

Liquidity, liquidity everywhere, not a drop to use

Why flooding banks with central bank reserves may not expand liquidity

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Conundrum: Where did all the liquidity go?

- Unprecedented expansion of central bank balance sheets since 2008
 - Central banks issue reserves (central bank liability) to commercial banks (commercial bank asset) while buying bonds
 - 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
 - UK Gilts: LDI (pension) crisis following the “mini budget” in October 2022
 - Uninsured depositor runs based on bank solvency concerns in March 2023
- Why?

How does the Fed expand its balance sheet?

- Till recently, only commercial banks held reserves
- Fed buys securities, pays with reserves (Fed money).
 - From public
 - From commercial bank

QE: Buying from public, expansion of bank 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	

After Purchase

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

QE: Buying from bank, no expansion of bank balance sheet

Initial Balance Sheet Conditions

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After purchase

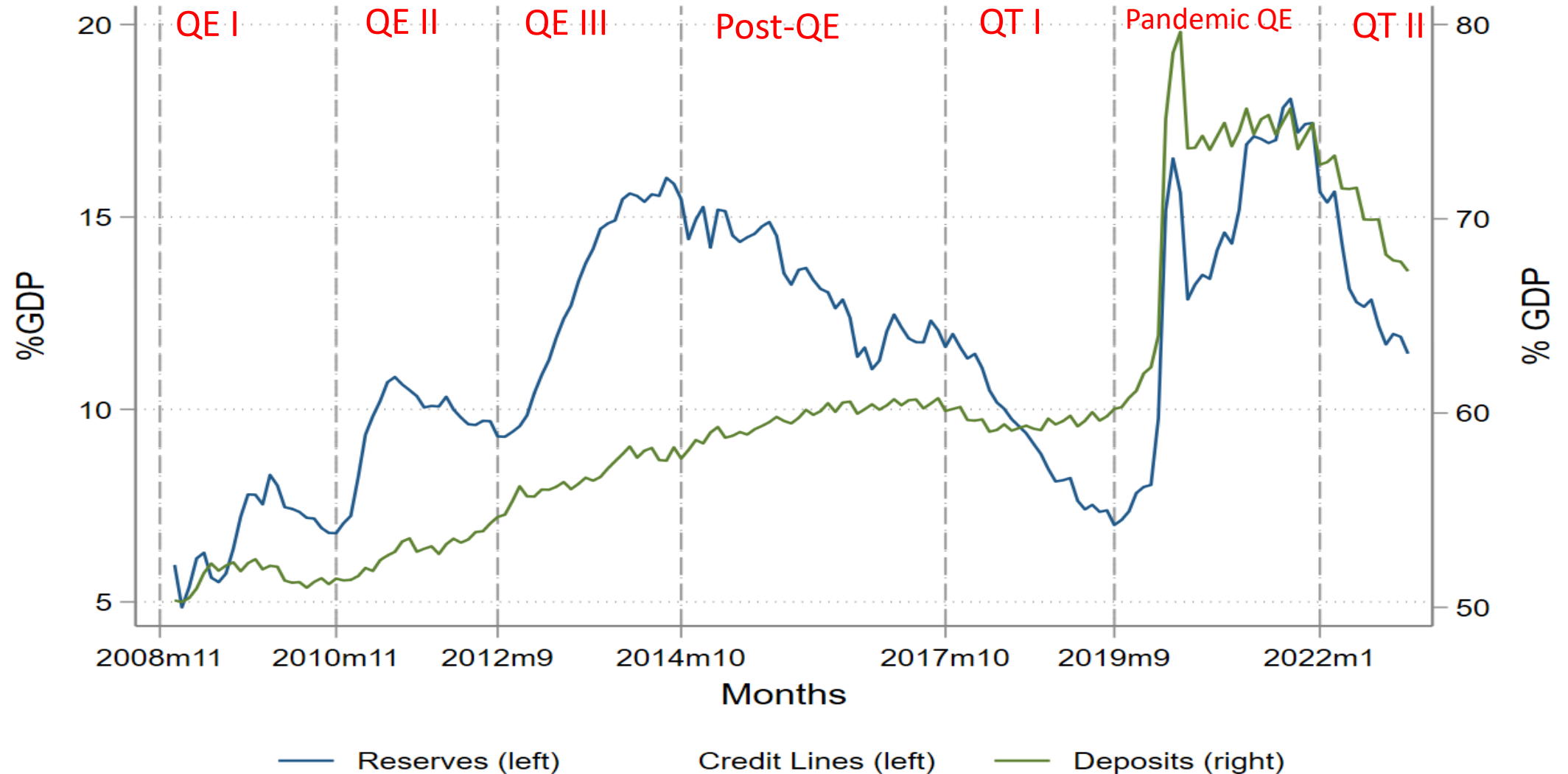
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Assets	Liabilities
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BANKING SECTOR	
Assets	Liabilities
Treasury securities -\$1	Deposits
Reserves at the Fed +\$1	

