Liquidity, liquidity everywhere, not a drop to use

Why flooding banks with central bank reserves may not expand liquidity

- Viral V Acharya (NYU Stern) and Raghuram G Rajan (Chicago Booth)

April 2022
Conundrum: Where did all the liquidity go?

• Unprecedented expansion of central bank balance sheets since the Global Financial Crisis
  - “flooding banks with central bank reserves”

• Yet surprisingly fragile liquidity conditions in money markets
  - Unexpectedly large spikes in repo markets in September 2019:
    - Encumbrances on liquidity, exogenous shrinkage, unwinding of levered trades in Treasuries
  - Dash for cash in March 2020:
    - Corporate credit line drawdowns on banks, lack of adequate market-making

• What will happen when the Fed shrinks its balance sheet?
Traditional view: Exogenous demand for liquidity

Price of Liquidity = Supply of Reserves

Exogenous demand for liquidity

- As demand is exogenous, increasing supply of reserves is stabilizing
Effective Fed Funds Rate-IOR spread and Reserves to GDP

Source: Lopez-Salido and Vissing-Jorgensen (2022)
Liquidity demand is endogenous to reserves

Supply of Reserves vs. Liquidity claims against Reserves

Price of Liquidity =

• Supply of reserves creates its own demand, which can destabilize
Reserves versus Deposits

Values graphed are for the last month of the quarter, 2009Q1-2021Q3.

Source: Lopez-Salido and Vissing-Jorgensen (2022)
Spread vs Deposit-adjusted Reserves

Source: Lopez-Salido and Vissing-Jorgensen (2022)
Our paper: Three important considerations

I. *Ex ante*: How are the reserves financed?

- When reserves are injected via asset purchases from non-banks, they typically deposit reserves in banks.
- Do banks rebalance these deposits with new capital issuances, or are reserves financed with deposits (and deposit-like) claims?
- The way reserves are financed matters as demand deposits will be a claim on reserves in future.
Some evidence on the financing of reserves

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
<th>In million $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>Bonds</td>
<td>-112,030</td>
</tr>
<tr>
<td>Debt Securities</td>
<td>Holding company investment</td>
<td>332,381</td>
</tr>
<tr>
<td>Loans</td>
<td>Commercial paper</td>
<td>-86,743</td>
</tr>
<tr>
<td>misc</td>
<td>Loans</td>
<td>108,019</td>
</tr>
<tr>
<td>Repos</td>
<td>Miscellaneous</td>
<td>184,540</td>
</tr>
<tr>
<td><strong>Reserves</strong></td>
<td>Insured deposits</td>
<td>-810,496</td>
</tr>
<tr>
<td>713,351</td>
<td>Uninsured deposits</td>
<td>2,528,429</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>2,144,100</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
\text{Deposits/Total Liabilities} & = 0.80124 \\
\text{Deposits}/(\text{Cash+Securities+ Repos+ Reserves}) & = 1.43187 \\
\text{Deposits}/(\text{Repos+Reserves}) & = 2.51177 \\
\text{Uninsured deposits}/(\text{Repos+ Reserves}) & = 3.69679 \\
\text{Uninsured deposits}/(\text{Uninsured+ insured deposits}) & = 1.47179
\end{align*}
\]
Some evidence...

**Pandemic** (between March 2020 to end 2020)  In million $

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>Bonds</td>
</tr>
<tr>
<td>15,843</td>
<td>26,083</td>
</tr>
<tr>
<td>Debt Securities</td>
<td>Holding company investment</td>
</tr>
<tr>
<td>1,041,056</td>
<td>202,606</td>
</tr>
<tr>
<td>Loans</td>
<td>Commercial paper</td>
</tr>
<tr>
<td>289,404</td>
<td>26,651</td>
</tr>
<tr>
<td>misc</td>
<td>Loans</td>
</tr>
<tr>
<td>272,661</td>
<td>-227,272</td>
</tr>
<tr>
<td>Repos</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td>179,821</td>
<td>-125,790</td>
</tr>
<tr>
<td><strong>Reserves</strong></td>
<td>Insured deposits</td>
</tr>
<tr>
<td><strong>1,282,417</strong></td>
<td><strong>1,317,938</strong></td>
</tr>
<tr>
<td><strong>3,081,202</strong></td>
<td>Uninsured deposits</td>
</tr>
<tr>
<td></td>
<td><strong>1,719,650</strong></td>
</tr>
<tr>
<td></td>
<td><strong>2,939,866</strong></td>
</tr>
</tbody>
</table>

