Lecture notes on money, finance, risk management, and public policy

Liquidity and liquidity risk

Allan M. Malz

Columbia University

Defining liquidity

Private liquidity creation

Liquidity risk and runs

Defining liquidity
- Maturity and liquidity transformations
- Information costs and market liquidity
- Liquidity as a stock

Private liquidity creation

Liquidity risk and runs

Financing long-term assets

- Financial and nonfinancial firms, as well as households, have long-term asset commitments
  - E.g. projects, factories, real estate, long-term securities, longer-term trading positions
- Desirable but possibly costly to match maturity/duration of funding to that of assets
- Nonfinancial firms generally try to maturity-match assets and liabilities
  - May be constrained by cost or marketability of long term debt
- Banks mismatch maturities of assets and liabilities as core part of business
  - By financing longer-term assets with shorter-term liabilities
- Leveraged trading positions: short-term funding, longer-term trade thesis

The closely-related meanings of liquidity

- "Liquidity" often used to describe the *state* of a market or participant
- **Funding liquidity** or **balance-sheet liquidity**
  - Ability to maintain debt-financed positions
  - A *market participant* is said to be liquid in this sense
- **Market liquidity** or or **transactions liquidity**
  - Ability to buy or sell without pushing prices against you
  - A *market* or *financial instrument* is said to be liquid in this sense
- "Liquidity" also used to describe a *stock of assets* available to carry out transactions

Linking market and funding liquidity

> *Why should anyone outside a lunatic asylum wish to use money as a store of wealth?* Keynes, "The General Theory of Employment" (1937)

- Two different ways to use an asset to raise funds
  - Funding liquidity reflects ability to borrow against an asset
  - Market liquidity defined by ease with which an asset can be exchanged for money
- Rooted in two key aspects of financial intermediation, create assets that resemble cash:

  Maturity or **duration transformation:** changing longer- into shorter-term debt

  Liquidity transformation: making an asset more readily transformable into goods or other assets

Maturity transformation

- Changing the term to maturity of a debt contract by borrowing short-term and lending long
- Historical evolution
  - Late-medieval, U.S. banks: focus almost exclusively on short-term lending, working capital→**real bills doctrine**
  - 19th c. and after, continental Europe: long-term loans to large enterprises
- Motivations of short-term borrowers and lenders lead to more mutually beneficial exchange:

  Borrower pays lower interest rate than he earns on longer-term assets

  Lender has a short-term *asset*→liquidity transformation

Liquidity transformation

- Forms of lending that create assets that function as money
- $\rightarrow$**Information-insensitive** debt
  - Perceived to be (relatively) free of asymmetric information problems
  - Low credit and liquidity risk, legally-sanctioned reliance on ratings
  - $\rightarrow$Low monitoring costs
- **Liquidity risk sharing** via banks:
  - Early liquidation of long-term investments generally possible only at a loss
  - Insure value of stored wealth if consumption desired earlier than planned
  - Coinsure against liquidity risk by pooling with other households, smooth out random fluctuations in withdrawals
  - Interbank market provides similar coinsurance to banks themselves
- Lower interest rate because deposits provide money services
- Permits circulation$\rightarrow$collateral markets

Information costs and market liquidity

- **Market** or **transactions liquidity** determined by search, trade processing costs, and information asymmetries
- **Market microstructure**: institutional arrangements that assist in search, e.g.
  - OTC markets vs. exchanges
  - **Quote-driven** trading system reliant on dealers vs. **order-driven** system resembling auction

Characteristics of market liquidity

Tightness is the cost of a round-trip (buy and then sell) transaction, typically measured by the **bid-ask spread**

Depth: how large an order it takes to move the market

Immediacy: speed at which an order can be executed

Resiliency is inverse to the time a large order moves the market away from the equilibrium price, measured by

Adverse price impact: impact on market price of an order

Slippage: change in market price induced by time it takes to get a trade done in a moving market

Liquidity and information traders

- Adverse selection increases search costs: each trader takes into account possibility counterparty has better information on security's value ($\rightarrow$information-insensitive assets)