Asset swap with banks

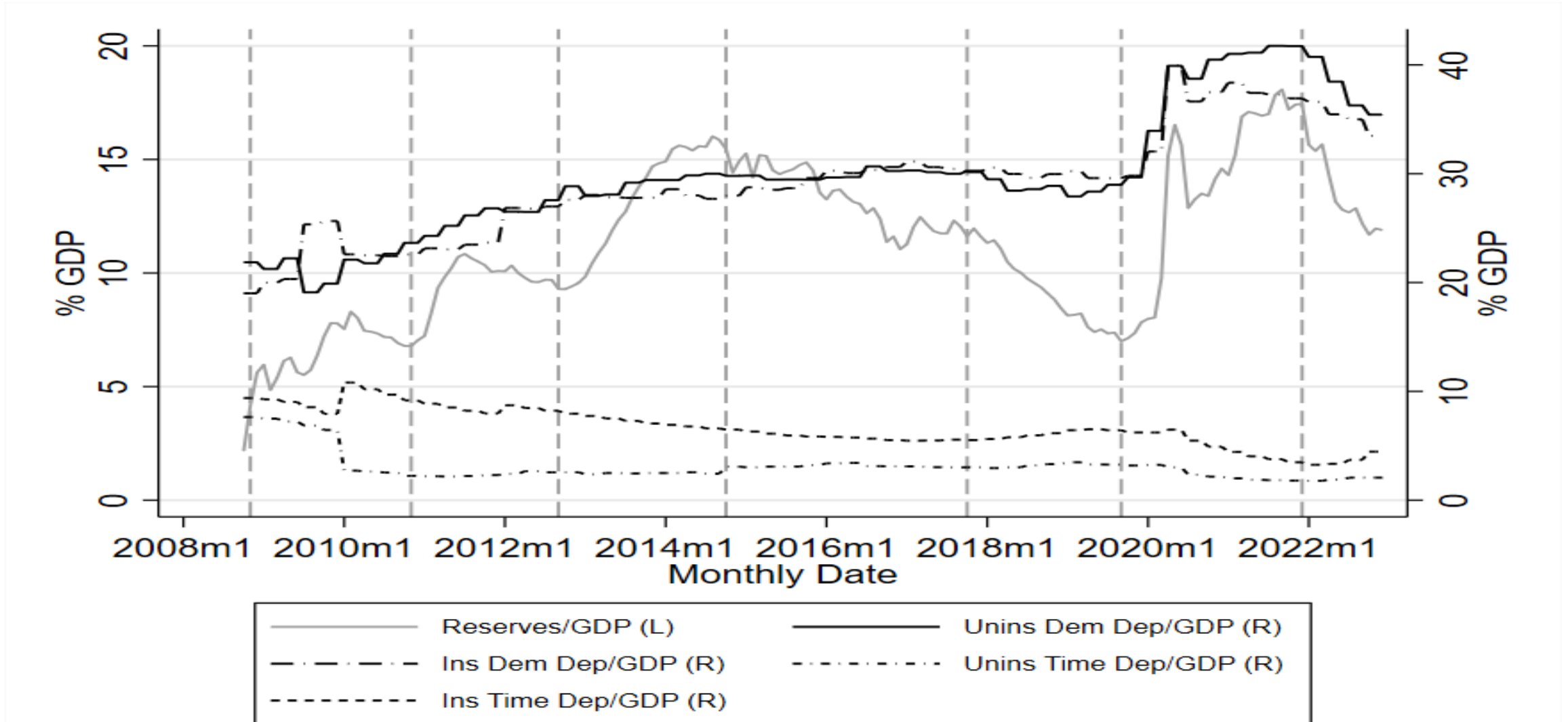
Source: "How the Fed Changes the Size of its Balance Sheet" (Leonard, Martin and Potter, *Liberty Street Economics*, 2017)

Reserves and Claims (% of GDP)



Uninsured/Insured Demandable/Time Deposits (Prop. of GDP)

QE I QE II QE III Post-QE QT I Pandemic QE QT II



Where we are going...

- Central bank reserve expansion works through commercial bank balance sheets.
- There seems to be hysteresis; QT is not a reversal of QE.
- Can (some of) this be modeled? A micro-banking model of QE/QT.

Implications:

- Ordinarily, far less spare liquidity than suggested by simple reserve expansion.
- In *extremis*, higher the reserves issued ex ante, more fragile the interbank markets and higher the inter-bank rates in stress
- This can have adverse real consequences on corporate investments

The Basic Model

Firms, Banks, Investors, ... Interbank market to shuffle around liquidity

Model: Firms, Banks, Depositors, Investors

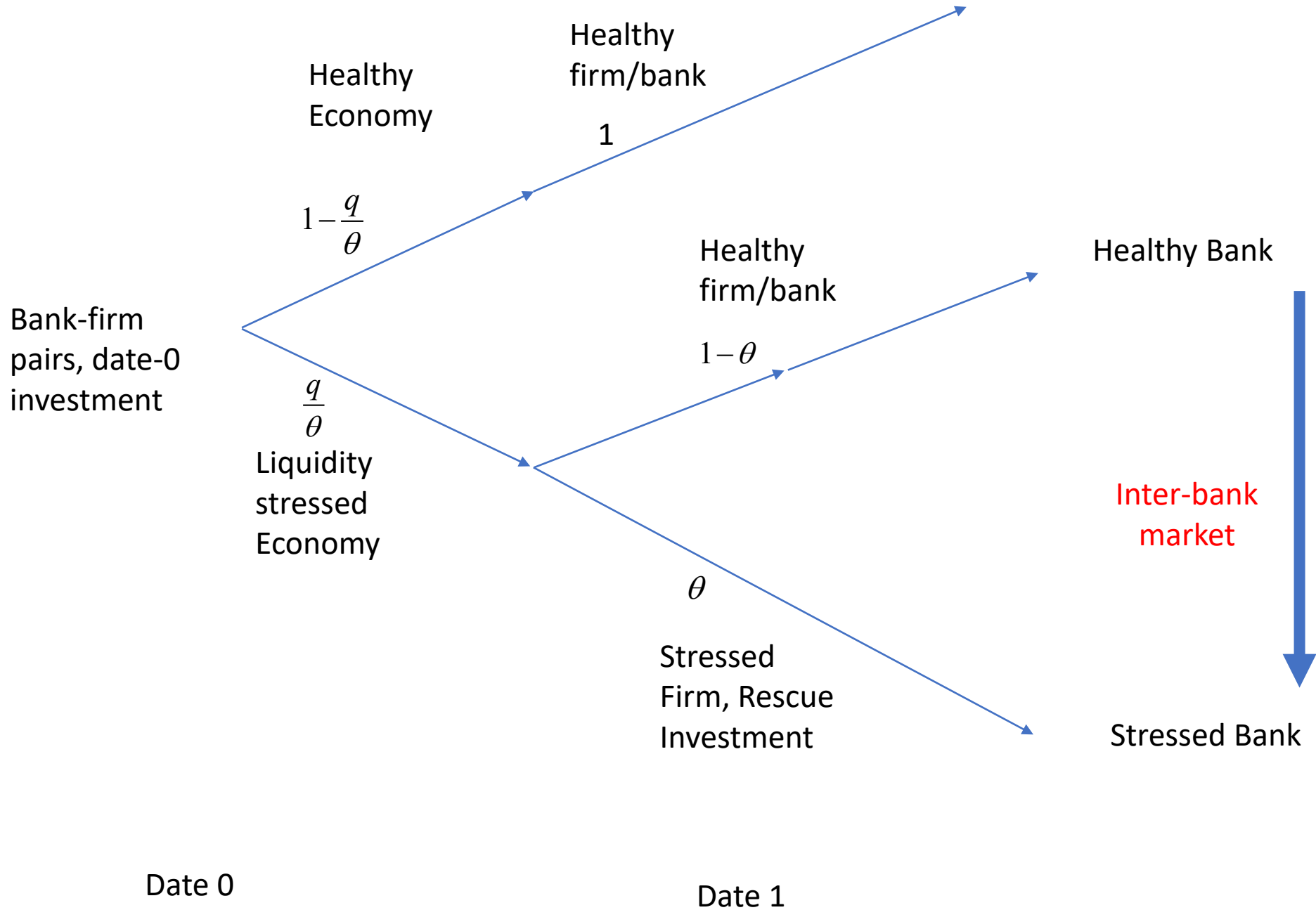
- Bank firm pairs
 - “regionally” or “sectorally” matched
- Firm and bank owners are risk-neutral, expected profit-maximizers
- Firms:
 - Invest I_0 at date 0 to obtain returns at date 2 , funded by
 - Firm owners' initial wealth W
 - Term loans from banks L
 - Place deposits D_0^F with bank.

