

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)

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Conundrum: Where did all the liquidity go?

- Unprecedented expansion of central bank balance sheets since the Global Financial Crisis
 - Central banks issue reserves (central bank liability) to commercial banks (commercial bank asset) while buying bonds from banks
 - Asset swap for bank.
 - Non-banks also tender their assets, but reserves typically stay with commercial banks.
 - Most liquid asset on planet.
- Yet surprisingly fragile liquidity conditions in money markets
 - Unexpectedly large spikes in repo markets in September 2019
 - Dash for cash in March 2020
- Focus on banking sector liability-side for financial stability implications of QE

Quantitative Easing: Expansion of Fed balance sheet

Initial Balance Sheet Conditions

FEDERAL RESERVE	
Assets	Liabilities
Treasury securities	Reserves held by banks Cash held by the Treasury

BANKING SECTOR	
Assets	Liabilities
Treasury securities	Deposits
Reserves at the Fed	

The Fed Purchases Assets from Banks
Balance Sheet Effects

FEDERAL RESERVE	
Assets	Liabilities
Treasury securities +\$1	Reserves held by banks +\$1 Cash held by the Treasury

BANKING SECTOR	
Assets	Liabilities
Treasury securities -\$1	Deposits
Reserves at the Fed +\$1	

Asset swap with banks

Quantitative Easing: Expansion of Fed balance sheet

Initial Balance Sheet Conditions

FEDERAL RESERVE	
Assets	Liabilities
Treasury securities	Reserves held by banks
	Cash held by the Treasury

BANKING SECTOR	
Assets	Liabilities
Treasury securities	Deposits
Reserves at the Fed	

PUBLIC	
Assets	Liabilities
Deposits	Wealth
Treasury securities	

The Fed Purchases Assets from the Public
Balance Sheet Effects

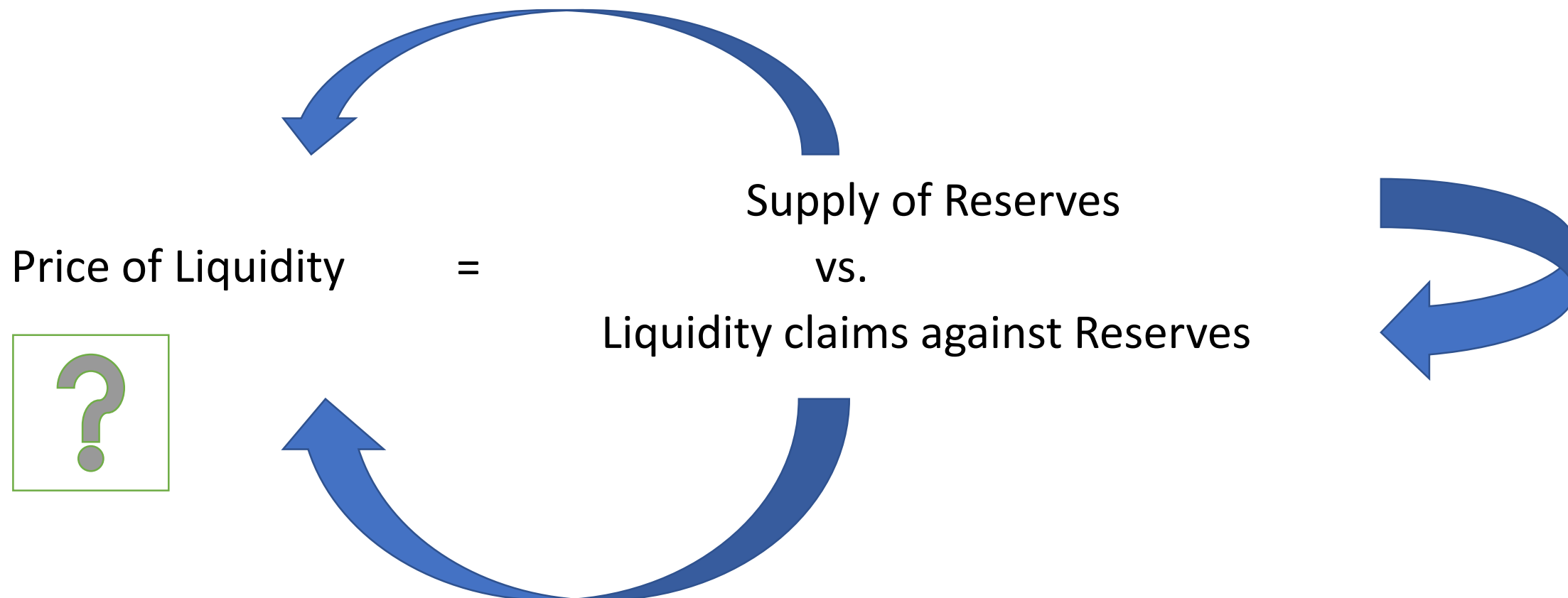
FEDERAL RESERVE	
Assets	Liabilities
Treasury securities +\$1	Reserves held by banks +\$1
	Cash held by the Treasury

BANKING SECTOR	
Assets	Liabilities
Treasury securities	Deposits +\$1
Reserves at the Fed +\$1	