- Deposits/Total Liabilities 1.03324
- Deposits/(Cash+Securities+ Repos+ Reserves) 1.20581
- Deposits/(Repos+Reserves) 2.07736
- Uninsured deposits/(Repos+ Reserves) 1.17604
- Uninsured deposits/(Uninsured+ insured deposits) 0.56612

Change / Change
Three important considerations

II. *Ex post*: Are the reserves free to move around to meet claims?

- Unused liquid reserves are a drain on bank profits – therefore their liquidity services are sold so that they are “fully” utilized.
  - Yankov (2020): LCR announcement in 2010 and implementation starting 2014 coincident with increase in bank credit line provision to shadow banks
- Speculation: Conditions under which reserves are created may spur risk-taking and the associated need for margins, central clearing guarantee funds, etc., all provided by commercial banks.
- Regulation: liquidity requirements “lock up” reserves in stress scenarios (Diamond and Kashyap, 2016; Vandeweyer, 2019; others)
- Ratcheting: reserves level creates its own supervisory demand (Nelson, 2019)
Three important considerations

III. *Ex post*: Will banks with free reserves lend them out?

- There can be a “convenience yield” on reserves during times of stress
  - Copeland, Duffie and Yang (2021): High-reserve balance banks delayed inter-bank payments

- Some surplus banks fear “taint” from lending to needy.
  - Instead prefer to receive flight-to-safety deposits passively, rather than lend out reserves in inter-bank markets actively

=> Liquidity hoarding limits the ex post availability of reserves.
Our primary insight

• Central bank reserve expansion is run through bank balance sheets.
• Ordinarily, this will mean there is far less spare liquidity than suggested by the simple reserve expansion
• In *extremis*, the higher the reserves issued ex ante, more fragile the interbank markets and higher the inter-bank rates in stress
  - Adverse real consequences on investments (ex post as well as ex ante) -- as in Diamond and Rajan (2011), Shleifer and Vishny (2010), or Stein (2012)
Does this matter? Yes, alters policy prescriptions

• Seeing ex post stress, some economists recommend
  • More ex ante central bank balance-sheet expansion (Copeland, Duffie and Yang, 2021)
  • Moving target!

• Reserve issuance may not crowd out deposit-like claims, may in fact enhance it.
  • Greenwood, Hanson and Stein (2015, 2016): depends on whether public holds reserves or it is intermediated by banks.

• Central bank balance-sheet expansion is not an unmitigated good – may exacerbate financial fragility.
  • Monetary vs financial stability tradeoff
The Basic Model

Firms, Banks, Investors, ... Interbank markets to shuffle around liquidity
Firms, Banks, Depositors, Investors

- Banks and firms “regionally” or “sectorally” matched
- Firms and banks owners are risk-neutral, expected profit-maximizers
- Firms:
  - Invest at date 0 to obtain returns at date 2, funded by
    - Firm owners’ initial wealth
    - Term loans from banks
  - Place deposits with bank (equivalent to committed line of credit, net of fees)
Firms, Banks, Depositors, Investors

- Banks at date 0:
  - Assets
    - Illiquid term loan to their firm/sector
    - Liquid reserves that “shrink/are encumbered” at date 1 ($\tau$, exogenous for now...)
  - Liabilities I: (Unlimited) Uninsured deposits from risk-averse investors at date 0
    - Log-utility investors as in Stein (2012)
    - Wholesale uninsured corporate/hedge fund depositors
  - Liabilities II: (Limited) capital from deep-pocket risk-neutral investors (Warren Buffet) with due-diligence costs
    - Deadweight costs of capital issuance: $\frac{\alpha_t}{2} e_t^2$ at date t due to due diligence costs, agency, market power, illiquidity
Liquidity stress in the economy

- State of the economy \((y)\) at date 1
  - Economic stress occurs with probability \(q/\theta\), healthy otherwise.