Firms, Banks, Depositors, Investors

- Banks at date 0:
 - Assets
 - Long term loan to their firm
 - Liquid reserves S_0 that shrink by encumbrance τ (net of interest on reserves) at date 1
 - Liabilities I: Uninsured deposits D_0 from risk-averse investors at date 0
 - Will run if firm/bank stressed at date 1
 - Liabilities II: Capital from deep-pocket risk-neutral investors
[or alternatively, costly-to-raise “core” deposits that do not run]
 - 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

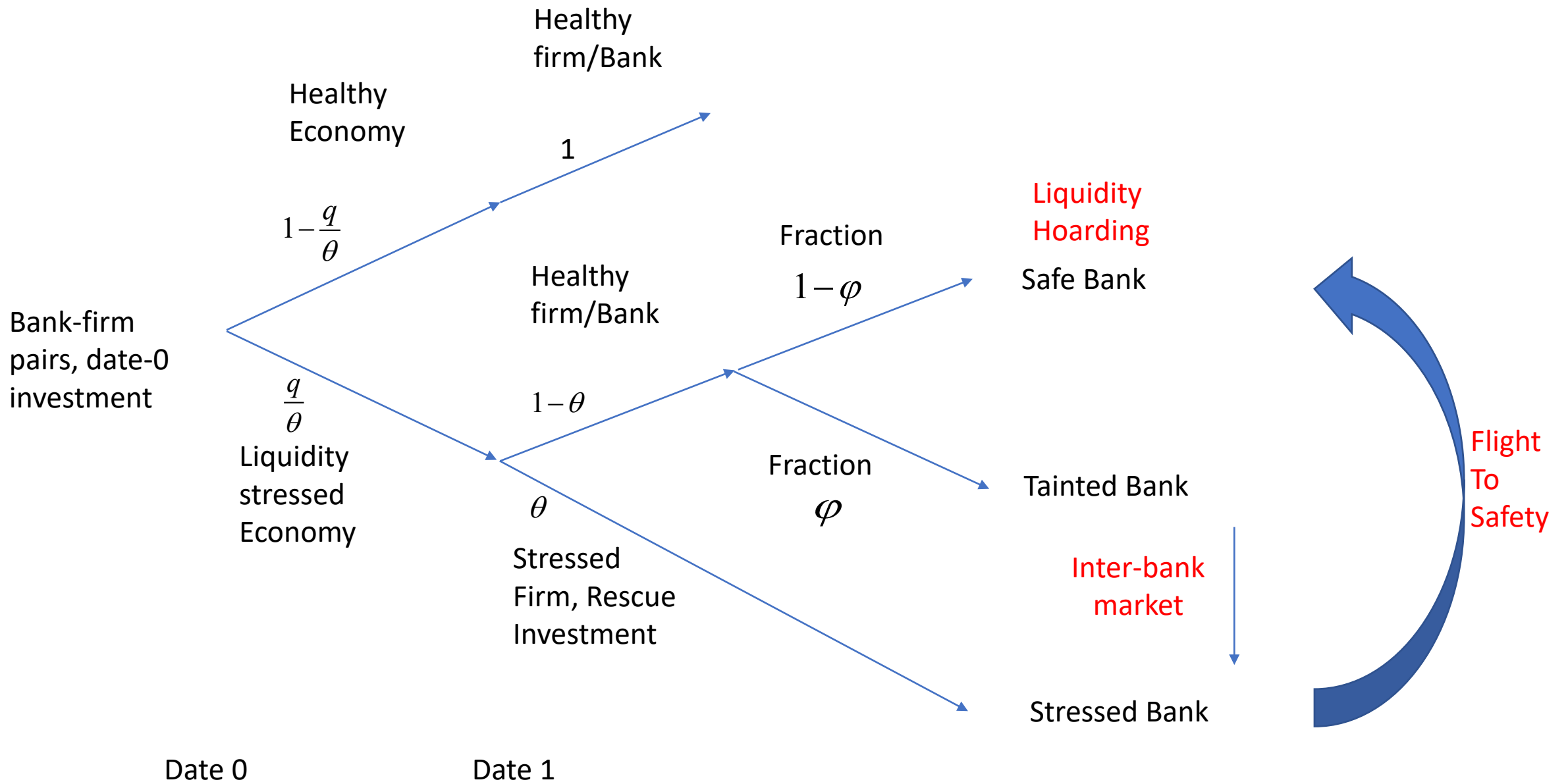


Stressed firm/bank at date 1

- 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.
- φ fixed for now



Firm's problem

- Date 0:

Term
loan

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

- Date 1:

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

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

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

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

When do more ex ante reserves increase ex post stress?

- How does the equilibrium rate r_1 change with S_0 ?
- Extra unit of reserves creates θ demand for liquidity from stressed banks
- Creates $(1 - \tau)[\varphi(1 - \theta) + \theta]$ supply of liquidity

Ex-ante reserves and degree of ex-post stress

- Rearranging, more ex-ante reserves enhance liquidity stress 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 $\tau > 0$.
- 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.
- Interesting result: the date-1 interbank market can shut down under a variety of circumstances.
 - The greater the convenience yield on reserves in stress, the larger the parameter range over which the interbank market shuts down
- Endogenize τ , the shrinkage of reserves, by adding in how QT works

I. Endogenizing hoarding and lending

- Deposits fleeing distressed banks migrate to “safe” banks
- Let safe banks earn a (small) *convenience yield* δ on reserves
 - value of liquidity 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 lend in the interbank market
 - equates profits from lending to profits from flight to safety deposits

Breakeven rate for inter-bank market to open up

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

“Tainted” Bank value

$$V_1^{1-\varphi} = \frac{\delta S_0 (1 - \tau) (\theta + (1 - \theta)\varphi)}{(1 - \theta)(1 - \varphi)}$$