PUBLIC	
Assets	Liabilities
Deposits +\$1	Wealth
Treasury securities -\$1	

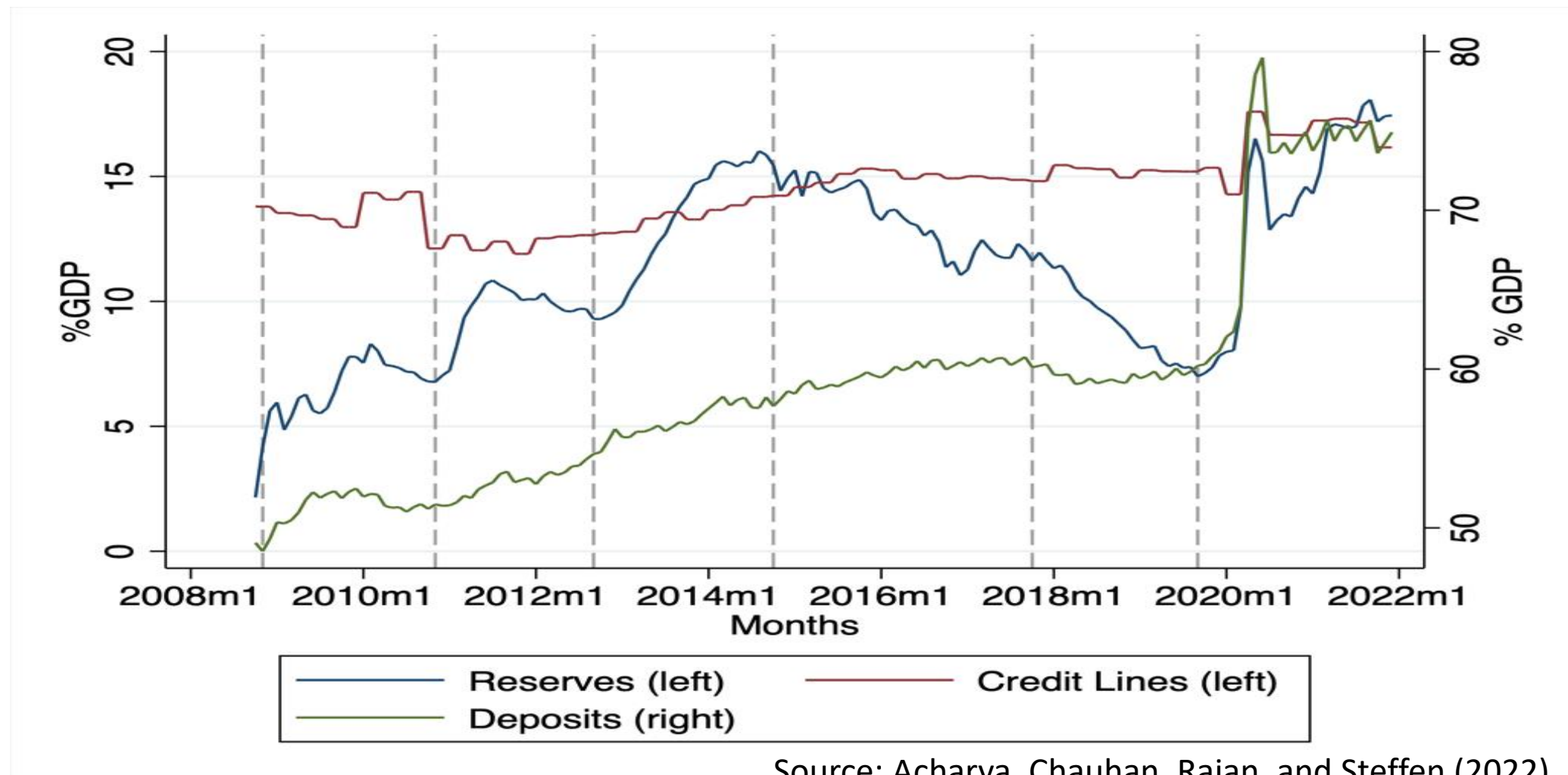
Expansion financed with bank deposits

Our point: Liquidity demand is affected by reserves

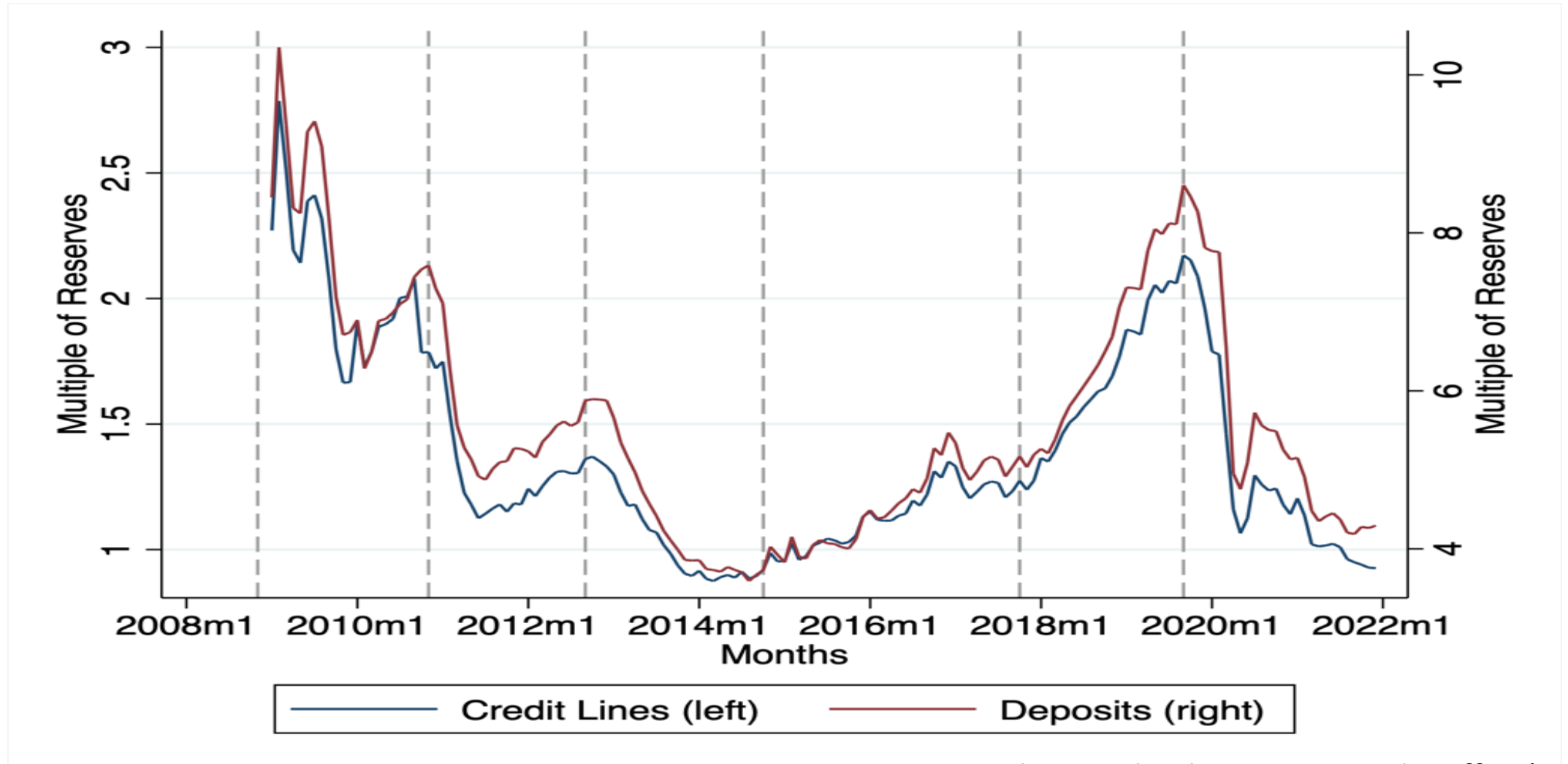


- Supply of reserves creates its own demand, new claims, which can destabilize

Reserves and Claims (fraction of GDP)