- State of each bank-firm pair \((z)\)
  - Conditional on economy stress, probability \(\theta\) investment has to be rescued
  - Unconditionally, w.p. \(q\)
  - Rescue investment at date 1 funded by
    - Firm withdrawing its bank deposit
    - Firm borrowing from its bank (or any other bank) in spot bank loan market
  - Rescue investment repays high return in expectation, making up for loss on initial investment
    - Focus on liquidity, not solvency
  - But... non-zero probability of no return (Stein 2012)
Banks at date 1

• y and z once resolved are common knowledge to all agents

• If bank-firm pair stressed
  • Risk averse depositors will run.
    ➢ If they anticipate default at date 2 -> Run at date 1 in case of stress even when the bank is solvent
  • Firm will withdraw deposit and ask for additional loan upto the size of its optimal date-1 “rescue” investment.

• Where do reserves go?
  • Flight-to-safety-deposits and proceeds of rescue investments go to “untainted” healthy banks
Bank funding at date 1

• Stressed banks will raise funding
  (1) From the inter-bank market.
  (2) They also can raise date-1 capital from Warren Buffet.

• Only a fraction \( \varphi \) of healthy banks lend to stressed banks in the inter-bank market
  - Fear of being “tainted” : \( \varphi \) exogenous initially, but endogenized later

• Remaining \( 1 - \varphi \) “safe” healthy banks receive flight-to-safety deposits.
Bank-firm pairs, date-0 investment

Healthy Economy (y=0)

\[ 1 \]

Liquidity stressed Economy (y=1)

\[ 1 - \frac{q}{\theta} \]

\[ \frac{q}{\theta} \]

Liquidity Hoarding

Fraction \( 1 - \varphi \)

Safe Bank (y.z=0)

Tainted Bank (y.z=0)

Inter-bank market

Flight To Safety

Fraction \( \varphi \)

Stressed Firm, Rescue Investment (z=1)

Stressed Bank (y.z=1)

Date 0

Date 1
Firms, Banks, Depositors, Investors

• Interest rates

- Common gross discount rate is 1 throughout, but ...

- Spot bank loans at date 1 to stressed firm at \( 1 + r_i + \gamma \)
  - \( r_i \) is the endogenous marginal cost of bank funding (via inter-bank borrowing)
  - \( \gamma \) is the premium bank charges in stress scenario to compensate monitoring costs
**Firm Balance Sheet at Date 0**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_0$</td>
<td>$L_0^F$</td>
</tr>
<tr>
<td>$D_0^F$</td>
<td>$W_0^F$</td>
</tr>
</tbody>
</table>

Net worth

**Bank Balance Sheet at Date 0**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$</td>
<td>$D_0$</td>
</tr>
<tr>
<td>$S_0$</td>
<td>$e_0$</td>
</tr>
</tbody>
</table>

Net worth

**Firm Balance Sheet at Date 1 if stressed**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_1$</td>
<td>$l_1^F$</td>
</tr>
<tr>
<td>$L_0^F$</td>
<td></td>
</tr>
</tbody>
</table>

Net worth

**Bank Balance Sheet at Date 1 if bank stressed**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$</td>
<td>Possible interbank borrowing = $b_1$</td>
</tr>
<tr>
<td>$\tau S_0$</td>
<td>$e_1$</td>
</tr>
<tr>
<td>$l_1^B$ ($= l_1^F$)</td>
<td>$e_0$</td>
</tr>
</tbody>
</table>

Net worth

Will run to "safe" banks if stressed

Rescue investment, Redeemed in "safe" banks

Encumbrance on reserves

Liquidity Demand at date 1
<table>
<thead>
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<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$</td>
<td>$D_0$</td>
</tr>
<tr>
<td>$S_0$</td>
<td>$e_0$</td>
</tr>
<tr>
<td></td>
<td>Net worth</td>
</tr>
</tbody>
</table>

**Bank Balance Sheet at Date 0**

**Bank Balance Sheet at Date 1 if bank healthy, economy stressed**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$</td>
<td>$D_0$</td>
</tr>
<tr>
<td>Interbank loans of up to $e_1 + (1-\tau)S_0$</td>
<td>$e_1$</td>
</tr>
<tr>
<td>Reserves of $(S_0 + e_1$-interbank loans)</td>
<td>$e_0$</td>
</tr>
<tr>
<td></td>
<td>Net worth</td>
</tr>
</tbody>
</table>

