Yield spreads on Treasuries (relative to inconvenient assets)

Monthly data, 2009M1-2023M4

Spreads on Treasuries
relative to corporate securities (in %)

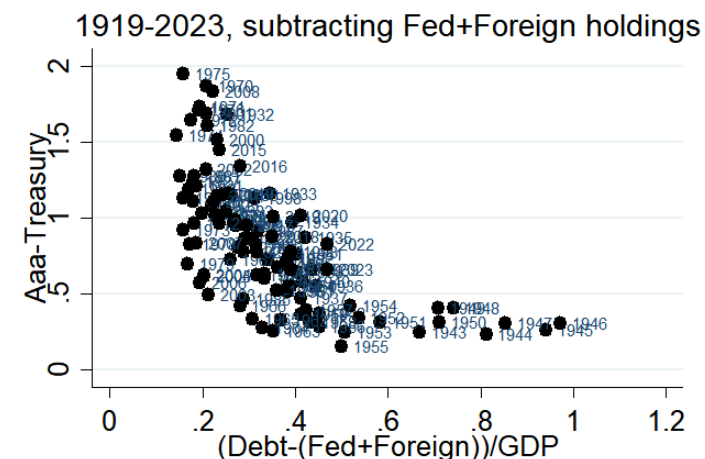
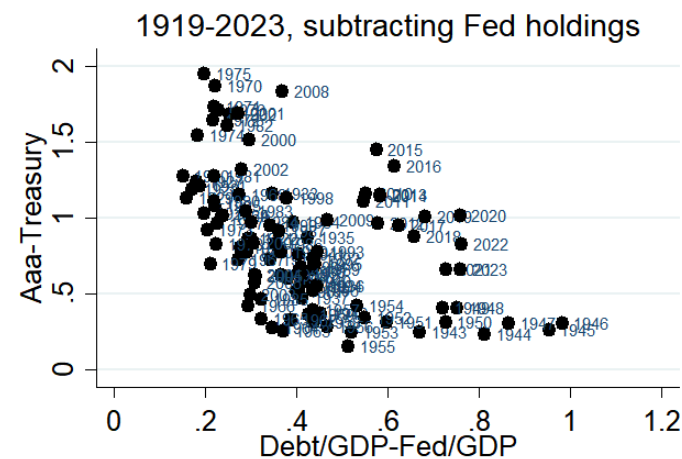
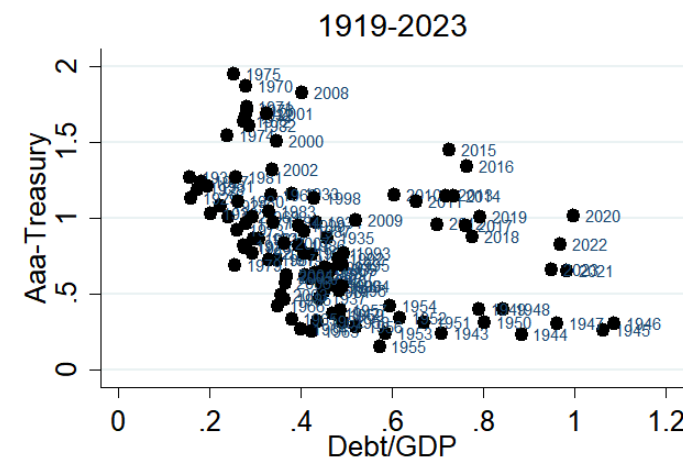
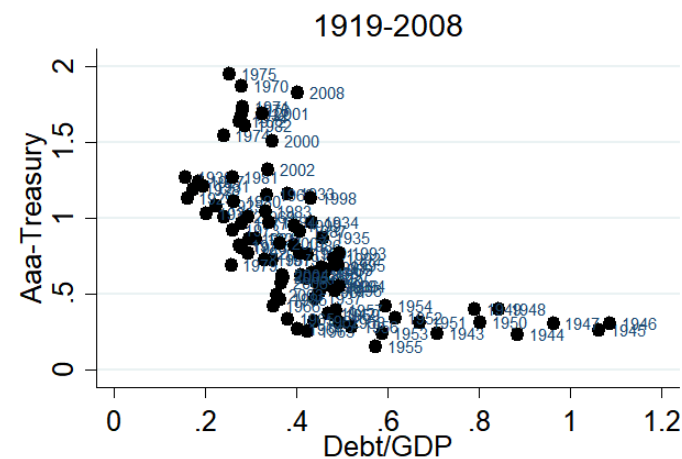


- $y^{Aaa} - y^{Treasury}$: Large across the sample
 - April 2023: 66 bps
 - Default component: Around 31 bps
 - Convenience yield: $v'_T(.)$ around 35 bps
- Use **Aaa - Treasury spread** (adjusted for default) as measure of **Treasury conv. yield in general**
 - Not much **term structure** in the Treasury convenience yield down to at least 3 years
 - Could use a weighted avg. of Aaa-Treasury & CP-Bill spreads

5. Estimating the convenience-maximizing reserve supply for the US

Estimating Treasury demand: Build on Krishnamurthy and Vissing-Jorgensen (2012)

Annual data, 1919-2023:



- **Top left:** $v'_T\left(\frac{Treasuries}{GDP}\right)$
- **Top right:** Demand shifted right post-GFC

Due to Fed & foreign demand shocks

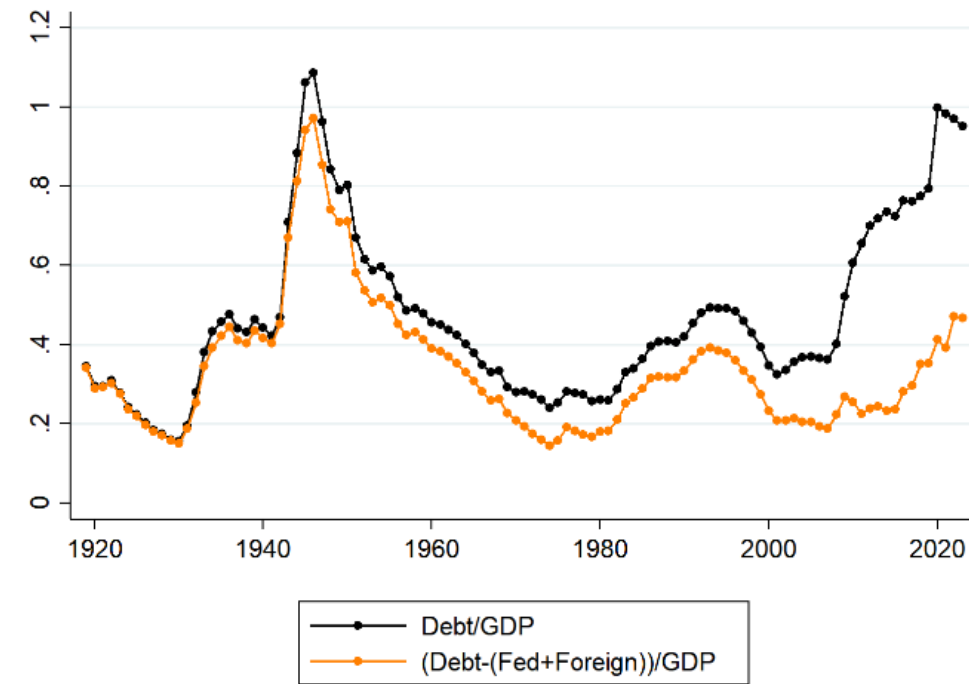
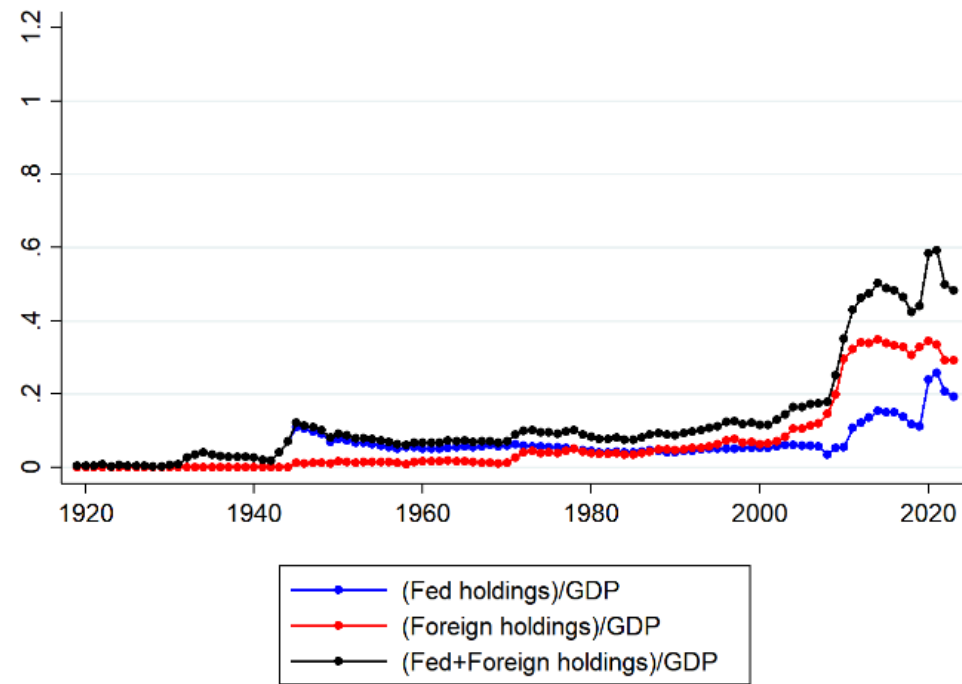
- **Bottom left:** Role of Fed demand shocks
- **Bottom right:** Role of foreign demand shocks