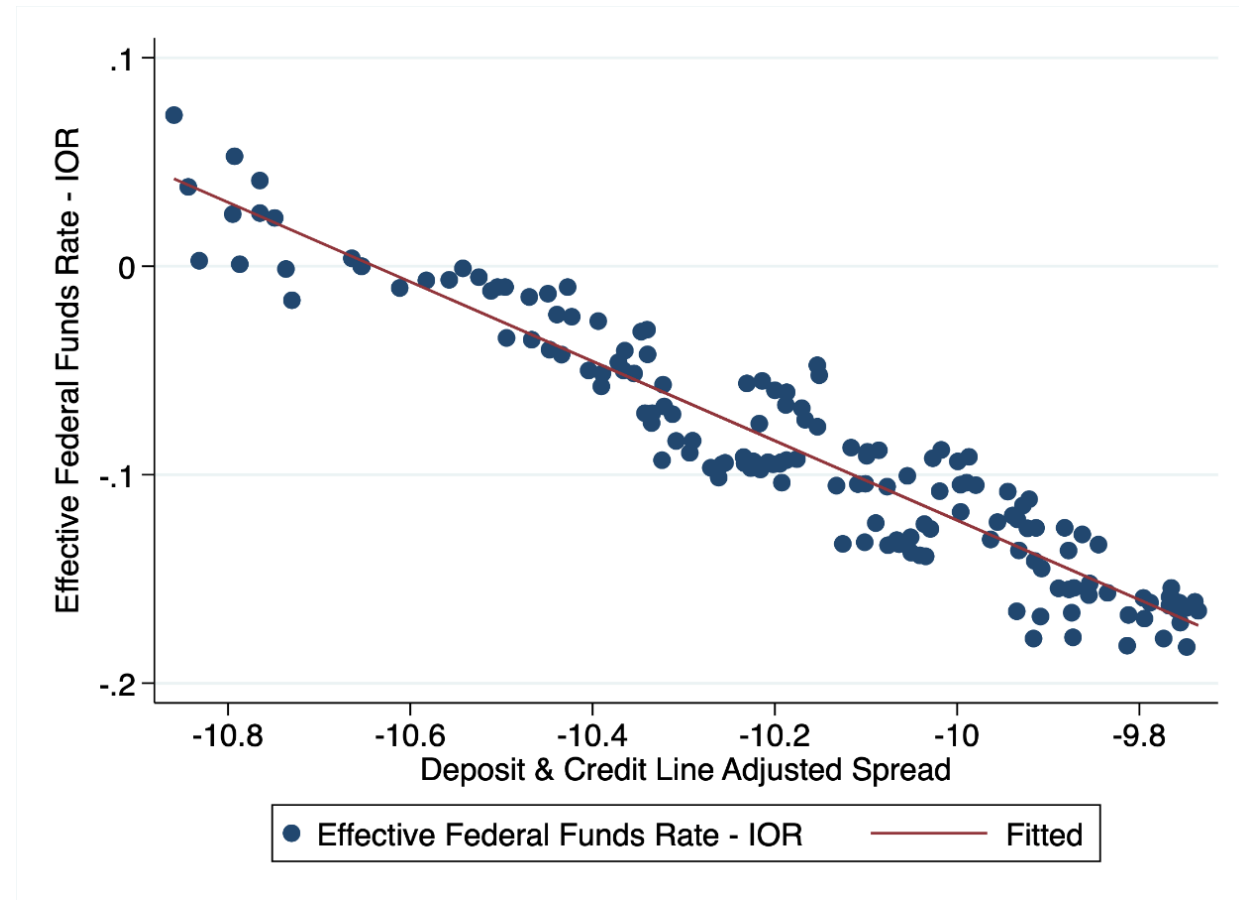
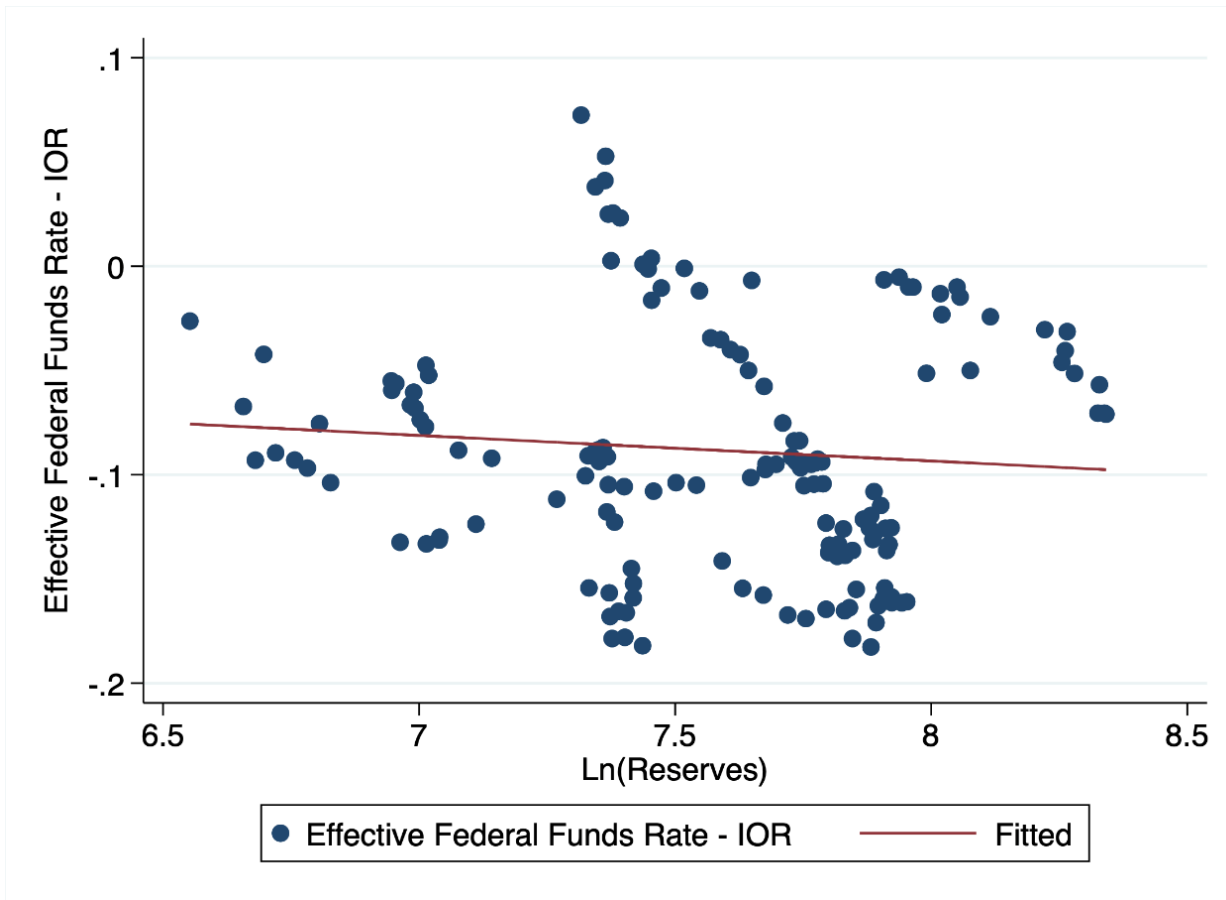