“Safe” Bank value

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

Breakeven Inter-bank rate For (some) Surplus Banks To Lend

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

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

Low reserves:

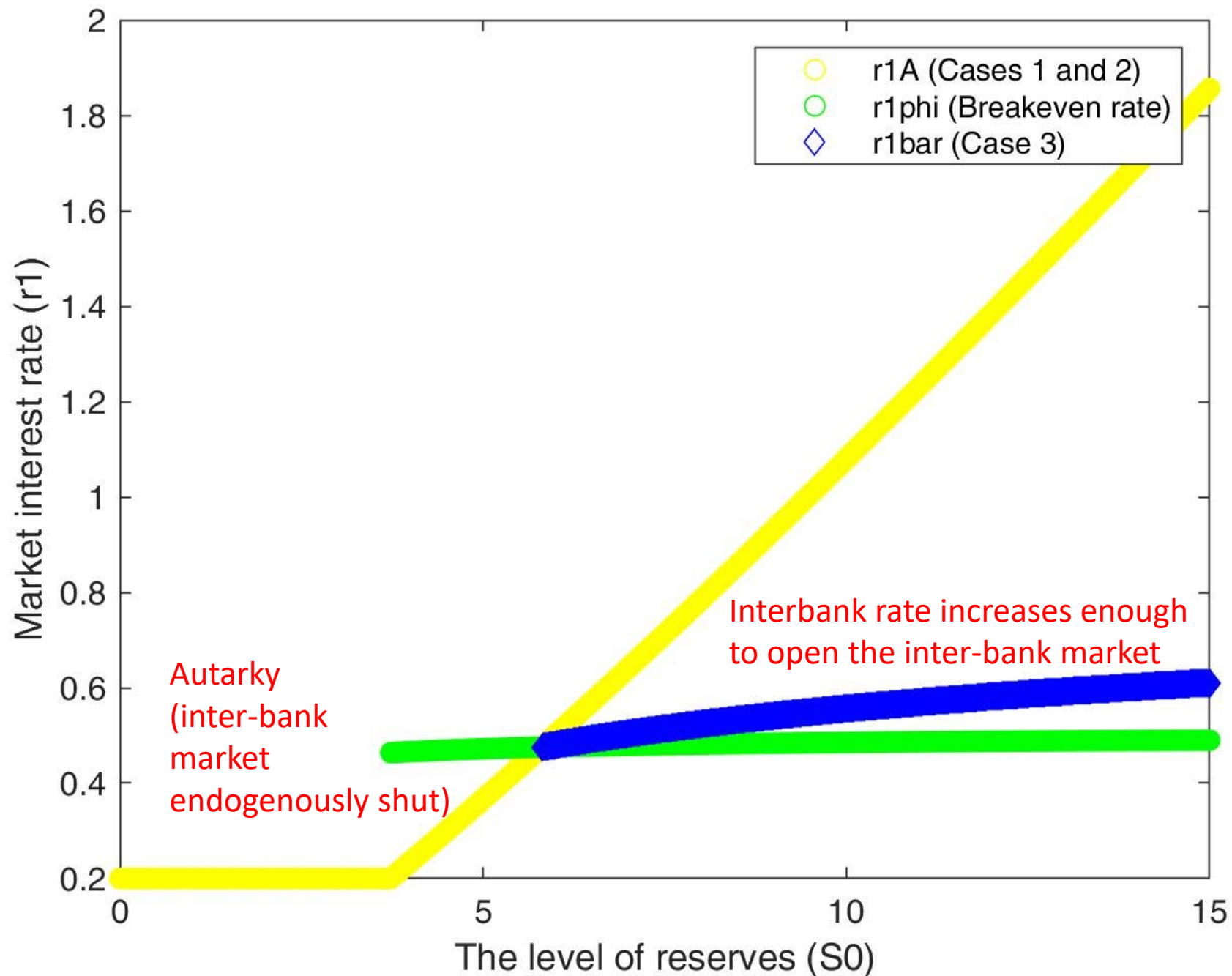
Banks manage with own funding

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



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 $\delta(r_1)$ may imply the interbank market never opens.

Endogenize reserve shrinkage τ : QT

- Suppose QT consists of the central bank selling securities
- Assume this takes place before uncertainty is realized.
- The central bank can sell securities
 - To banks : Asset swap
 - This will shrink bank reserves, without shrinking bank deposits.
 - To the public
 - This will shrink bank reserves and deposits
- In 2017-19, largely seemed to be asset swap

QT: Asset swap with banks, no contraction of deposits

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Asset swap with banks

Why might QT take this form?

- Central bank wants to sell securities
- Bank is prime broker with public clients holding deposits in bank.
 - Bank balance sheet contraction as clients pay for securities with their deposits
- Or it can buy securities itself.
 - Asset swap
- Assume securities are not as liquid as reserves, but can be “repo’ed” for reserves in a stressed market at a haircut h .

Will the bank buy CB securities itself or sell to clients

In stressed state

- If a bank stressed,
 - Balance sheet contraction: It gave up \$1 of reserves for \$1 of deposit shrinkage
 - Asset swap: repo the security for $(1-h)$ of reserves, but have to pay 1 to deposits
 - It is always better off having contracted its balance sheet.
 - If a bank healthy and wants to lend in interbank
 - Balance sheet contraction: It gave up \$1 of reserves which it cannot lend
 - Asset swap: It has $(1-h)$ of repo'ed reserves which it can lend in the interbank market.
 - Prefers asset swap
 - Ex ante, if θ small, φ high, and h small, asset swap dominates.
- => Reserve shrinkage τ relative to deposits high.

Why would banks engage in asset-swap in QT?

- Suppose banks assume that $r_1 > 0$ in the liquidity stressed state
- Then banks desire liquid assets in QT ($s = 1$) if and only if

$$\left[1 + \frac{(1-\theta)}{\theta} \varphi \right] > \frac{p}{(1-h)}$$

- Likely the case if
 - Securities are priced low (we assume in the paper $p = 1$)
 - Expected haircut in LOLR is low
 - Expected probability of liquidity stress is low
- Intuition: Individual bank incentives to keep reserves, taking as given the aggregate liquidity risk, engender aggregate liquidity risk!

To recap: Three considerations in whether past CB balance sheet expansion could create liquidity stress.