Convenience-maximization:

- Need $v'_T\left(\frac{Treasuries^{Private}}{GDP}\right)$ (bottom left)

5. Estimating the convenience-maximizing reserve supply for the US

Treasury holdings of Federal Reserve and foreigners Annual data, 2019-2023



5. Estimating the convenience-maximizing reserve supply for the US

Estimating Treasury demand:

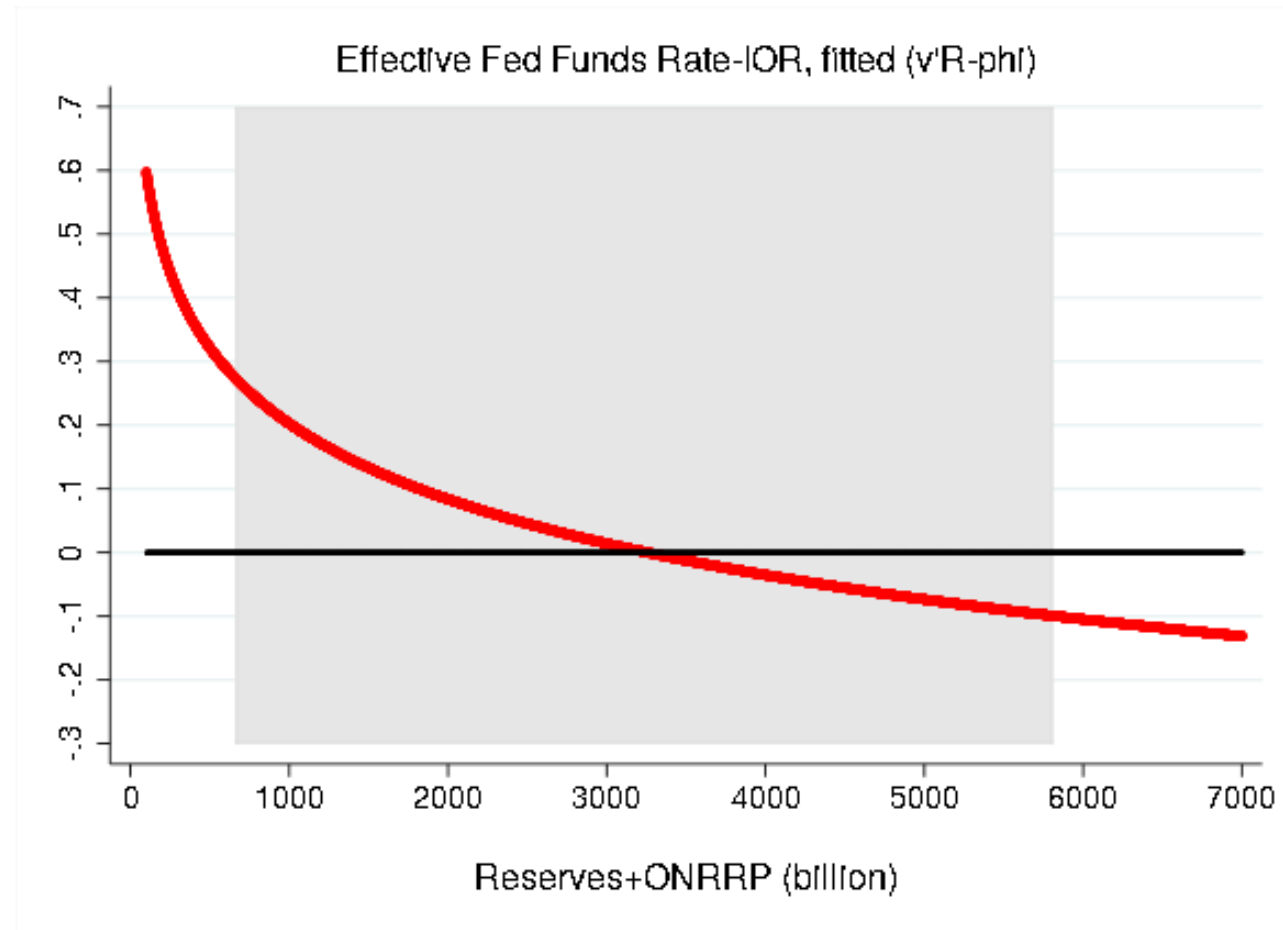
- $v'_T\left(\frac{\text{Treasury}^{\text{Private}}}{\text{GDP}}\right)$ log-linear in Debt/GDP
- Accounting for demand shocks post-GFC and estimating default component as asymptote (C_T):

$$y^{\text{Aaa}} - y^{\text{Treasury}} = \max(A_T + B_T * \ln\left(\frac{\text{Treasury}^{\text{Private}}}{\text{GDP}}\right) + \sum_{i=2009}^{2023} \beta_i D(\text{year} = i), C_T) + U$$

- Annual data, 1919-2023
 - $\widehat{A}_T = -0.219$, $\widehat{B}_T = -0.933$, $\widehat{\beta}_{2023} = 0.620$, $\widehat{C}_T = 0.306$
 - $R^2 = 0.91$ (0.89 on original sample from 1919-2008)
 - \widehat{B}_T , $\widehat{\beta}_{2023}$, \widehat{C}_T (but not \widehat{A}_T) significant at 1% level (accounting for autocorrelation up to 10 annual lags)

5. Estimating the convenience-maximizing reserve supply for the US: Case A

April 2023:



Gray shaded area: Range of data used in estimation

- **Red line:** Fitted $v'_R(\cdot) - \varphi$

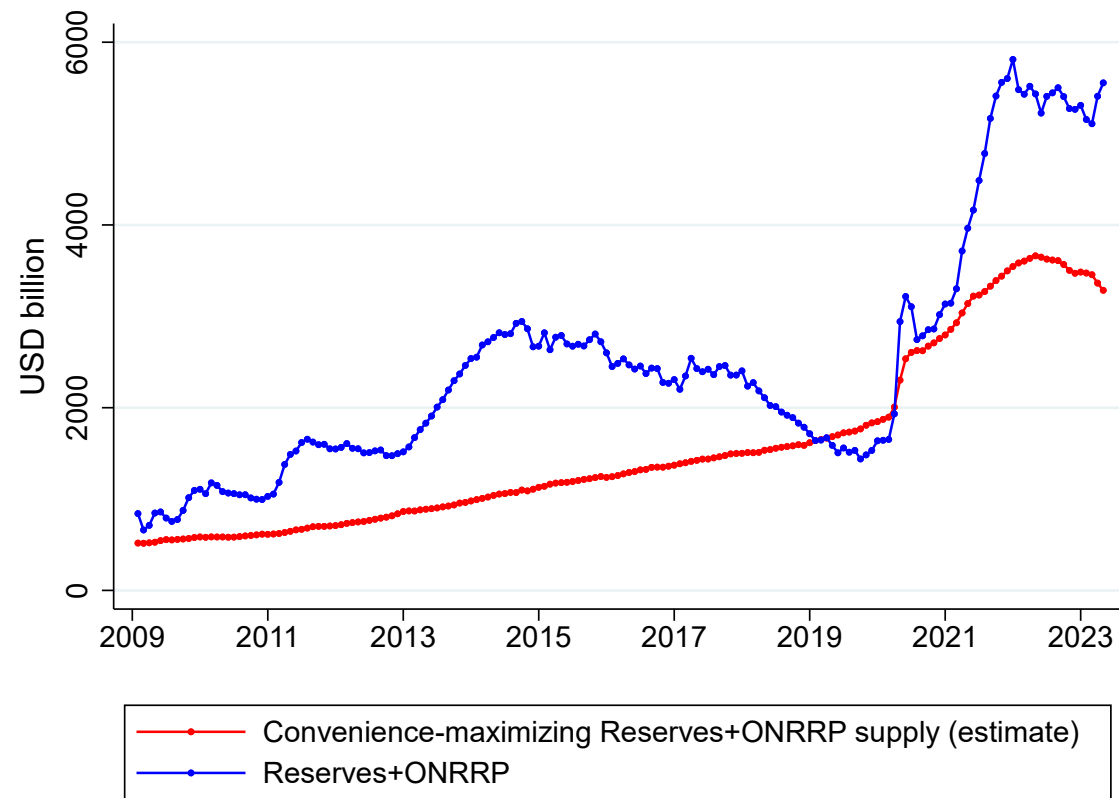
$$v'_R(\cdot) - \varphi = \widehat{A}_R + \widehat{B}_R * \ln(\text{Reserves} + \text{ONRRP}) + \widehat{C}_R * \ln(\text{Deposits})$$

using deposits for April 2023: **\$17.2T**

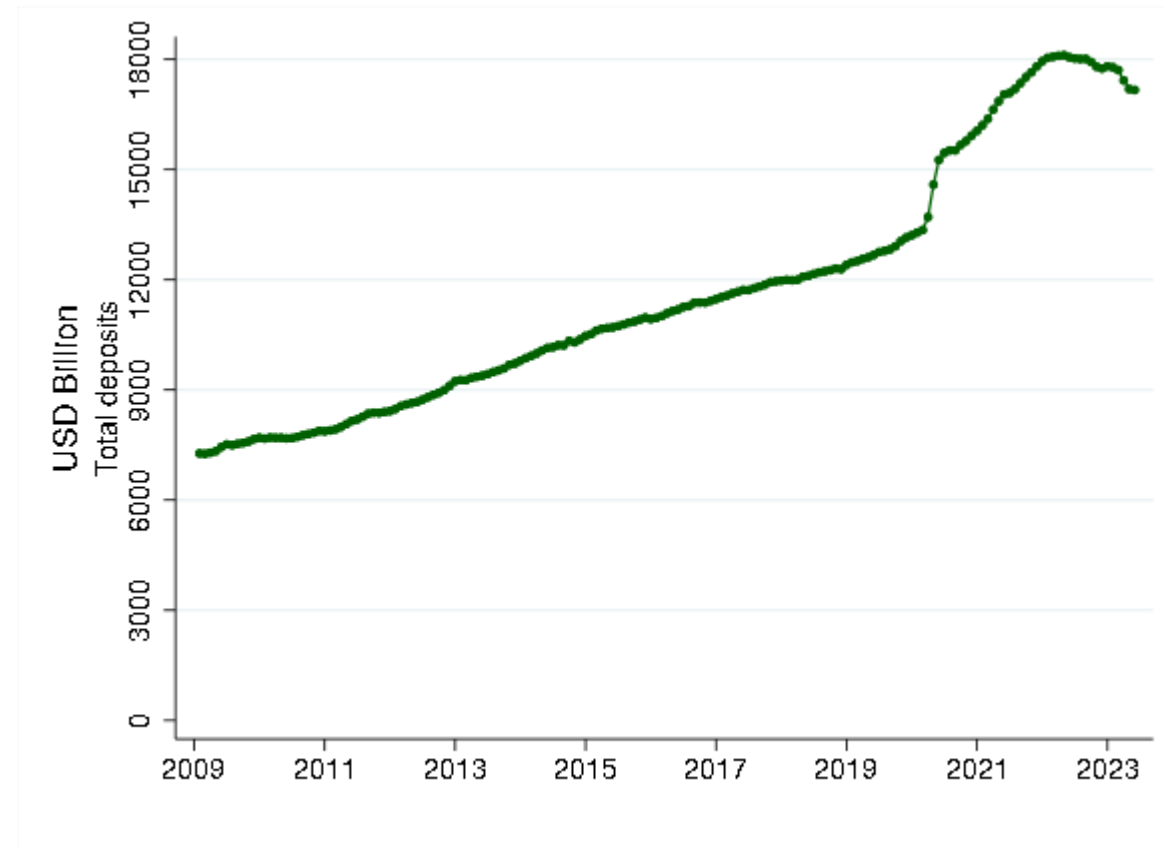
- $v'_R(\cdot) - \varphi = 0$: **Reserves+ONRRP=\$3.257T**
(Actual=\$5.6T in Apr 2023, \$4.5T in Oct 2023)
- **Survey of Primary Dealers, Sept. public data:**
Expected Reserves+ONRRP, 2025Q4
= \$3.338T (median response)

5. Estimating the convenience-maximizing reserve supply for the US: Case A

Conv. max. supply over time

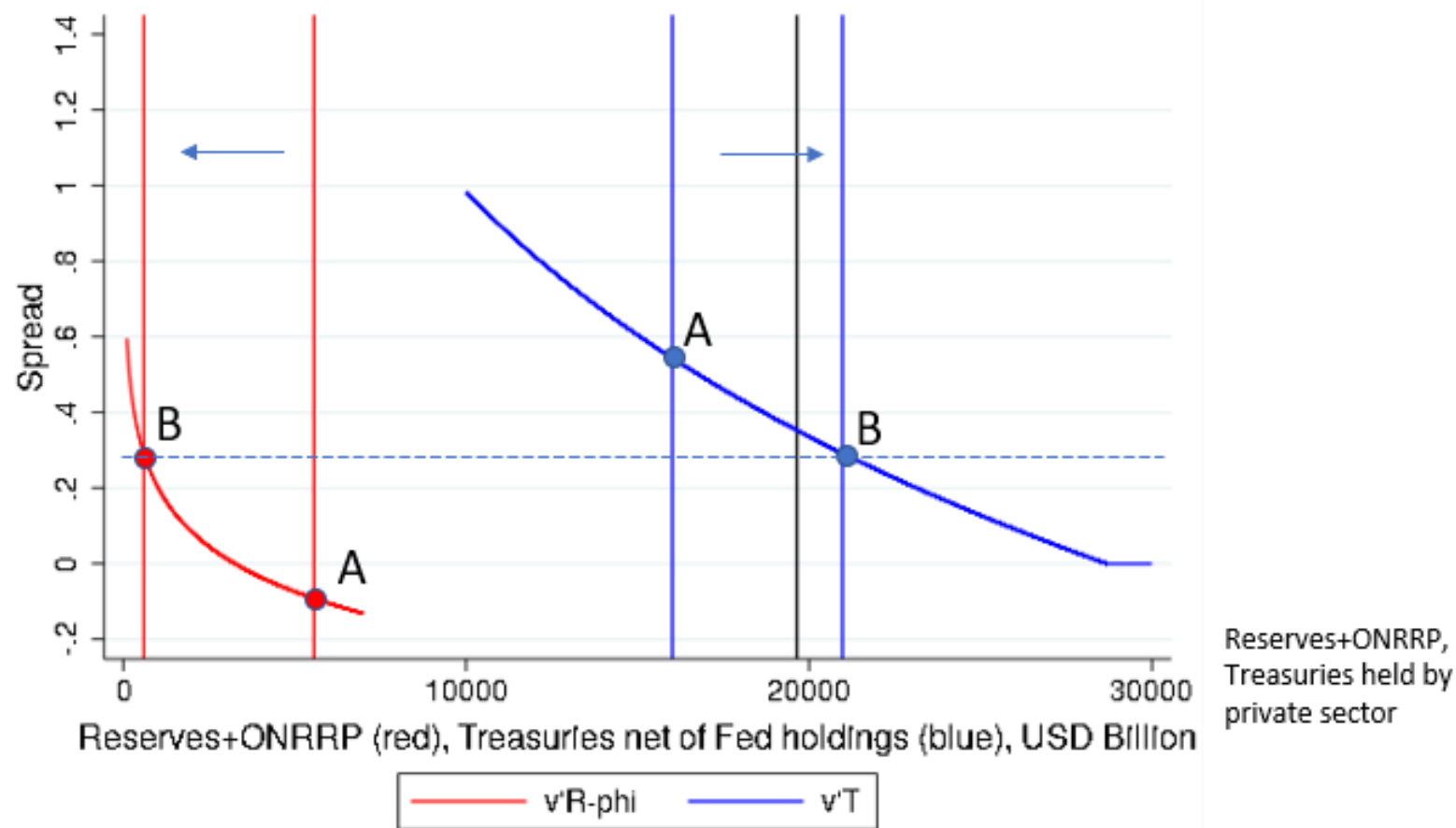


Deposits



5. Estimating the convenience-maximizing reserve supply for the US: Case B

April 2023:



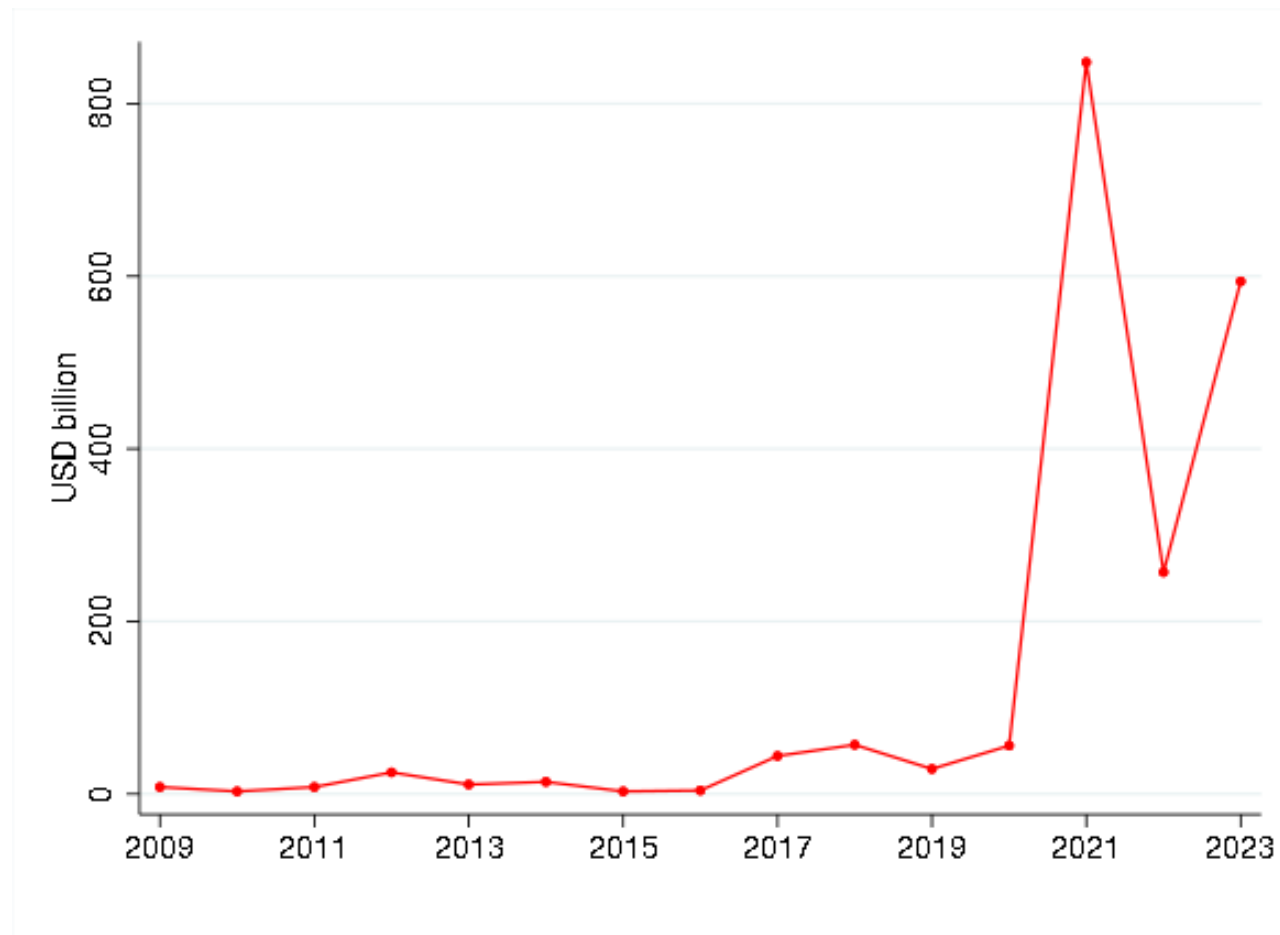
Vertical black line: $Treasuries^{Private}$ given that Fed currently holds Treas. and MBS

- **Red:** $v'_R(.) - \varphi$ given current deposits
- **Blue:** $v'_T \left(\frac{Treasuries^{Private}}{GDP} \right)$ given current GDP
- **A:** Locations at **current** Reserves+ONRRP if Fed only held Treasuries
- **B:** Locations at **convenience-maximizing** Reserves+ONRRP if Fed only holds Treasuries

Convenience yields equalized at **29 bps**
Reserves+ONRRP=\$593B (slightly below lowest value \$662B used in estimation)

5. Estimating the convenience-maximizing reserve supply for the US: Case B

Conv. max. supply over time



- Conv. max. value x (R^B) for year i solves:

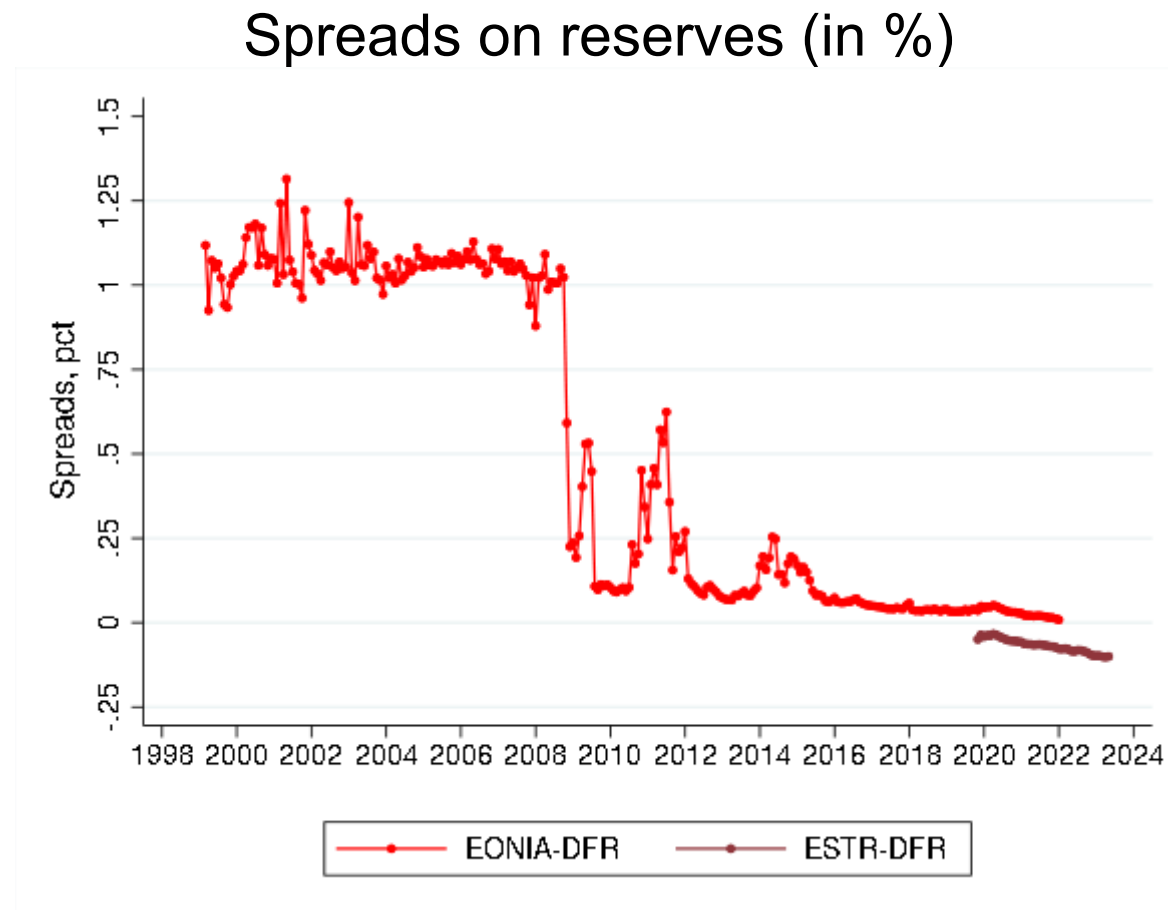
$$\widehat{A}_R + \widehat{B}_R * \ln(x) + \widehat{C}_R * \ln(\text{Deposits})$$
$$= \max \left(\widehat{A}_T + \widehat{B}_T * \ln \left(\frac{\text{Treasuries} - [x + AF]}{GDP} \right) + \hat{\beta}_i - \widehat{C}_T, 0 \right)$$