  Liquidity or **noise traders** traders reallocating to or from cash
  Information traders have a view on value
- Adverse price impact protects noise traders

Defining the stock of liquidity

- Stock of liquidity is larger than stock of money as generally measured ($\rightarrow$central banks)
- Most liquidity and money is privately issued
  - Claims on other market participants, not central banks or government
  - Fractional-reserve banking and money multiplier
- Standard definitions of money supply—e.g. M1 in the U.S.—include
  - Cash, a government liability
  - Most bank deposits and retail money market mutual funds (MMMFs), privately-issued liabilities
- Government role: issuance of
  - Cash, central bank reserve balances
  - Low-risk (($\rightarrow$)"safe") assets serving as collateral for short-term loans

Wider definitions of stock of liquidity

- Privately-issued liabilities such as
  - Short-term loans collateralized by securities
  - Institutional MMMFs
- These carry out some functions of money
  - Can be transformed into money at very short notice at or close to par value
  - But not used to buy and sell goods, services or assets
  - Has been termed **"shadow banking system"**

Defining liquidity

Private liquidity creation

- Commercial banking
- Collateralized security loan markets and safe assets
- Money market mutual funds

Liquidity risk and runs

Commercial banking

- **Commercial banks** carry out both maturity and liquidity transformation
- Historically and primarily by taking deposits and making illiquid loans with limited to marketability
- Effected by "using balance sheet": bank lending is inherently deposit creation
  - Maturity: short-term deposits fund long-term lending
  - Liquidity: transferable and redeemable on demand
- U.S. regulatory term **depository institutions** includes other deposit-taking intermediaries

Other elements of commercial banking business

- Most deposits instantantly redeemable, serve as transactions accounts, but some longer-term deposits
- Provide liquidity via **lines of credit** or **loan commitments** as well
- Effect settlement, clearing of payments, offset of debts
  - Pay one debt with another (the ledger)
- Loan underwriting: assessing borrower creditworthiness
  - As basis for loan terms, primarily lending rates and maturity
- **Delegated monitoring**: banks monitor borrower credit quality
  - Modeled as agent relationship to depositors as principals

Synergies in commercial banking

- Deposits and lending
  - Liquid asset, delegated monitoring in exchange for low-cost funding
- Deposits and credit lines
  - Supported by same stock of liquid assets
- Term loans, commitments both require underwriting
- Deposits integrated into payment systems
- But associated risks
  - High correlation of redemptions, draws on credit lines under stress conditions
  - Does non-zero run probability impose discipline?

Fractional-reserve banking

- **Demand deposits** have unique contractual characteristics that provide liquidity
  - **Sequential service constraint** ("first-come first-served")
  - **Par redemption:** depositors' right to transform asset into cash without delay
- Deposits are general claims, not claims on specific precious metals or currency deposited
- Bulk of deposits freed up for lending
- Bank lends at term for projects requiring time to pay off, deposit is redeemable on demand
- Liquidity transformation: hold sufficient reserves so
  - Bank can offer a better return to short-term depositors than projects' early liquidation value
  - But viable only if bank accurately predicts timing of withdrawals ($\rightarrow$runs)

Schematic balance sheet of a commercial bank

<table>
<tr><th>Assets</th><th>Liabilities</th></tr>
<tr><td rowspan="2">Liquidity reserve: cash and government bonds $15</td><td>Capital: common equity $10</td></tr>
<tr><td rowspan="2">Deposits $80</td></tr>
<tr><td>5-year corporate loans $85</td></tr>
<tr><td></td><td>Longer-term borrowing $10</td></tr>
</table>