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

- Central bank buys bonds from public, creates reserves deposited in commercial banks.
- Are reserves financed with deposits or do banks rebalance deposits with new capital issuances?
- The way reserves are financed matters as demand deposits will be a claim on reserves in future

Three considerations...

II. Ex post: Shrinkage and/or Additional encumbrances on reserves

- Quantitative Tightening (QT) shrinks reserves but need not shrink liquidity claims
 - Acharya, Chauhan, Rajan and Steffen (2022)
 - Equivalent to QT being an asset-swap with banks (QE being asset-swap with non-banks)
- Commercial banks reluctant to leave reserves idle – therefore sell contingent claims on liquidity – credit lines to non-bank financials and non-financials – so that reserves are “fully” or “efficiently” utilized (ACRS, 2022; Yankov, 2020).
- 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 considerations...

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

- 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 prefer to stay “safe” and receive flight-to-safety deposits passively.

⇒ Liquidity hoarding limits the ex-post availability of reserves.

[Hoarding can be for other reasons too, e.g., if runs are indiscriminate.]

- Ordinarily, far less spare liquidity than suggested by simple reserve expansion.
- In *extremis*, higher the reserves issued ex ante, more fragile the interbank markets and higher the inter-bank rates in stress
 - This can have adverse real consequences on corporate investments

Policy Considerations

- Liquidity concerns would imply the central bank should set reserves such that $r_1 = 0$.
- But un-modeled monetary policy concerns in an era of too-low inflation 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, ex post liquidity stress 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)).
 - With φ endogenous, social planner wants to set capital lower!

Qualifies other policy recommendations

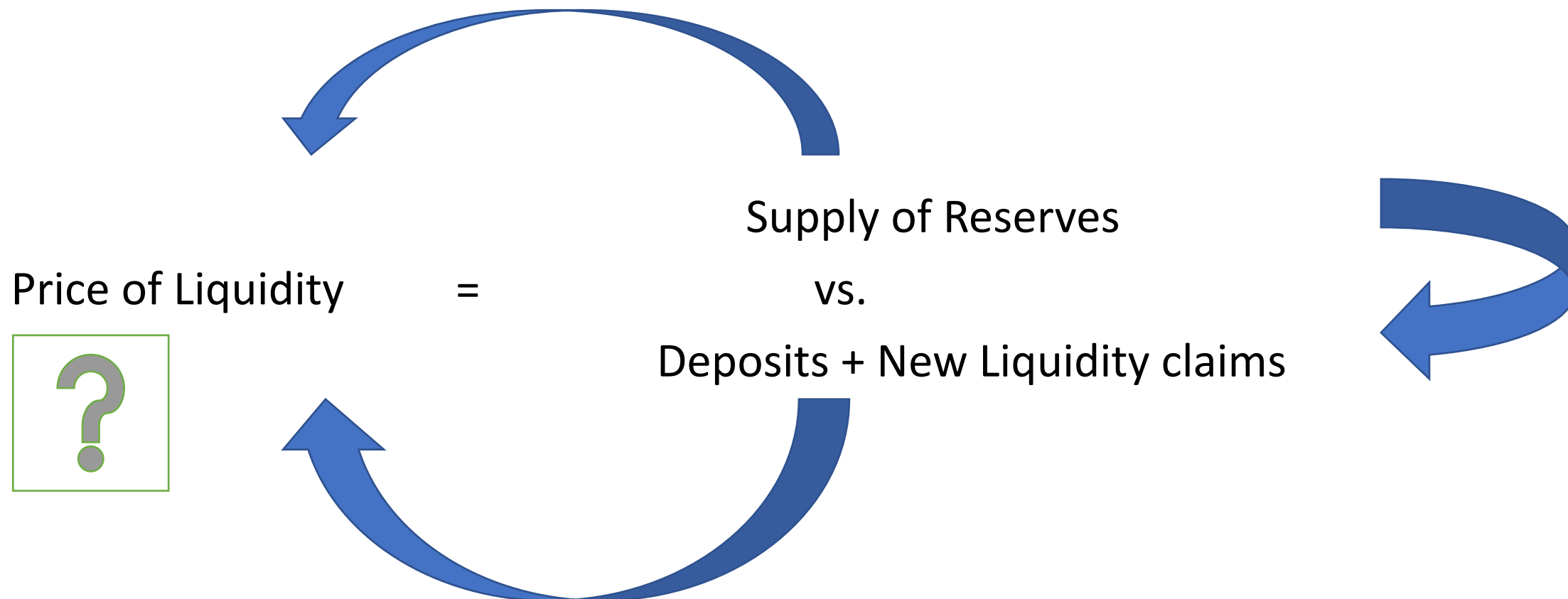
- Would more ex ante central bank balance-sheet expansion (Copeland, Duffie and Yang, 2021) work to alleviate ex post liquidity stress?
 - Under certain conditions could be a moving target!
- Would reserve issuance crowd out deposit-like claims (Greenwood, Hanson and Stein (2015, 2016))?
 - Our base model says it would enhance them.
 - Requires reserves to be held by non banks (e.g., money market funds).

Cannot the central bank intervene ex post?