- Fluctuations over time due to:
 - Deposits, GDP, Treasuries, autonomous factors
 - Shifts in Treasury convenience yield curve $\hat{\beta}_i$
- $\text{Deposits} \uparrow \rightarrow$ Reserves scarcer $\rightarrow R^B \uparrow$
- $\text{Treasuries} \uparrow \rightarrow$ Treasuries are less scarce $\rightarrow R^B \uparrow$

5. Estimating the convenience-maximizing reserve supply for the euro area

Yield spreads on reserves (relative to inconvenient assets)

Monthly data, 1999M2-2023M4



- Measure $v'_R(.) - \varphi$ by:
ESTR (or EONIA-8.5 bps)-DFR
April 2023: **-10 bps**
- Spike around European sovereign debt crisis, likely related to bank default-risk → Estimate euro area reserve demand for **2013M1-2023M4**

5. Estimating the convenience-maximizing reserve supply for the euro area

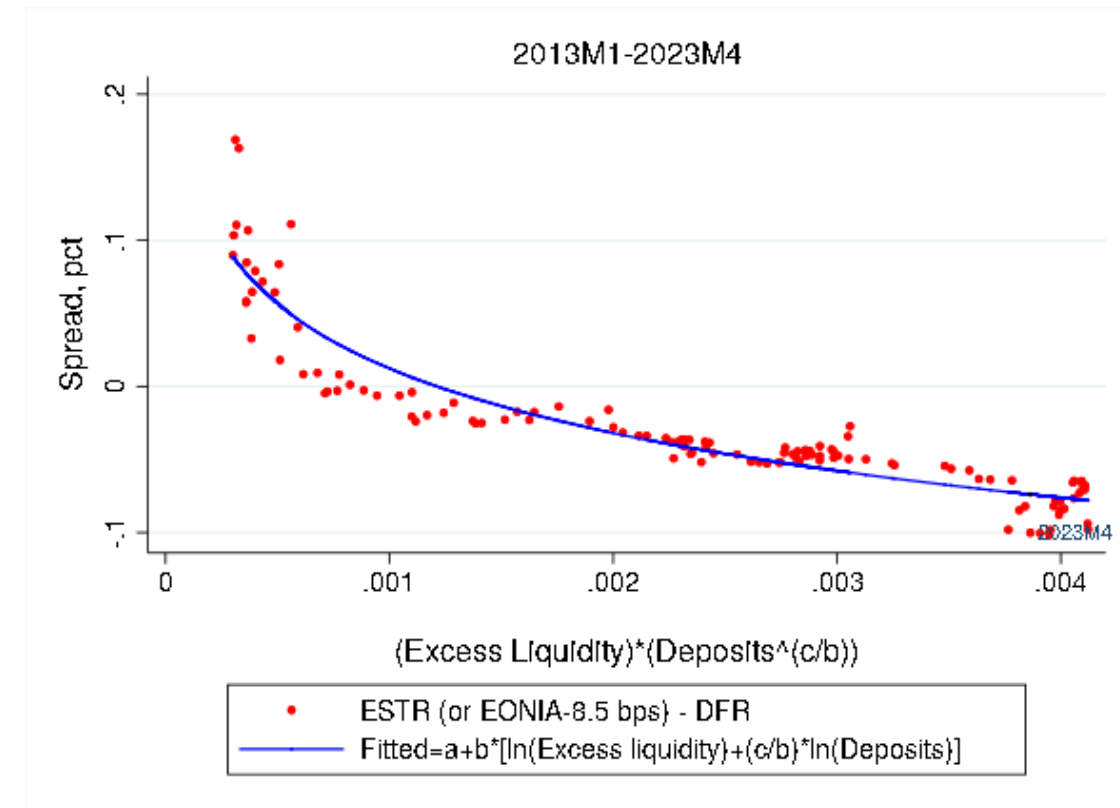
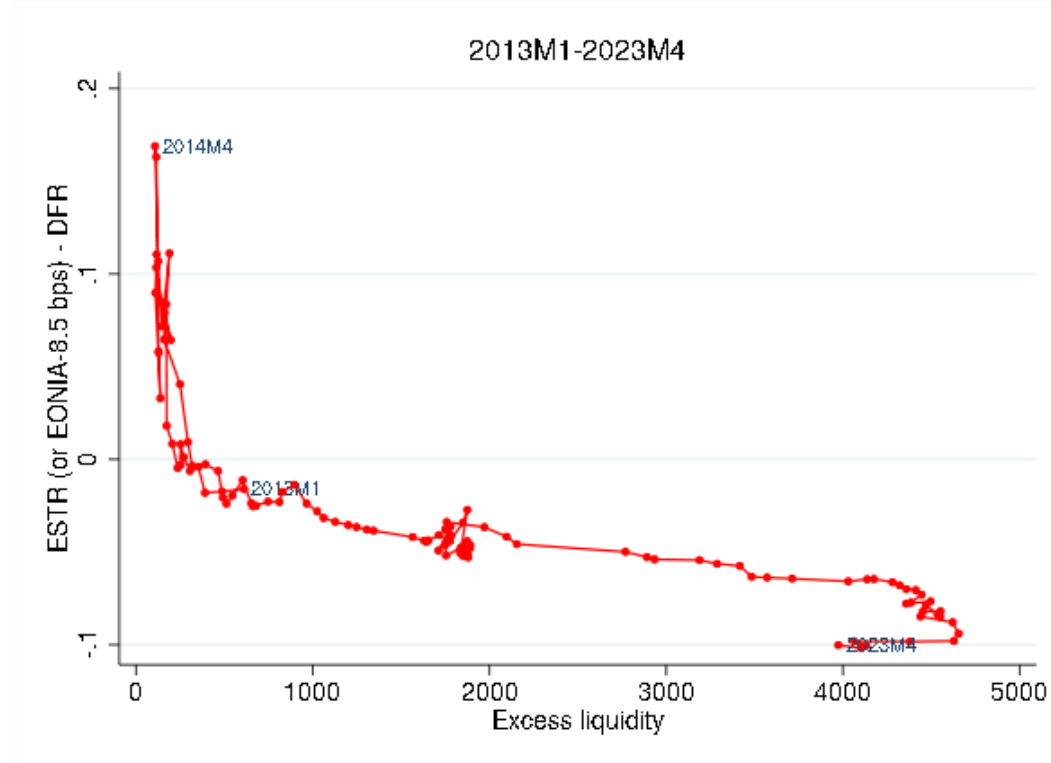
Estimating reserve demand

$$\begin{aligned} ESTR - DFR &= a + b * \ln(Excess Liquidity) + c * \ln(Deposits) + u \\ &= a + b * \ln \left[\underbrace{(Excess Liquidity) * (Deposits)^{\frac{c}{b}}}_{Deposit-adjusted\ excess\ liquidity\ supply} \right] + u \end{aligned}$$

- Excess liquidity (excess reserves) = [Current account+Deposit facility]-[Required reserves]
- No ONRRP facility → Don't need to instrument for reserves
- Fit slightly better controlling for overnight deposits rather than total deposits
- Monthly data, 2013M1-2023M4
 - $\hat{a} = -0.428$, $\hat{b} = -0.064$, $\hat{c} = 0.097$
 - b and c significant at the 1% level (a at 10% level) accounting for autocorr. up to 12 monthly lags
 - $R^2 = 0.87$