“Tainted” Bank

Liquidity Supply

Available reserves
Firm’s problem

• Date 0:

\[
\max_{l_0^F, D_0^F} (1-q) \left[ g_0(I_0) + D_0^F \right] + q \left[ g_1(I_1) - l_1^F (1 + \gamma + r_1) \right] - R_0^L L_0^E
\]

• Date 1:

\[
\max_{l_1^F} g_1(I_1) - l_1^F [1 + \gamma + r_1]
\]

• Budget constraints:

\[
s.t. \quad I_0 = L_0^F + W_0^F - D_0^F \quad \text{and} \quad I_1 = l_1^F + D_0^F
\]
Bank’s problem

\[ \text{Max}_{L_0^B, e_0, \alpha_1} \quad R_0^L L_0^B + S_0 - e_0 - \frac{\alpha_0}{2} e_0^2 - D_0 \]
\[ + \frac{q}{\theta} \theta \left[ -\frac{\alpha_1}{2} e_1^2 - r_1 \left( b_1(y = 1, z = 1) - l_1^B \right) \right] \]
\[ + \frac{q}{\theta} (1-\theta) \varphi \left[ -\frac{\alpha_1}{2} e_1^2 - r_1 b_1(y = 1, z = 0) \right] \]

s.t. \quad D_0 + e_0 = L_0^B + \frac{1}{2} \lambda (L_0^B)^2 + S_0

\[ b_1(y = 1, z = 1) = l_1^B + D_0 - S_0 (1 - \tau) - e_1 \quad \text{if stressed bank} \]
\[ b_1(y = 1, z = 0) = -S_0 (1 - \tau) - e_1 \quad \text{if tainted bank} \]

Deposits are decided residually based on capital issuance;
It will turn out that deposits increase one for one with reserves
Symmetric Rational Expectations Equilibrium

• The market for term loans clears at date 0 (taking $r_1$ as given)
• The market for spot loans clears at date 1 at $r_1$.
• Capital supplies the residual: $e_1 = \alpha_1^{-1} r_1$

$$\left[ \varphi(1 - \theta) + \theta \right] \alpha_1^{-1} r_1 = \theta \left[ I_1 + (D_0 - D_0^F) \right] - \left[ \varphi(1 - \theta) + \theta \right] S_0 (1 - \tau)$$

- Additional liquidity raised via date-1 capital issuances
- Firm’s Rescue Investment
- Risk averse depositor run ("leakage")
- Unencumbered liquidity with stressed and tainted banks

• How does the equilibrium rate $r_1$ change with the ex ante level of reserves $S_0$?
Ex ante reserves and degree of ex post stress

• What matters for whether higher ex ante reserves enhance or alleviate liquidity stress (as measured by $r_1$) is whether

\[ \theta > \frac{\varphi(1 - \tau)}{\tau + \varphi(1 - \tau)} \]

• If the inter-bank market is shut ($\varphi = 0$), the shadow inter-bank rate always increases in reserves.

• If inter-bank market fully open ($\varphi = 1$), then the interbank rate increases whenever $\theta > (1 - \tau)$
A stressed inter-bank market

\[ \theta > \frac{\varphi(1-\tau)}{\tau + \varphi(1-\tau)} \]

“Counter-intuitive” case: High aggregate risk, high shrinkage, high hoarding

Depositors demand more than the post-shrinkage available reserves

\[ r_1 = \alpha_1 f(r_1, S_0) \]
Policy Considerations

- Liquidity stress will affect ex ante real rates and activity.
- Liquidity concerns would imply the central bank should set reserves such that $r_i = 0$.
- But un-modeled monetary policy concerns might require setting reserves at a different level.
- Divergence between concerns most likely when $\theta > \frac{\phi(1-\tau)}{\tau + \phi(1-\tau)}$.
Policy Considerations

• If so, illiquidity effects will offset some of the beneficial effects of monetary policy when reserves set too high from a liquidity perspective.

• Would capital requirements help?
  • No, when \( \varphi \) exogenous, private and social optima in capital structure coincide since we have only a pecuniary externality (unlike Lorenzoni (2008) or Stein (2012)).
Extensions

• Endogenous hoarding because of a date-1 convenience yield \( \delta \) associated with reserves.
  • Exogenous convenience yield
  • Endogenous convenience yield increasing with degree of date-1 liquidity stress.