Yes but

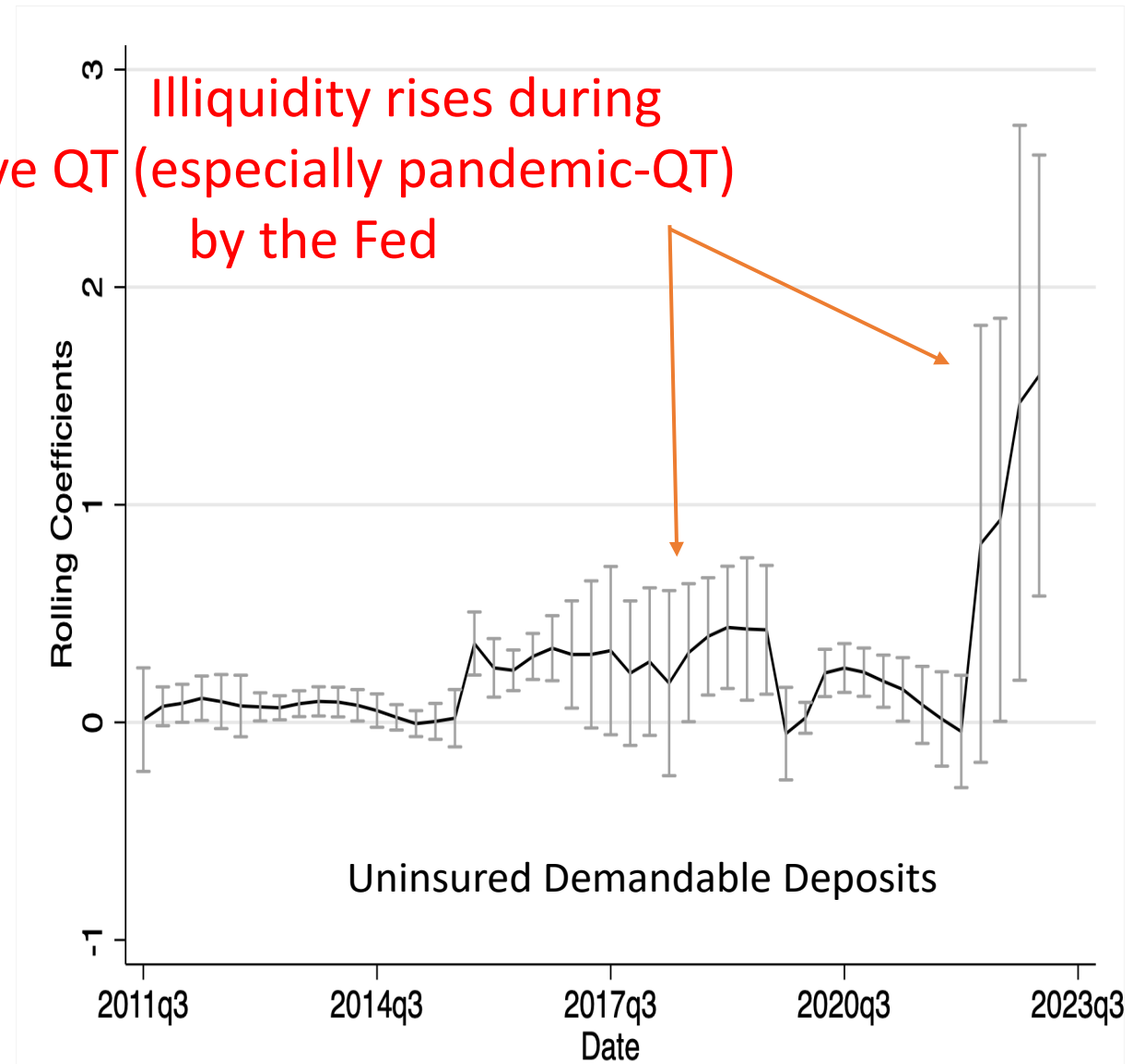
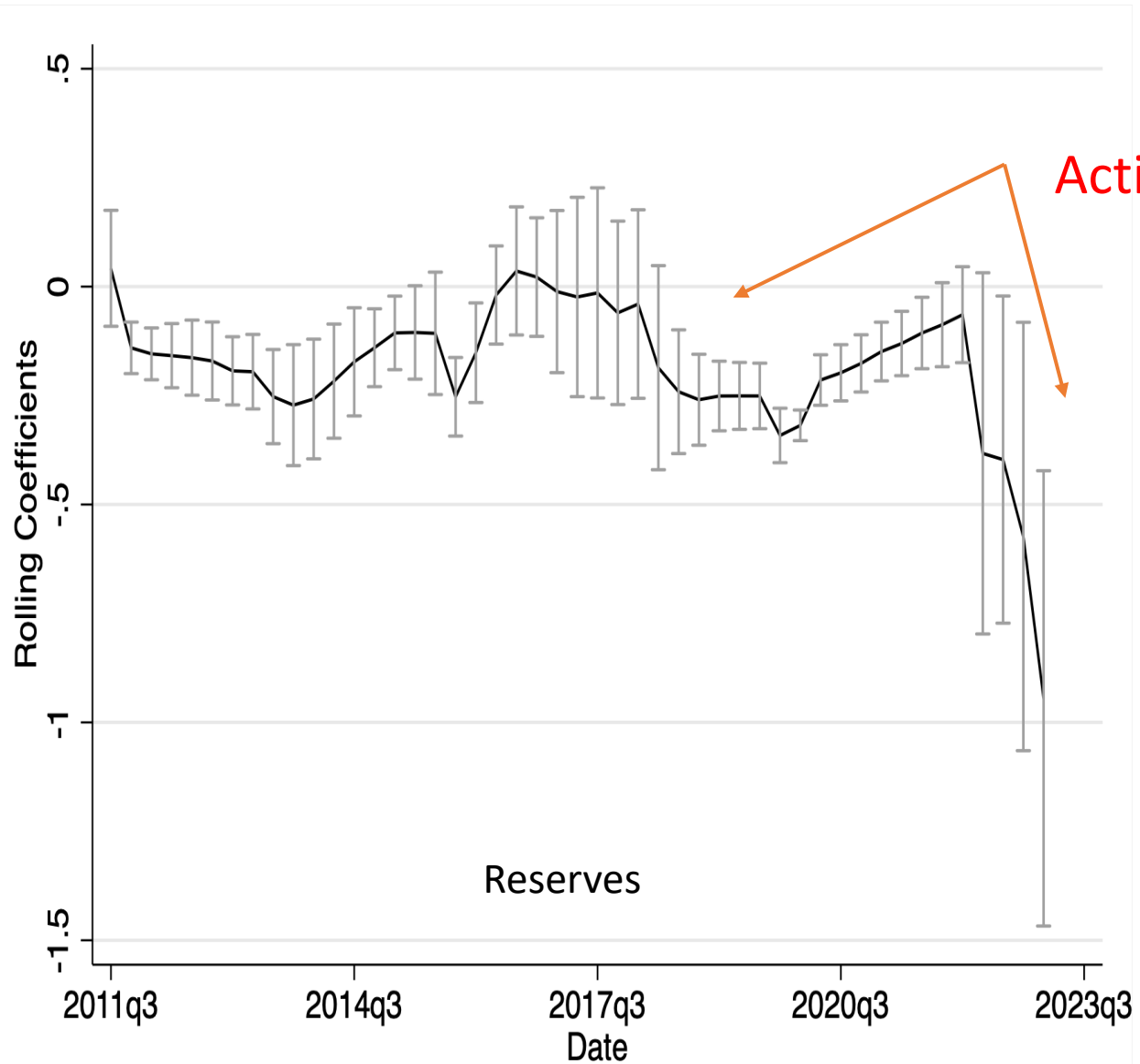
- Crowds out private ex-post lending by surplus banks – more hoarding
- Central banks typically lend against collateral
 - High quality collateral financed with deposits does not add additional liquidity
- Unsecured interventions or lending against all manner of assets (March 2023)
 - In principle, can 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.