5. Estimating the convenience-maximizing reserve supply for the euro area

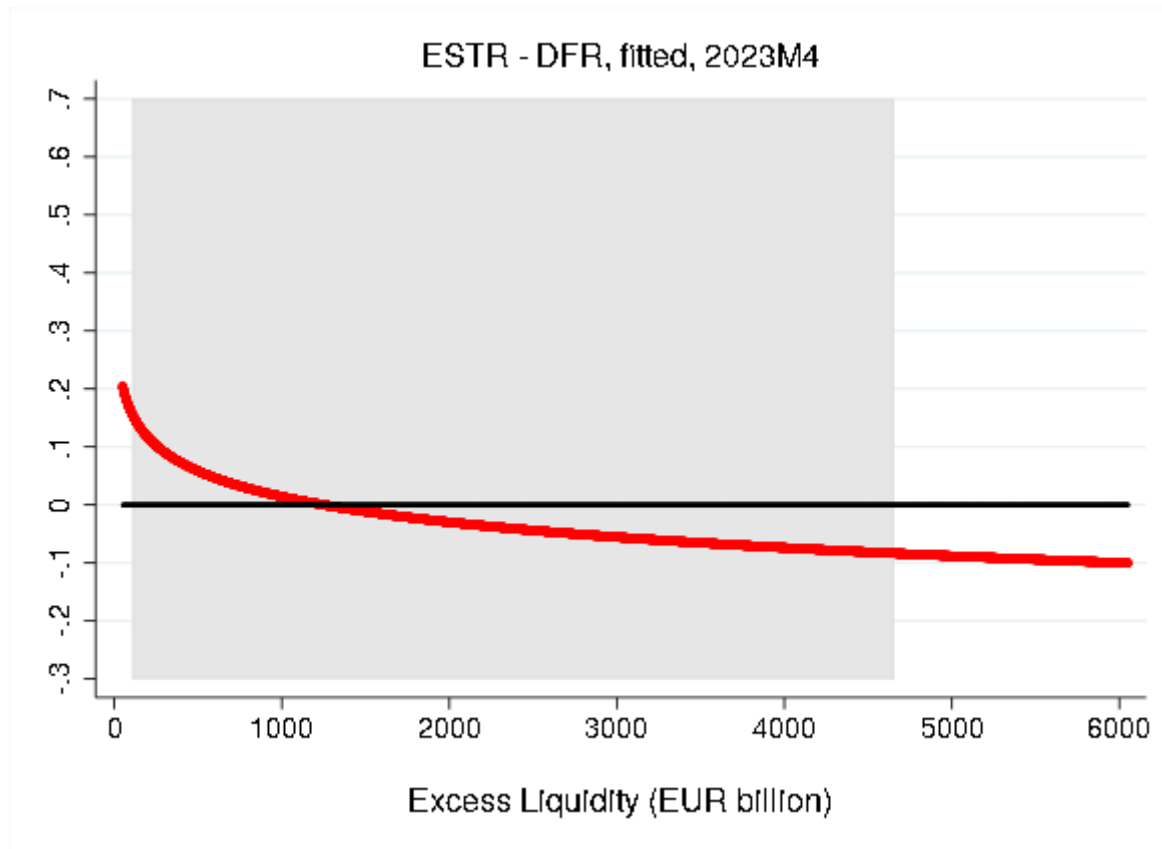
Estimating reserve demand



- Correlation($\ln(\text{Excess liquidity})$, $\ln(\text{Deposits})$)=0.94 (0.86 for the US)
- But ignoring deposits would incorrectly give constant convenience-maximizing supply for all years
- Could try other **functional forms** to get more curvature for low deposit-adjusted excess liquidity supply

5. Estimating the convenience-maximizing reserve supply for the euro area: Case A

April 2023:



Gray shaded area: Range of data used in estimation

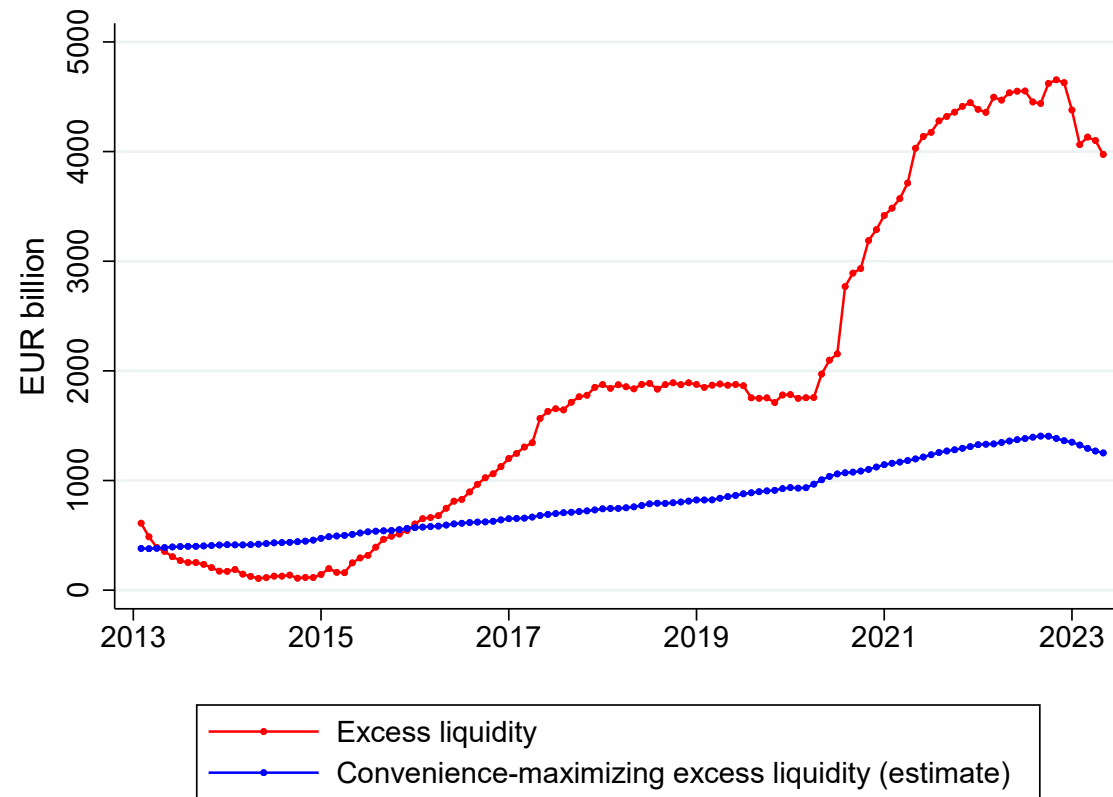
- **Red line:** Fitted $v'_R(\cdot) - \varphi$
$$v'_R(\cdot) - \varphi = \hat{a} + \hat{b} * \ln(\text{Excess Liquidity}) + \hat{c} * \ln(\text{Deposits})$$

using overnight deposits for April 2023: € 9.4T
- $v'_R(\cdot) - \varphi = 0$:

Excess liquidity	= € 1.251T
+ Required reserves	€ 165B
Liquidity	= € 1.416T
- Likely somewhat higher than the true convenience-maximizing value (functional form issue mentioned)