• Encumbrance
  • Endogenize as financing speculative activity – encumbrance turns out to be proportional to reserves
  • Explore consequences of a fixed encumbrance also

• Endogenous reserve holdings by banks
• Non-bank holding of reserves
Flight to safety and hoarding

Will surplus banks necessarily channel liquidity to the deficient ones?
Altered assumptions

• Recall that flighty deposits migrate to “safe” banks

• Let safe banks earn a (small) convenience yield $\delta$ on extra reserves
  - The value of having liquid assets in case of additional stress
  - Customer franchise value associated with maintaining their transaction accounts

• To be perceived as “safe” healthy banks must not get “tainted” by being seen as connected to the stressed banks via inter-bank loans

• However, as liquidity stress rises, the higher interbank rate induces such loans.
  • What fraction $\varphi$ of unstressed banks lends?
  • Can the inter-bank market remain shut altogether ($\varphi = 0$)?
Breakeven rate for inter-bank market to open up

\[ V_1^\phi (y = 1, z = 0) = \left[ (r_1 - \delta) S_0 (1 - \tau) + \frac{r_1^2}{2\alpha_1} \right] \]

“Tainted” Bank value

\[ V_1^{1-\phi} (y = 1, z = 0) = \frac{\delta S_0 (1 - \tau)(\theta + (1 - \theta)\phi)}{(1 - \theta)(1 - \phi)} \]

“Safe” Bank value

\[ V_1^\phi = V_1^{1-\phi} \quad (1 - \phi) = \frac{\delta S_0 (1 - \tau)}{(1 - \theta) \left( r_1 S_0 (1 - \tau) + \frac{r_1^2}{2\alpha_1} \right)} \]
\( \delta = 0.2, \tau = 0.2 \)
\( \theta = 0.6 < (1 - \tau) \)

**Low reserves:**
Banks manage with own funding

**Moderate reserves:**
Banks need liquidity but inter-bank markets shut (Autarky)

**High reserves:**
Banks need liquidity and inter-bank markets open up as \( r_1 \) is attractive

Interbank rate increases enough to open the inter-bank market.
$\tau = 0.2$
$\theta = 0.6 < (1 - \tau)$

As the convenience yield on reserves increases...

Inter-bank markets remain endogenously shut for longer, and

Inter-bank rates in stress times rise more
\[ \tau = 0.2 \]
\[ \theta = 0.6 < (1 - \tau) \]

As the convenience yield on reserves increases, more surplus banks hoard, and the extent of inter-bank liquidity transfer reduces.
Implications

- Benchmark model assumed inter-bank markets are always open
- Flight to safety and liquidity hoarding imply this need not be the case
- As reserves increase, inter-bank markets can remain closed for a larger range of parameters as hoarding incentives strengthen when $\delta > 0$
  - Benefits to hoarding flight-to-safety deposits rise
  - Breakeven rate at which inter-bank market opens up rises
Implications

• The greater the perceived benefit $\delta$ of reserves hoarding during stress, the more likely it is that higher ex ante reserves lead to financial fragility.

• Endogenous $\delta$ may imply the interbank market never opens.

• Social planner wants lower capital than privately optimal to be held at date 0 to reduce hoarding (contrast with Stein (2012))
  • Higher capital up front lowers the market clearing rate, increases ex post hoarding, liquidity shortage, and costly date-1 capital issue.
Some Final Considerations
Cannot the central bank intervene ex post?

• Crowd out private ex-post lending by surplus banks – more hoarding
• Central banks typically lend against collateral
  - High quality collateral financed with deposits does not add additional liquidity
  - Stigma in borrowing from the central bank facilities?
• Unsecured interventions or lending against all manner of assets
  - In principle, can solve all liquidity problems, BUT... typically distort asset prices
Cannot the central bank intervene ex post?