Claims on Liquidity (multiple of reserves)



Source: Acharya, Chauhan, Rajan, and Steffen (2022)

What explains the price of liquidity?



Source: Acharya, Chauhan, Rajan, and Steffen (2022), inspired by Lopez-Salido and Vissing-Jorgensen (2022)

Three important considerations in whether past issuance of central bank reserves helps or hurts when liquidity is abruptly drawn down.

I. Ex ante: How are the reserves financed?

- When the central bank buys bonds, it creates reserves that are typically deposited in commercial banks.
- Do banks rebalance these deposits with new capital issuances, or are reserves primarily financed with deposits (and deposit-like) claims?
- The way reserves are financed matters as demand deposits will be a claim on reserves in future

Three important considerations...

II. Ex post: Additional encumbrances on reserves

- Commercial banks are reluctant to leave reserves idle – therefore they sell other contingent claims on liquidity so that reserves are “fully” utilized.
 - Bank credit lines
 - Back up guarantees to speculators: Margin calls, central clearing guarantee funds, etc.,
- Regulation: liquidity requirements “lock up” reserves in stress scenarios (Diamond and Kashyap, 2016; Vandeweyer, 2019; others)
- Ratcheting: the level of reserves creates own supervisory demand (Nelson, 2019)

Three important considerations

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

- There will be a high rate paid in the interbank market for reserves when the system is stressed.
- However, some surplus banks fear a “taint” from lending to needy.
- Instead they prefer to stay “safe” and receive flight-to-safety deposits passively (and realize the convenience yield from having excess reserves), rather than lend out reserves in inter-bank markets actively

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

In sum

- Central bank reserve expansion works through commercial 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.
- Absent ex-post central bank intervention, this can have adverse real consequences on corporate investments (ex post as well as ex ante) -- as in Diamond and Rajan (2011), Shleifer and Vishny (2010), Stein (2012).
- In practice, *hysteresis* or ratcheting demand for central bank intervention: *liquidity dependence*.

Model: Firms, Banks, Depositors, Investors

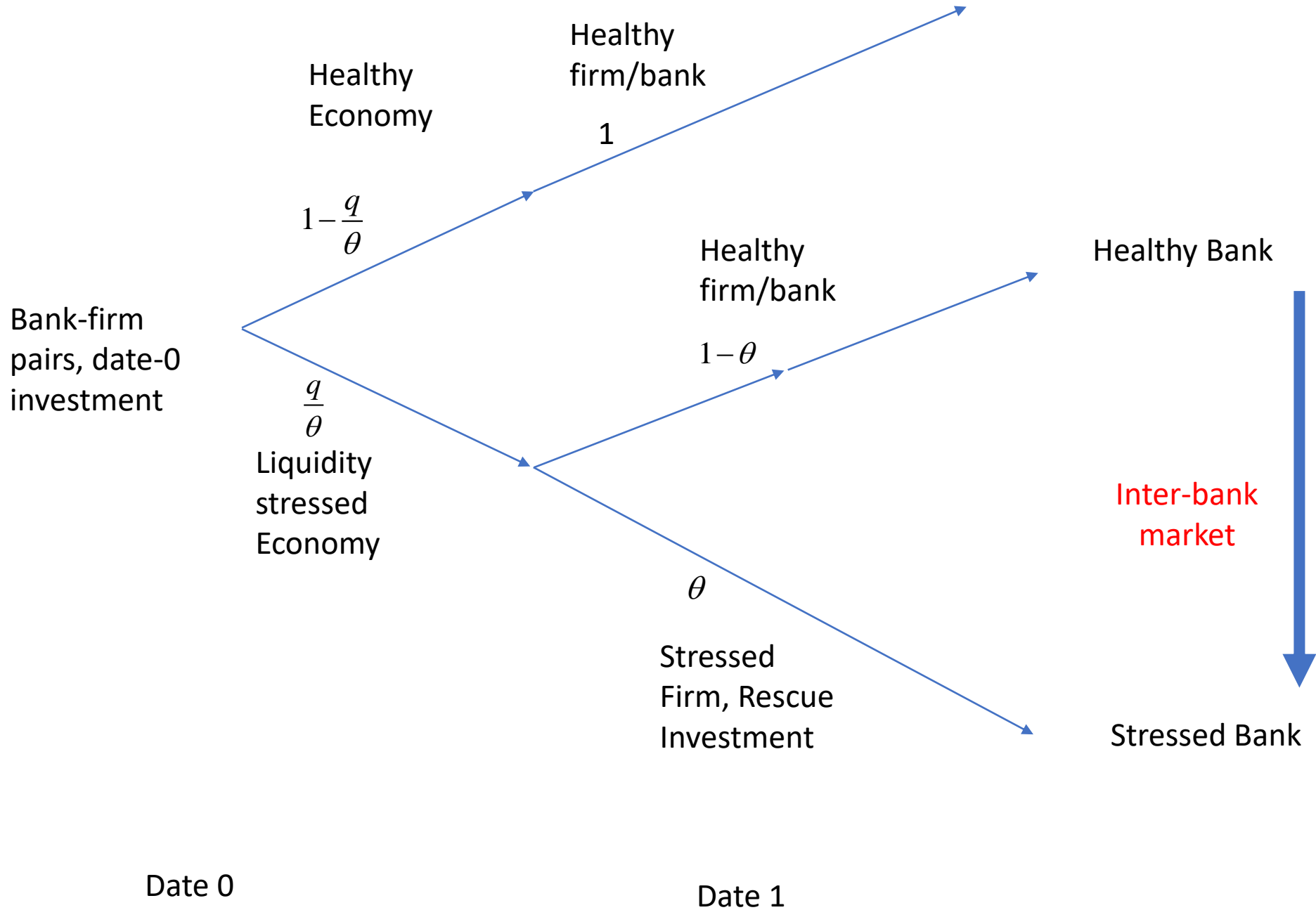
- Bank firm pairs
 - “regionally” or “sectorally” matched
- Firm and bank owners are risk-neutral, expected profit-maximizers
- Firms:
 - Invest I_0 at date 0 to obtain returns at date 2 , funded by
 - Firm owners’ initial wealth
 - Term loans from banks
 - Place deposits D_0^F with bank.