Our point: Liquidity demand is affected by reserves



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

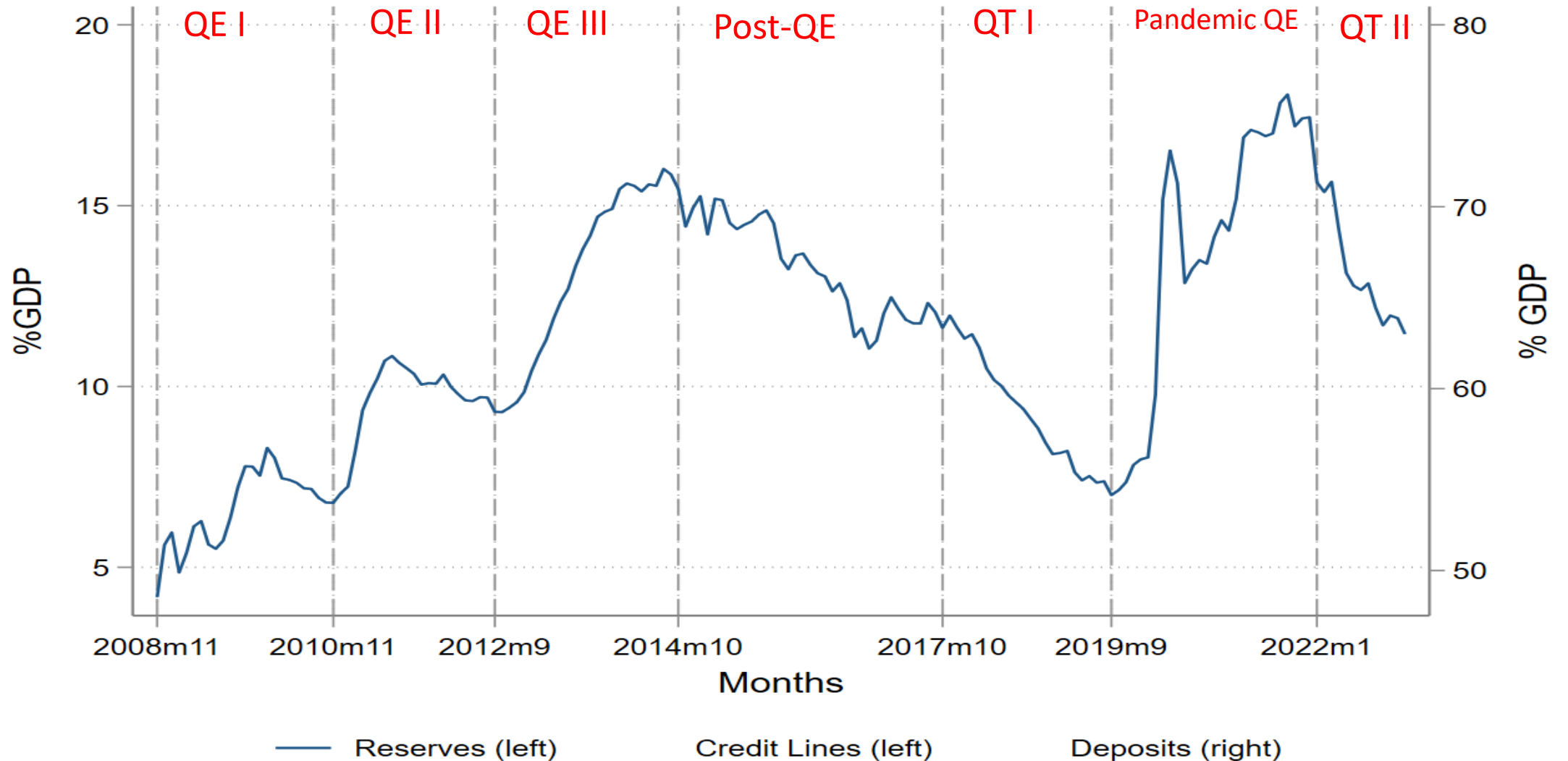
Qtrly Rolling Coefficient of EFFR-IOR on Reserves + UDD