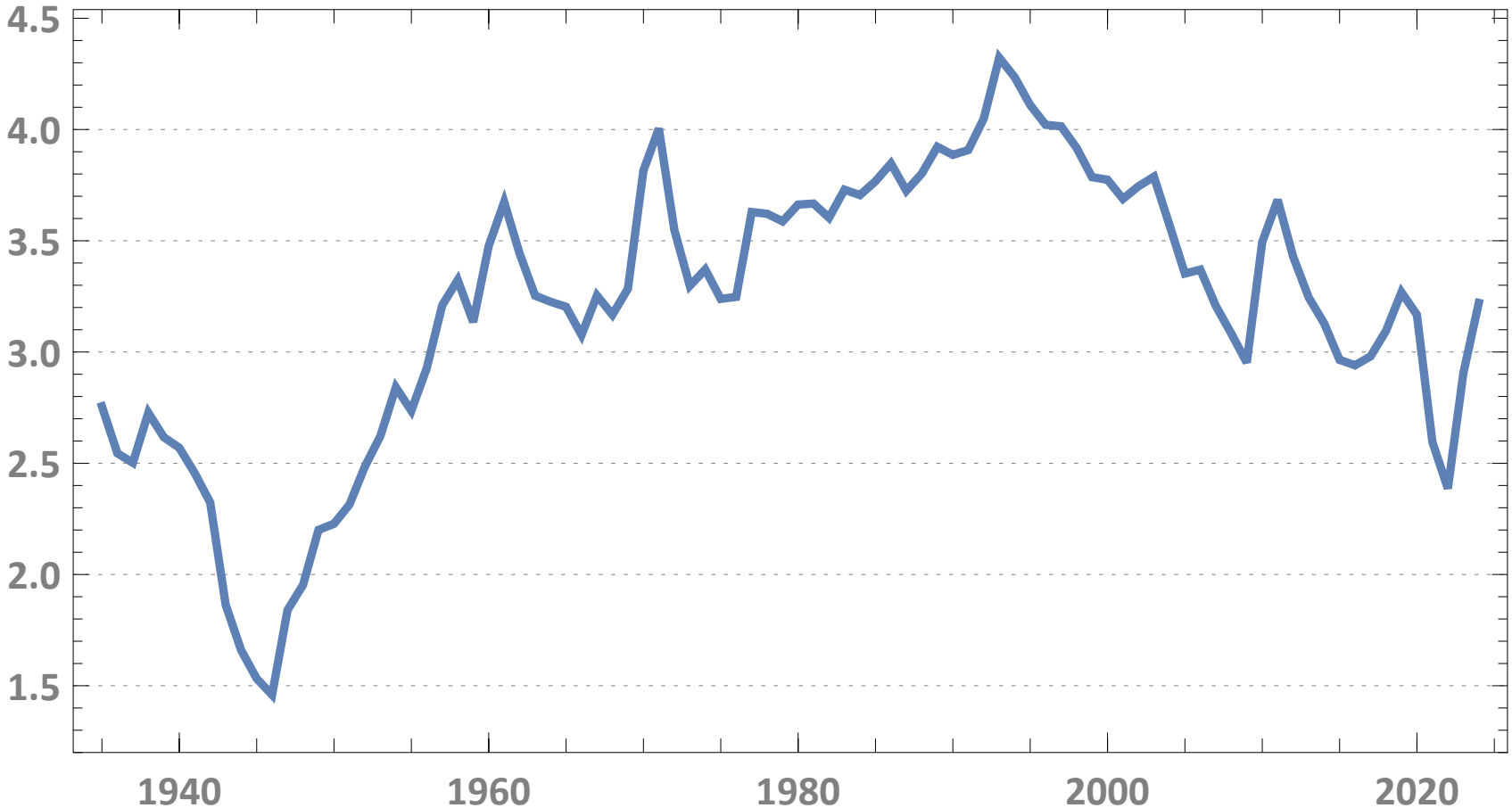
Net interest margin

- Yield and spread curves typically upward-sloping
- **Net interest margin** (NIM):

$$\frac{\text{net interest income}}{\text{interest earning assets}} = \frac{\text{interest income} - \text{interest expense}}{\text{interest earning assets}}$$

- But net interest income generally relies on **duration** or **maturity mismatch** on the balance-sheet of the short-term borrower/longer-term lender
- Requires **asset liability management** (ALM): project and align future cash flows

Net interest margin of U.S. banks 1934–2023



Ratio of net interest income to total interest earning assets, all FDIC-insured commercial banks, annual, percent. *Source*: Federal Deposit Insurance Corporation (FDIC), Historical Statistics on Banking, Tables CB04 and CB16.