Firms, Banks, Depositors, Investors

- Banks at date 0:
 - Assets
 - Long term loan to their firm
 - Liquid reserves S_0 that shrink by encumbrance τ at date 1
 - Liabilities I: (Unlimited) Uninsured deposits D_0 from risk-averse investors at date 0
 - Will run if firm/bank stressed at date 1
 - Liabilities II: (Limited) capital from deep-pocket risk-neutral investors (Warren Buffet)
 - Stable but costly capital funding e_t available at date t
 - Quadratic costs $\frac{\alpha_t e_t^2}{2}$

Liquidity stress in the economy

- Economy stressed with probability q / θ , healthy otherwise.
- Conditional on economy stress, probability θ that specific bank-firm pair's investment is stressed and has to be “rescued” with additional investment I_1

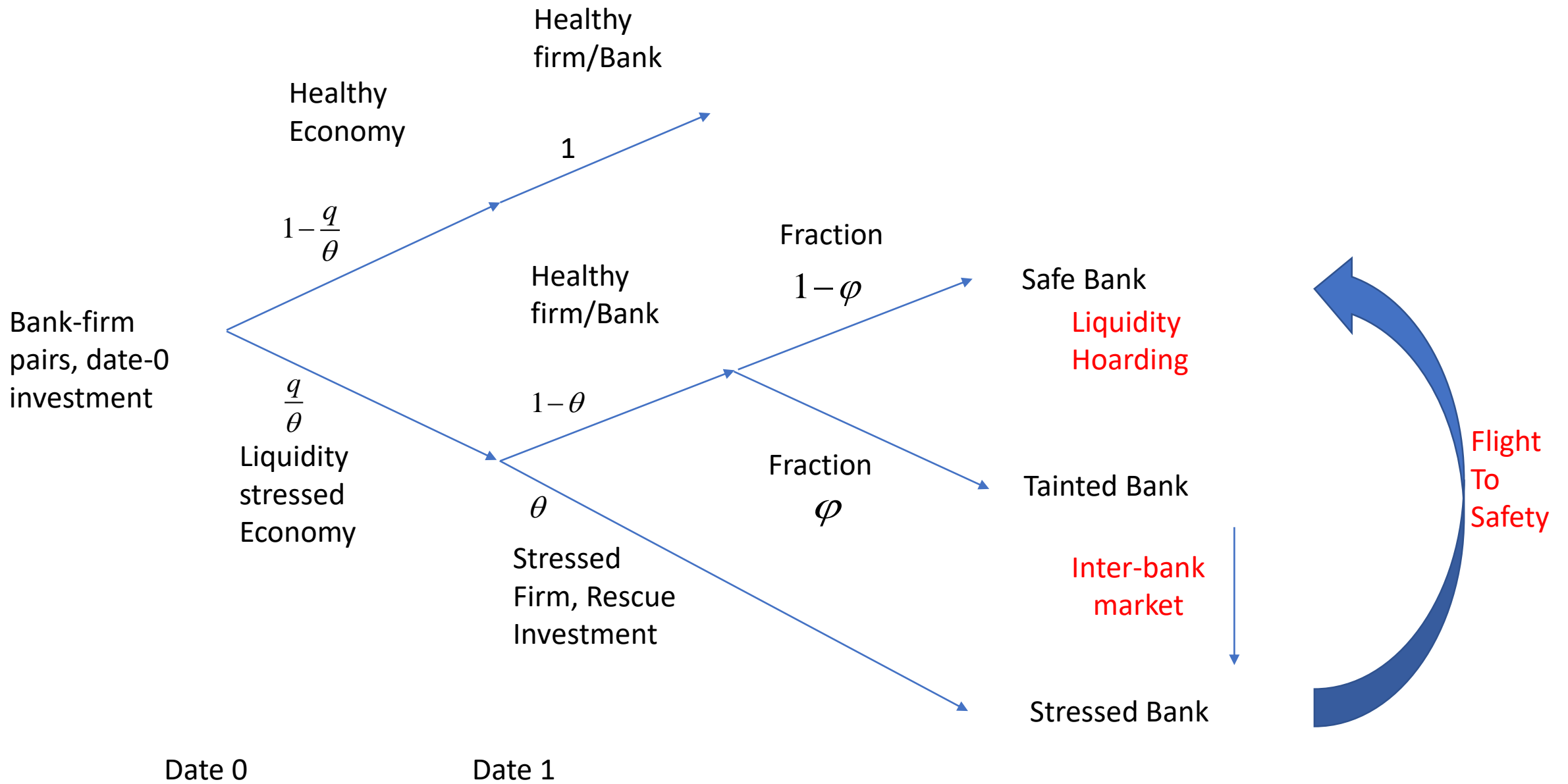


Stressed firm/bank at date 1

- If bank-firm pair stressed
 - Firm will withdraw deposit and ask for additional loan to fund its optimal date-1 “rescue” investment.
 - Risk averse depositors will run.
- Stressed banks will raise funding
 - (1) From the date-1 inter-bank market at rate r_1 .
 - (2) They also can raise date-1 capital e_1

Healthy bank behavior at date 1

- Only a fraction φ of healthy banks lend to stressed banks in the inter-bank market.
- Remaining fear being tainted: $(1 - \varphi)$ “safe” healthy banks
 - forego lending
 - but being seen as safe, receive flight-to-safety deposits that run from stressed banks.