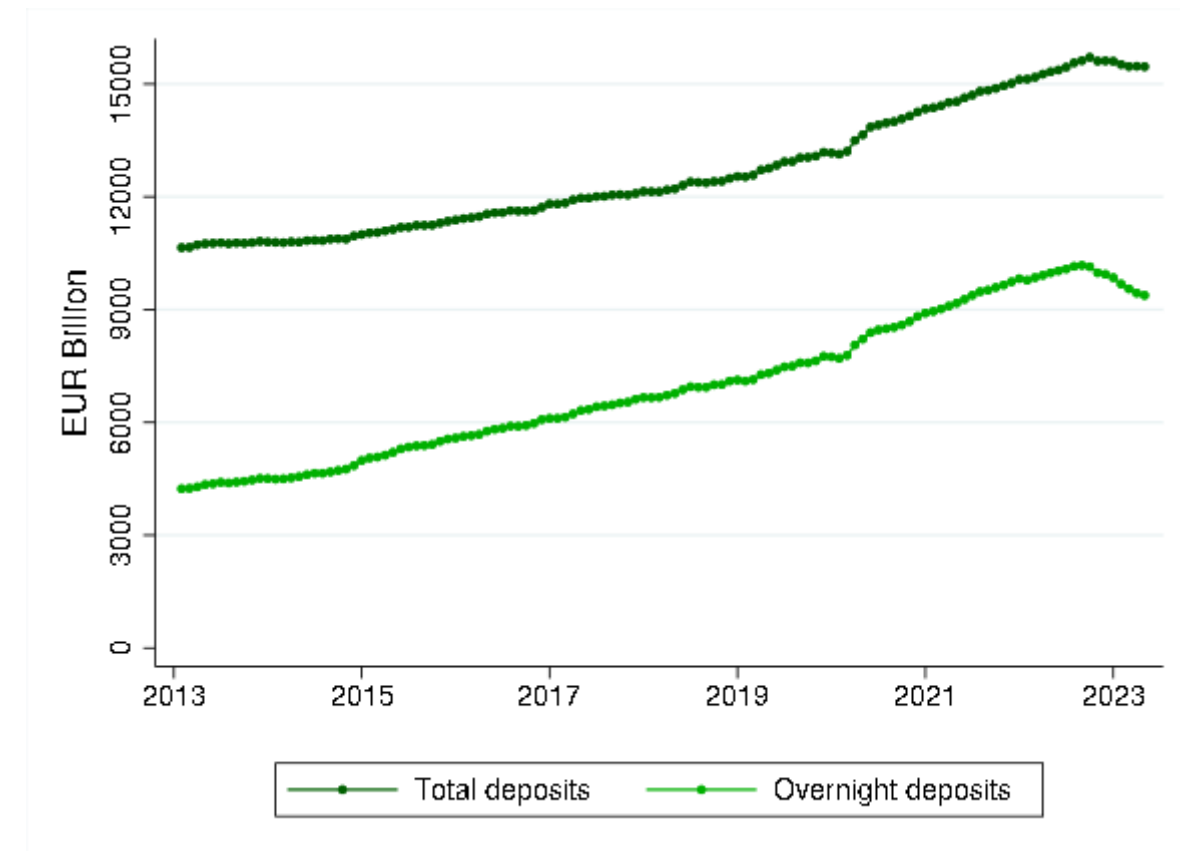
5. Estimating the convenience-maximizing reserve supply for the euro area: Case A

Conv. max. supply over time



Conv. max. value of excess liquidity grows from under €400B in 2013M1 to €1.25T in 2023M4

Deposits

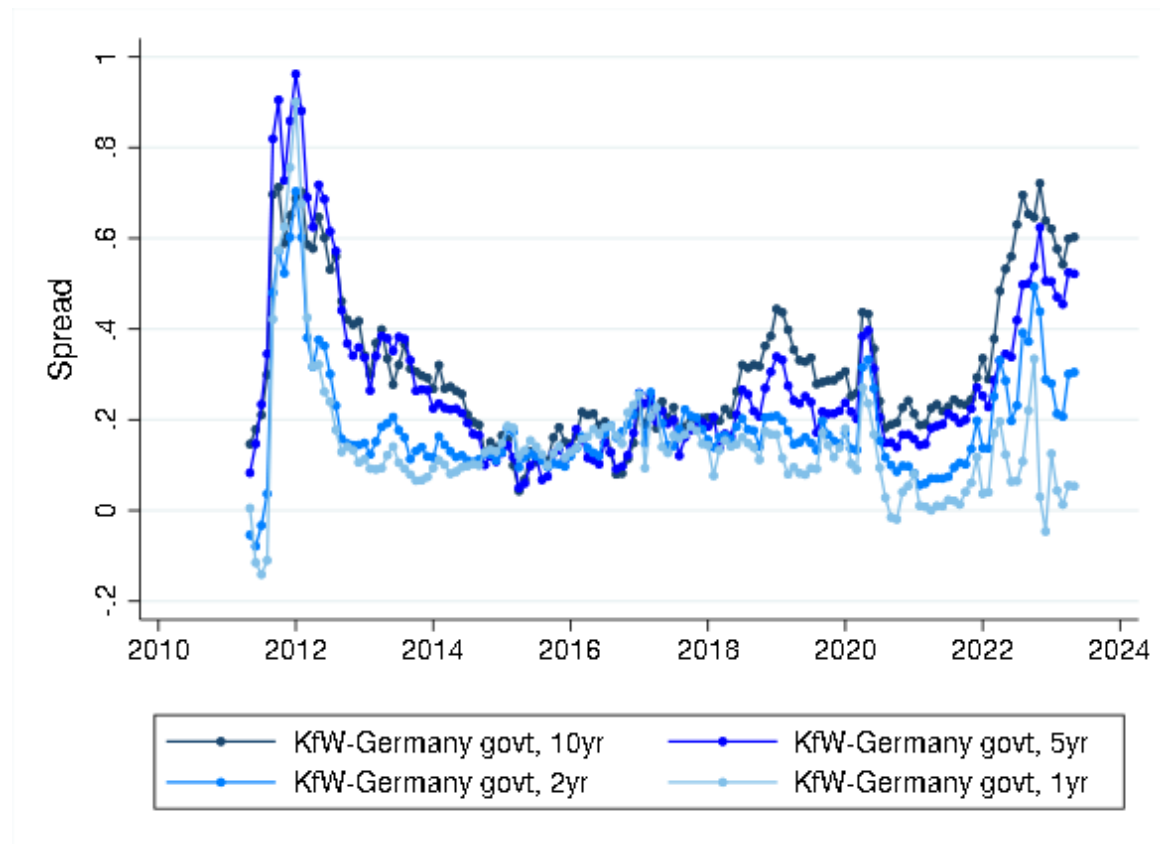


Driven by growth in overnight deposits:
Increase from € 4.3T in 2013M1 to € 9.4T in 2023M4

5. Estimating the convenience-maximizing reserve supply for the euro area: Case B

ECB can supply reserves via inconvenient assets. Does that matter? Yes

Spreads on government bonds: Germany



Measure **Bund conv. yield** by **KfW - Bund** spread

- April 2023: 10-year maturity: **60 bps**
2-year maturity: **30 bps**
- If **ECB** supplied reserves via govt. bonds only ($\omega = 1$), in proportion to **capital key** (Germany: $\alpha_1 = 0.214$) and **only German Bunds (B_1)** have convenience yields

$$v'_R(R) - \varphi = \underbrace{v'_B(B_1^{priv})}_{\text{Around 40 bps}} * \underbrace{\omega}_{=1} * \underbrace{\alpha_1}_{=0.214}$$

will fall as B_1^{priv} increases

$$\rightarrow v'_R(R^B) - \varphi \leq 8 \text{ bps}$$

$$\rightarrow \text{Liquidity} \geq \mathbf{\text{€}521\text{B}}, < \mathbf{\text{€}1.4\text{T}}$$

Conclusion

Laid out framework for thinking about **balance sheet policy when $r > \text{ELB}$** : Central role of **convenience yields**

“**Convenience-maximizing**” reserve supply:

- Depends on **asset choice** which is affected by **political constraints**
- **Changes over time** with the inputs the calculation (deposits, Treasury supply etc.)
- **Is just one input** into thinking about optimal balance sheets, in addition to other factors

(a) If reserves are supplied via central bank holdings of assets **without convenience yields**:

$$v'_R(\cdot) - \varphi = 0$$

ECB?

(b) If reserves are supplied via central bank holdings of assets **with convenience yields**:

$$v'_R(\cdot) - \varphi = v'_B(\cdot)$$

Federal Reserve?