• Ex-ante moral hazard
  - Create greater balance sheet illiquidity, insolvency, and herding by banks

• Ever increasing intervention

“When Norges Bank keeps reserves relatively high for a period, it appears that banks gradually adjust to this level... With ever increasing reserves in the banking system, there is a risk that Norges Bank assumes functions that should be left to the market. It is not Norges Bank’s role to provide funding for banks... If a bank has a deficit of reserves towards the end of the day, banks must be able to deal with this by trading in the interbank market.”
Modeling Choice

• $\theta$ is invariant to reserve accumulation. Should the risk of stress not fall with higher reserves on bank balance sheets?
• Possibly not.
  • Certainly implications will hold over a range.
  • More importantly, incremental reserves financed with flighty wholesale deposits.
    • Small losses have large effects.
  • For modeling convenience, we have not allowed bank financing opportunities, and the financing of speculative activity, to grow with bank balance sheets.
Shadow banking and maturity-matching

• What if reserves are allowed to be held by non-banks (RRP facilities)?
• Shadow banks likely to maturity-match assets and liabilities
  - The risk of rollover costs on deposits; higher premia in long-term financing
  - More short-term assets facilitate greater short-term liabilities
• Reinstatement in April 2021 of the Supplementary Leverage Ratio on banks
  - Banks “pushing away” reserves and corporate deposits to money market funds
Conclusion

• Large central bank balance sheet need not imply the financial system has plenty of spare liquidity.
• Supply of ex ante reserves creates its own ex-post demand for reserves, limiting the central bank’s ability to use and expanded balance-sheet to enhance financial stability and growth
• Reserve issuance may not crowd out private deposit-like claims, may in fact enhance it.
• Take care when you shrink the central bank balance sheet: hysteresis.
Discussion and Robustness issues
Endogenizing shrinkage of reserves ($\tau$)

• Speculation:
  - Banks must hold some margins against prime-brokerage services
  - Search costs for prime-brokerage services reduces in unencumbered liquidity
  - This way, reserves can get encumbered away from stress-time withdrawals
  - In practice:
    - CCP initial margins/guarantee funds, often kept at central banks
    - March 2020 Treasury relative trades (Barth and Kahn, 2021) show positions grew from $200 bln in 2013 to $800 bln by 2020, needing significant margins ex post
Speculation (formally...)

\[ \kappa = \text{Margin to be set aside per speculative position} \]

\[
\max_x \left( 1 - \frac{q}{\theta} \right) \left( \eta - f \right) x - \frac{\nu}{2} \frac{x^2}{S_0 - \kappa \bar{x}}
\]

Expected Speculative Return net of Prime-brokerage Fee
Search Costs for Prime-brokerage Services:
Increase in Speculative position,
Decrease in Unencumbered reserves

\[
\Rightarrow \kappa \bar{x} = \frac{S_0 \kappa \left( 1 - \frac{q}{\theta} \right) (\eta - f)}{\nu + \kappa \left( 1 - \frac{q}{\theta} \right) (\eta - f)} = \tau S_0
\]
Endogenizing shrinkage of reserves ($\tau$)… cont’d

- Regulation (intra-day liquidity and resolution-planning requirements):
  - Must be maintained by each bank even during stress (Diamond-Kashyap, 2016)
  - Jamie Dimon, CEO of JP Morgan, on 2019 episode:

  “[...] we have $120$ billion in our checking account at the Fed, and it goes down to $60$ billion and then back to $120$ billion during the average day. But we believe the requirement under CLAR and resolution and recovery is that we need enough in that account, so if there’s extreme stress during the course of the day, it doesn’t go below zero.” (D’Avernas and Vanderweyer (2021))
Reserve requirements

• Ex-ante reserve requirements: \( D_0 \leq \zeta S_0 \)

• Up to a level of reserves, serve effectively as a constraint on deposits and incentivize capital issuance

• Our model suggests these may be worth reconsidering in the modern financial system

• Constrain lending at date 0 but stabilize lending in stress at date 1
Interest on excess reserves (IOER) and privately optimal reserves holdings

• Privately optimal demand for reserves in general differs from the socially optimal levels
  - Private costs (IOER) factored in
  - Private gains from lending in inter-bank markets factored in
  - BUT... social benefits/costs in the form of impact on inter-bank rates ignored

• Central bank can “fine tune” the IOER to align the private desire for reserves with the social one
  - Can reduce the “hot potato” syndrome with large reserves

• This does not, however, address the issue of whether more or less reserves are desirable in the first place