Firm Balance Sheet at Date 0	
<u>Assets</u>	<u>Liabilities</u>
I_0	L_0^F
D_0^F	W_0^F
	Net worth

Bank Balance Sheet at Date 0	
<u>Assets</u>	<u>Liabilities</u>
$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$	D_0
S_0	e_0
	Net worth

Will run to "safe" banks if stressed

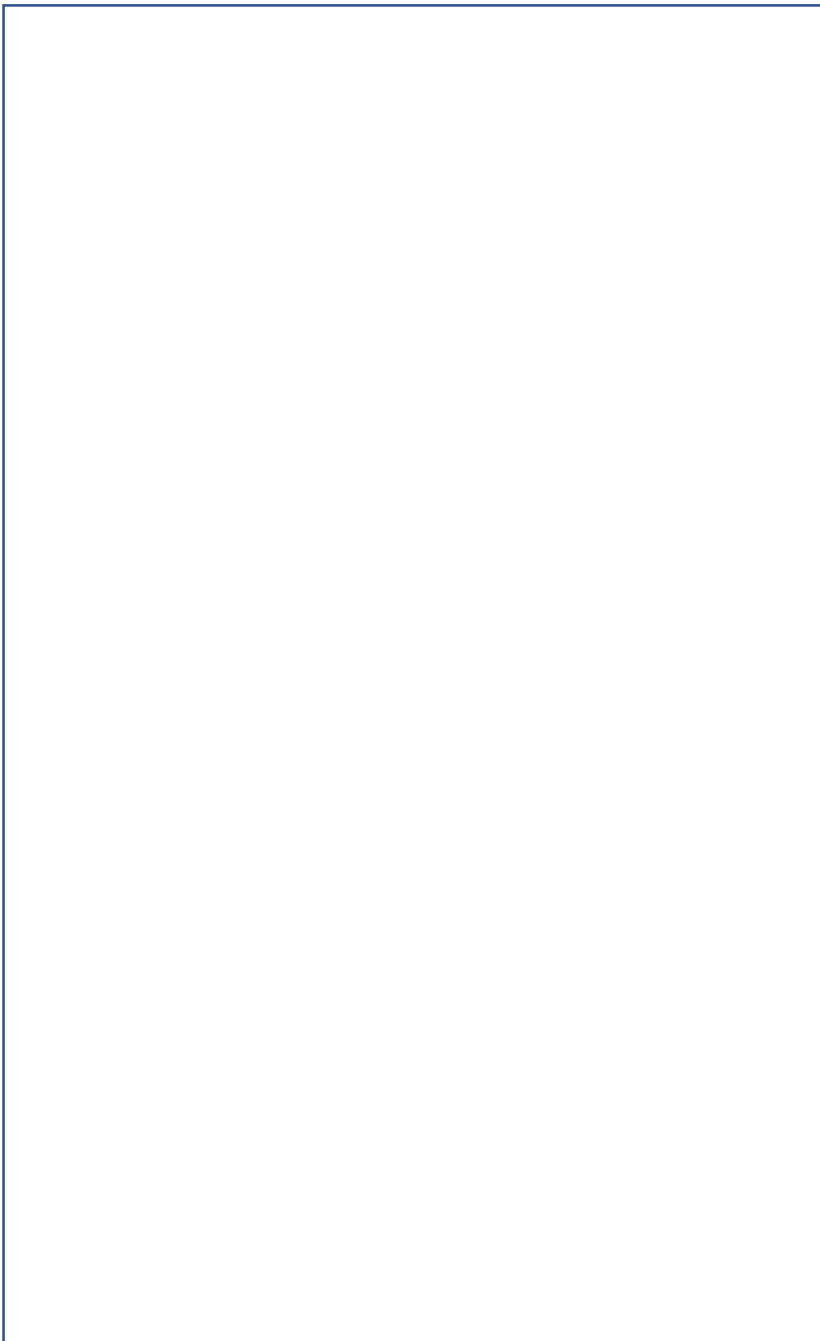
Firm Balance Sheet at Date 1 if stressed	
<u>Assets</u>	<u>Liabilities</u>
$\rightarrow I_1$	l_1^F
	L_0^F
	Net worth

Rescue investment, Redeeposited In "safe" banks

Bank Balance Sheet at Date 1 if bank stressed	
<u>Assets</u>	<u>Liabilities</u>
$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$	Possible interbank borrowing = b_1
$\rightarrow \tau S_0$	e_1
$l_1^B (= l_1^F)$	e_0
	Net worth

Encumbrance on reserves

Liquidity Demand at date 1

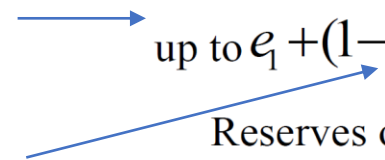


Bank Balance Sheet at Date 0	
Assets	Liabilities
$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$	D_0
S_0	e_0
	Net worth

Bank Balance Sheet at Date 1 if bank healthy, economy stressed	
Assets	Liabilities
$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$	D_0
Interbank loans of up to $e_1 + (1 - \tau) S_0$	e_1
Reserves of $(S_0 + e_1 - \text{interbank loans})$	e_0
	Net worth

“Tainted”
Bank

Liquidity Supply →
Available reserves



Firm's problem

- Date 0:

Term
loan

$$\underset{L_0^F, D_0^F}{\text{Max}} (1-q) \left[g_0(I_0) + D_0^F \right] + q \left[g_1(I_1) - l_1^F (1 + \gamma + r_1) \right] - R_0^L L_0^F$$

- Date 1:

$$\underset{l_1}{\text{Max}} g_1(I_1) - l_1^F [1 + \gamma + r_1]$$

Spot
loan

Rescue investment

(risky at date-2 but no date-1 solvency concerns)

- Budget constraints:

$$\text{s.t. } I_0 = L_0^F + W_0^F - D_0^F \text{ and } I_1 = l_1^F + D_0^F$$

Bank's problem

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

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

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

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

$$b_1(y=1, z=0) = -S_0(1-\tau) - e_1 \quad \text{if tainted bank}$$


Conditional on liquidity stress in the economy.

- The market for spot loans clears at date 1 at r_1 .
- Stressed and tainted banks also issue capital at marginal cost $\alpha_1 e_1$. Since banks will not issue at a higher cost than r_1 , it must be that $e_1 = \alpha_1^{-1} r_1$


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

Increases one for one with S_0


Additional liquidity raised via date-1 capital issuances




Firm's fund requirement for rescue investment



Risk averse depositor run



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

- Higher ex ante reserves enhance liquidity stress (as measured by r_1) if

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

- If the inter-bank market is shut ($\varphi = 0$), the date-1 shadow inter-bank rate *always* increases in ex ante reserves.
- If inter-bank market fully open ($\varphi = 1$), then the shadow interbank rate increases whenever

$$\theta > (1-\tau)$$

Extensions

- Endogenize φ , the extent of hoarding by introducing a small but positive convenience yield on reserves.
- Endogenize τ , the encumbrances on reserves by introducing a speculative demand and associated margins.
- Endogenize δ , the convenience yield on reserves as rising in times of inter-bank market stress.
- Interesting result: the date-1 interbank market can shut down under a variety of circumstances.