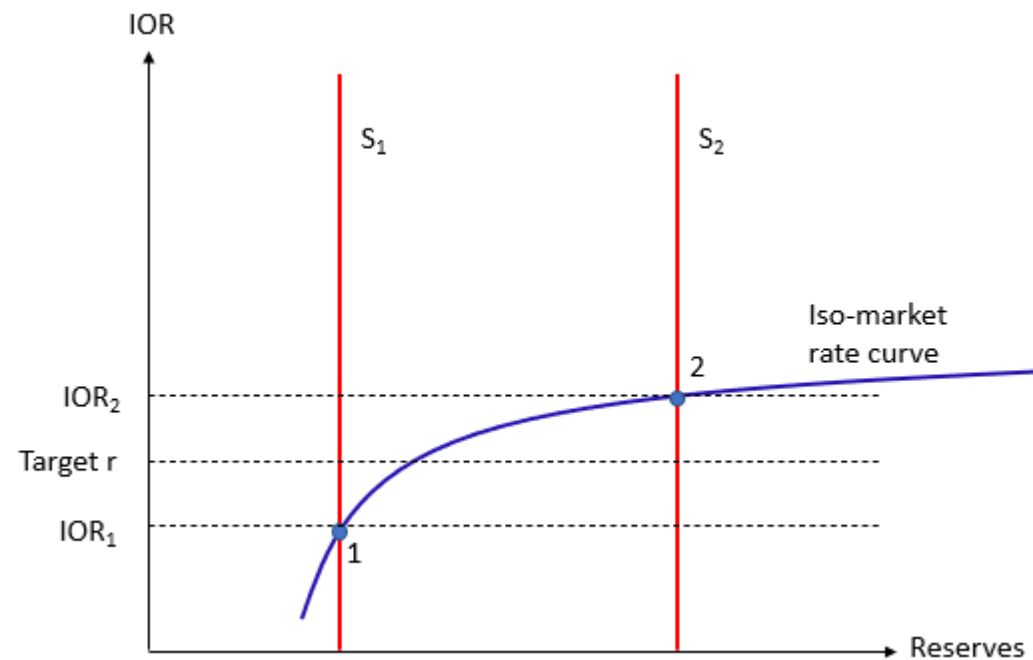
1. Reminder: Too many tools above the ELB

Most relevant: Iso-market rate curve for **long market rate** (better summarizes overall policy stance)

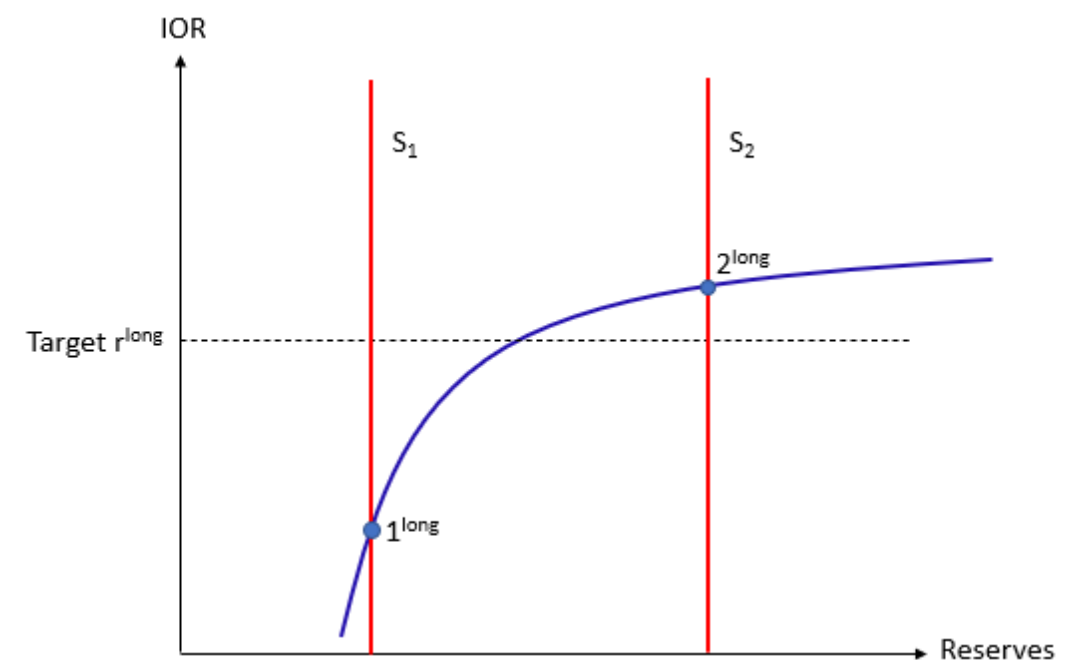
$$r = IOR + v'_R(\text{Reserves}, \text{Deposits}) - \varphi + \text{Risk Premium} \text{ (for duration/pre-payment/credit risk)}$$

- Reserves up $\rightarrow v'_R(\text{Reserves}, \text{Deposits}) - \varphi$ down and *Risk Premium* down
- Larger increase in IOR needed to hit a given long rate than a given short rate
- Same conclusion: Many (IOR, reserves) combination given similar policy stance

Iso-market rate curve for short rate



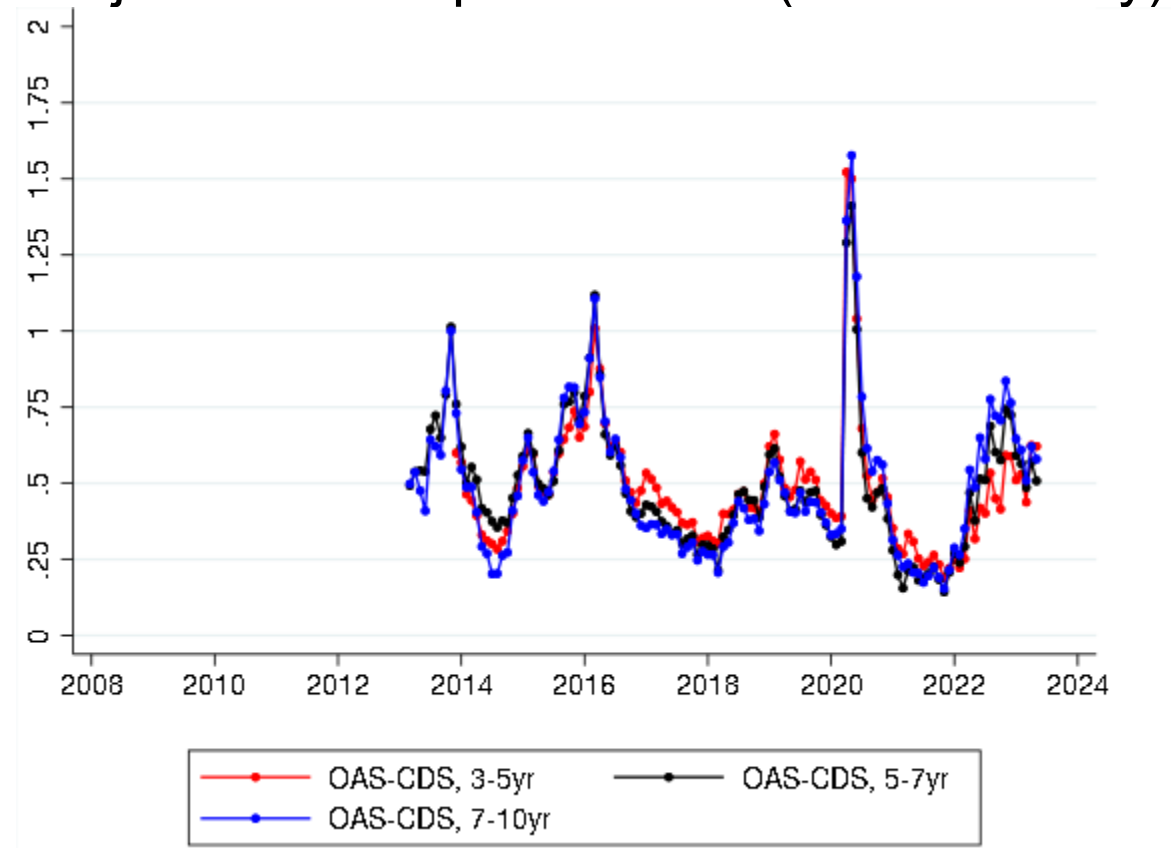
Iso-market rate curve for long rate



5. Estimating the convenience-maximizing reserve supply for the US

Monthly data, 2009M1-2023M4

Spreads on Treasuries relative to corporates
adjusted for corporate CDS (and callability)



Alternative approach to measure Treasury convenience yield

- Adjust for corporate default risk using **CDS rate** on corporate bonds
 $(y^{Corporate} - y^{Treasury}) - (\text{Corporate CDS rate})$
- Adjust for callability of corporate bonds w/**option-adjusted spread** (relative to Treasuries)
 $OAS - \text{Corporate CDS rate}$
April 2023: $v'_T(.)$ between 51 and 62 bps
→ *Not much term structure past 3 yr*