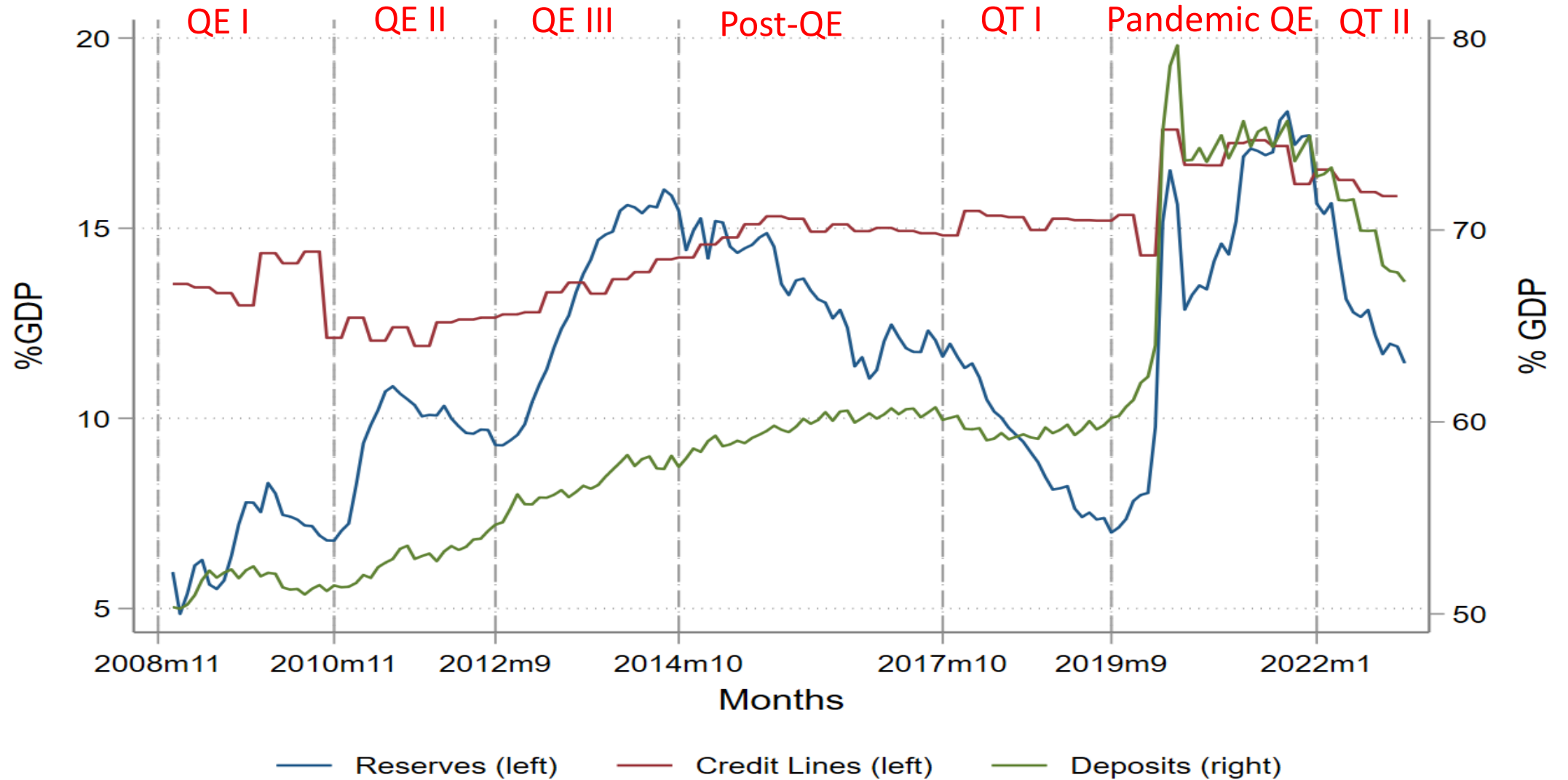
Conclusion

- 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
- Limits 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.
 - Engage in QT while “feeling the stones” for financial fragility
 - Monitor claims on liquidity also to see if they shrink.
 - Alternative: Target QT as sales to non-banks?
- Revisit desirable scale, scope, duration of QE: “pushing on a string”?

Reserves and Claims (% of GDP)



Reserves and Claims (% of GDP)



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>
→ I_1	l_1^F
	L_0^F
	Net worth

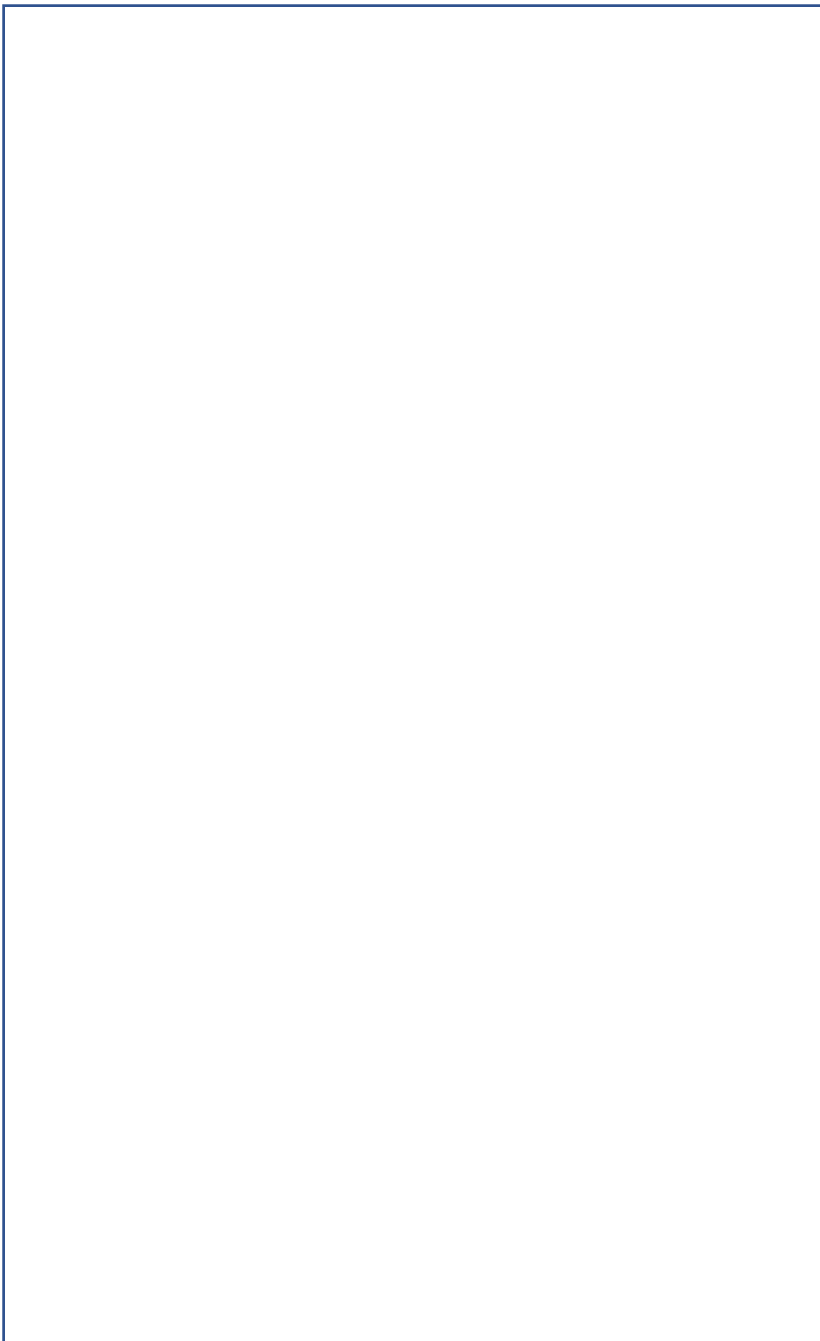
Rescue investment, Redeposited In "safe" banks

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
→ τS_0	e_1
$l_1^B (= l_1^F)$	e_0
	Net worth

Shrinkage or Encumbrance on reserves

← Liquidity Demand at date 1

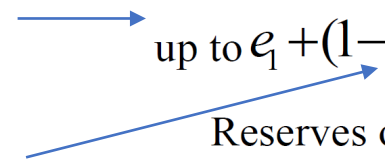


Bank Balance Sheet at Date 0	
Assets	Liabilities
$L_0^B + \frac{1}{2} \lambda (L_0^B)^2$	D_0
S_0	e_0
	Net worth

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



Traditional view: Exogenous demand for liquidity



Price of Liquidity = Supply of Reserves
vs.
Exogenous demand for liquidity

- As demand is exogenous, increasing supply of reserves is stabilizing