Endogenizing hoarding and lending

- Recall that deposits fleeing distressed banks migrate to “safe” banks
- Let safe banks earn a (small) *convenience yield* δ on extra reserves
 - The value of having liquid assets in case of additional stress
- To be perceived as “safe” and attract deposits, healthy banks must not get “tainted” by lending to stressed banks.
- But they then forego the return r_1 from lending in the interbank market.
- Equilibrium fraction of banks φ that choose to lend in the interbank market equates profits from lending to profits from receiving flight to safety deposits and earning convenience yield δ on them.

Breakeven rate for inter-bank market to open up

$$V_1^\varphi(y=1, z=0) = \left[(r_1 - \delta) S_0 (1 - \tau) + \frac{r_1^2}{2\alpha_1} \right] \quad \text{“Tainted” Bank value}$$

$$V_1^{1-\varphi}(y=1, z=0) = \frac{\delta S_0 (1 - \tau) (\theta + (1 - \theta)\varphi)}{(1 - \theta)(1 - \varphi)} \quad \text{“Safe” Bank value}$$

$$V_1^\varphi = V_1^{1-\varphi} \quad \longrightarrow \quad (1 - \varphi) = \frac{\delta S_0 (1 - \tau)}{(1 - \theta) \left(r_1 S_0 (1 - \tau) + \frac{r_1^2}{2\alpha_1} \right)}$$

$$\delta = 0.2, \tau = 0.2$$

$$\theta = 0.6 < (1 - \tau)$$

Low reserves:

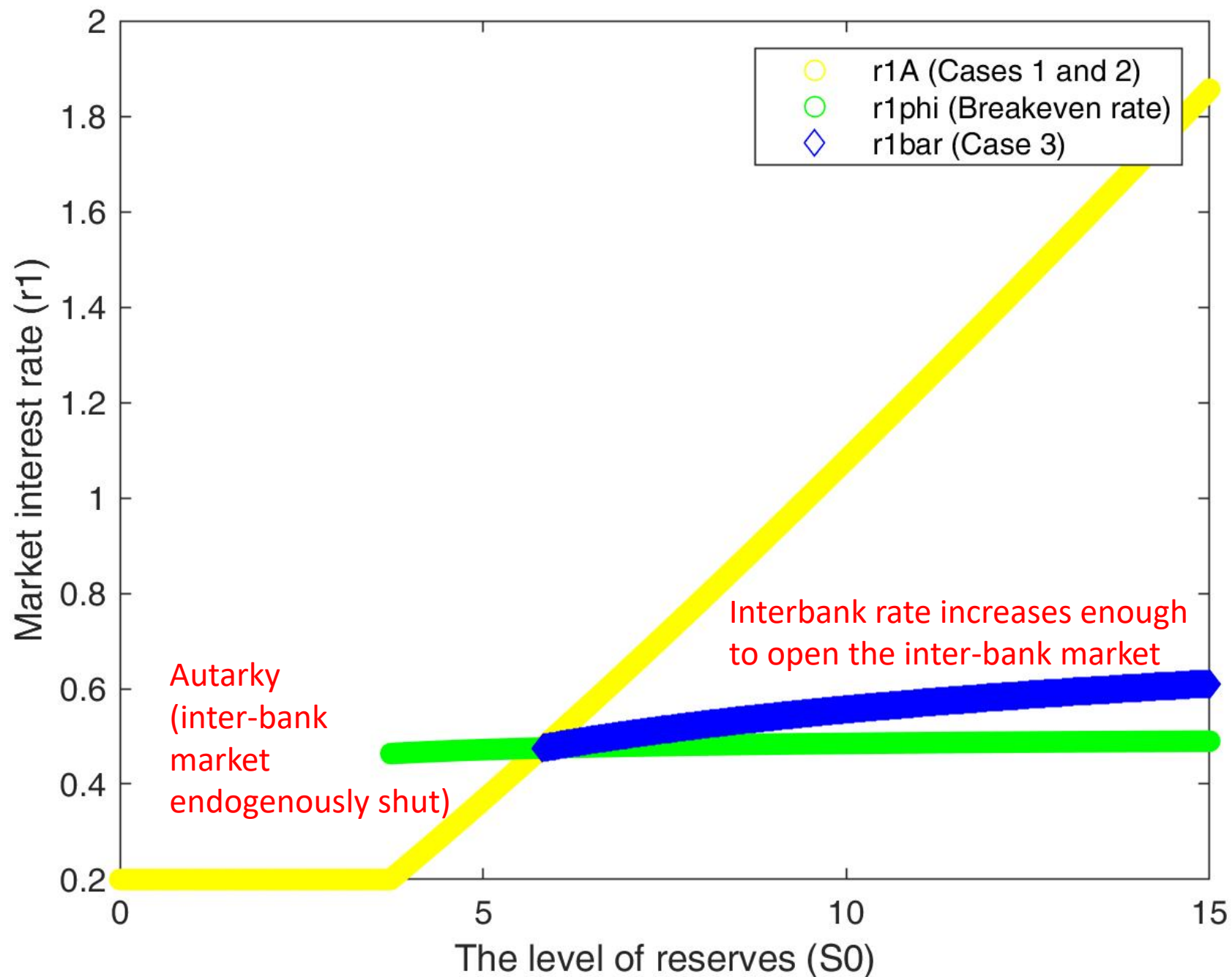
Banks manage with own funding

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



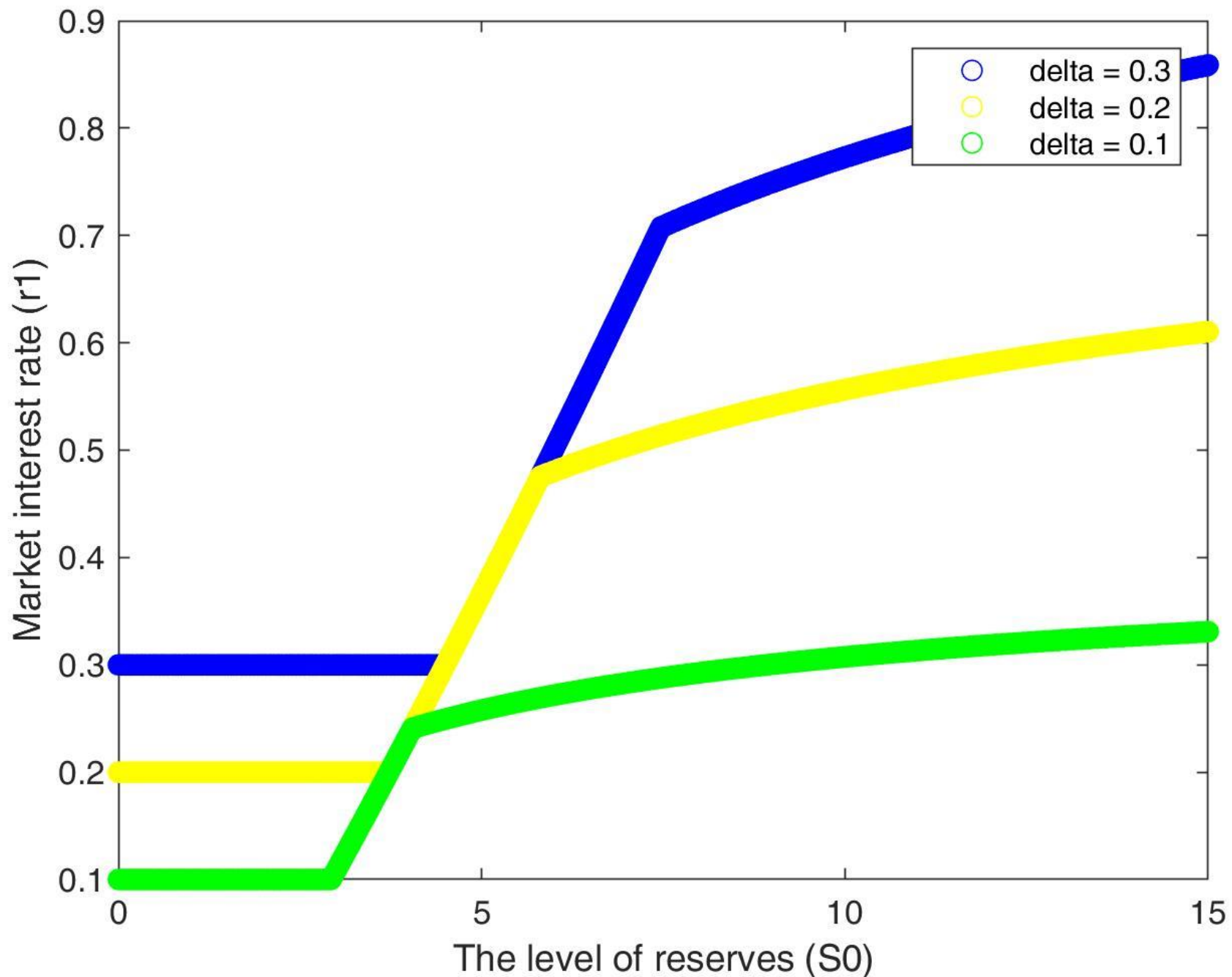
$$\tau = 0.2$$

$$\theta = 0.6 < (1 - \tau)$$

As the convenience yield on reserves increases...

Inter-bank markets remain endogenously shut for longer, and

Inter-bank rates in stress times rise more



Implications

- The greater the perceived benefit δ of reserves hoarding during stress, the more likely it is that higher ex ante reserves lead to financial fragility
- Endogenous δ 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, increases the liquidity shortage, and costly date-1 capital issuance.

Policy Considerations

- Liquidity concerns would imply the central bank should set reserves such that $r_1 = 0$.
- But un-modeled monetary policy concerns might require setting reserves at a different level (QE).
- Divergence between concerns most likely when degree of liquidity stress rises in ex ante reserves.
- If so, illiquidity effects will offset some of the beneficial effects of monetary policy when reserves are set too high from a liquidity perspective.
- Would capital requirements help?
 - No, when φ exogenous, private and social choice in capital structure coincide since we have only a pecuniary externality (unlike Lorenzoni (2008) or Stein (2012)).

Qualifies other policy recommendations

- Would more ex ante central bank balance-sheet expansion (Copeland, Duffie and Yang, 2021) work to alleviate ex post liquidity stress?
 - Under certain conditions could be a moving target!
- Would reserve issuance crowd out deposit-like claims (Greenwood, Hanson and Stein (2015, 2016))?
 - Depends on whether public/narrow banks hold reserves or it is intermediated by banks/less liquid money market funds.

Cannot the central bank intervene ex post?

Yes but

- Crowds 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
- Unsecured interventions or lending against all manner of assets (March 2022)
 - In principle, can solve all liquidity problems, BUT... typically distort asset prices and has fiscal component: moral hazard
- Ex-ante moral hazard
 - Acharya, Shin and Yorulmazer (2011), Diamond and Rajan (2012), Farhi and Tirole (2011)
- Ratcheting intervention: liquidity dependence.

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
 - Similar problem unless they are narrow banks (or households)
 - For example, money market funds substitute for banks in holding reserves

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 an expanded balance-sheet to enhance stability or growth
- Take care when you shrink the central bank balance sheet: hysteresis.
 - Monitor claims on liquidity also to see if they shrink.

Endogenizing shrinkage of reserves (τ)

- Speculation:

- Banks must hold some margins against prime-brokerage services
- Search cost 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 relative-value Treasury 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...)

$\kappa =$ Margin to be set aside per speculative position

$$\text{Max}_x \left(1 - \frac{q}{\theta}\right) [\eta - \rho] x - \frac{\nu}{2} \frac{x^2}{(S_0 - \kappa \bar{x})}$$

Expected Speculative Return net of Prime-brokerage Fee

Search Costs for Prime-brokerage Services: Increase in Speculative position, Decrease in Unencumbered reserves

$$\Rightarrow \kappa \bar{x} = \frac{S_0 \kappa \left(1 - \frac{q}{\theta}\right) (\eta - \rho)}{\nu + \kappa \left(1 - \frac{q}{\theta}\right) (\eta - \rho)} = \tau S_0$$

Speculation (Cont'd)

- Competitive market for prime-brokerage implies zero-profit condition from such services:

$$\left(1 - \frac{q}{\theta}\right) \rho = \frac{q}{\theta} [\varphi(1 - \theta) + \theta] \bar{r}_1 \kappa$$

- Encumbrance per unit of reserves is greater at low level of rates:

$$\tau'(\bar{r}_1) \leq 0.$$