Collateral as money

- Liquidity and **information-insensitive assets**
  - Owner of high-quality collateral can borrow nearly equal amount of cash
- Good collateral facilitates securities trading, thus analogue to means of payment
- Collateral circulates via **rehypothecation chains**: multiple re-use by successive borrowers
  - Relationship of velocity—length of chain—of collateral to economic activity similar to that of money velocity
  - And inversely when collateral held rather than rehypothecated
- Collateral supports maturity transformation
- Bond liquidity value⇒lower spread, incentives to issue
- Limits: central bank money and collateral imperfect substitutes in crisis

Collateral shortage

- A.k.a. "scarcity of collateral": diminished availability of "good collateral" since the crisis
  - Growth in demand for "safe," liquid assets
  - Partial explanation of low government bond yields, repo rates ↑credit spreads, ↑funding liquidity risk
- Responses include **collateral swaps**, swap lower- for higher-quality collateral for a fee
- Restraints on rehypothecation leads to ↓supply of collateral
- For European banks in particular, additional pressure from **encumbrance** of assets
  - Assets pledged or otherwise committed→subordination of remaining debt
  - **Covered bonds**: bonds secured by specific assets, usually mortgage loans
  - **Long Term Refinancing Operations** (LTROs): European Central Bank program provides 3-year loans against eligible collateral

Growth in demand for "safe" assets

- Concern about putative shortage of "safe" assets, those with
  - Low credit risk, e.g. advanced-economy sovereign and private AAA debt
  - Low purchasing power risk from inflation, devaluation
  - Low liquidity risk
- Demand said to be growing before, accelerating since crisis
  - Rise in global savings rates ($\rightarrow$savings glut): longer-term trend, begins in earnest following Asian Crisis 1997-98
  - Demographic trends: rising longevity
  - Use of safe assets as collateral
  - International imbalances: preference for U.S. assets, inflows of capital to U.S. from developing countries
  - Increase in monetary reserves ($\rightarrow$rise of large capital pools)
  - Capital standards for and asset-liability management by institutional investors, esp. pension funds, insurers
- Distinct from 2007–09 crisis-induced flight to liquidity

Shortage of safe assets

- Supply responses to safe-asset demand before the crisis: regulatory framework encouraged creation and market acceptance of safe assets
  - ($\rightarrow$)Basel capital standards:
    - Zero risk weights permitted for AAA and AA government debt
    - Low risk weights permitted for AAA private debt
  - Perception of implicit guarantees by eurozone collectively
    - Perception underpinned by high exposure of eurozone core-country banks
  - $\rightarrow$Incentive to securitization, creation of "AAA" assets
- Reduction in supply since the crisis
  - Eurozone periphery debt no longer safe (but possibly returning to "safe" due to low rates, recovery)
  - Reduction in securitization issuance
- $\rightarrow$**Safety trap:** safe-asset shortage induces recession under unconventional monetary policies

Advent of money market mutual funds

- Origin 1970–71, evasion of Regulation Q interest-rate ceilings
- Constitute largest single investor group in short-term debt
- Rapid growth after 1983 SEC **Rule 2a-7**
  - **Fixed** or **stable net asset value** (NAV) at par plus accrued
  - Unless mark-to-market losses above threshold ($\frac{1}{2}$ percent): "breaking the buck"
  - Restrictions on maturities and credit quality of assets
- Growth varies with term structure of interest rates
  - Declining short-term rates, flattening yield curve early 2000s→decline in volume
  - Rising short-term rates, flattening yield curve 2005–07→increase in volume

Typology of money market mutual funds

- Types of MMMF by share ownership:

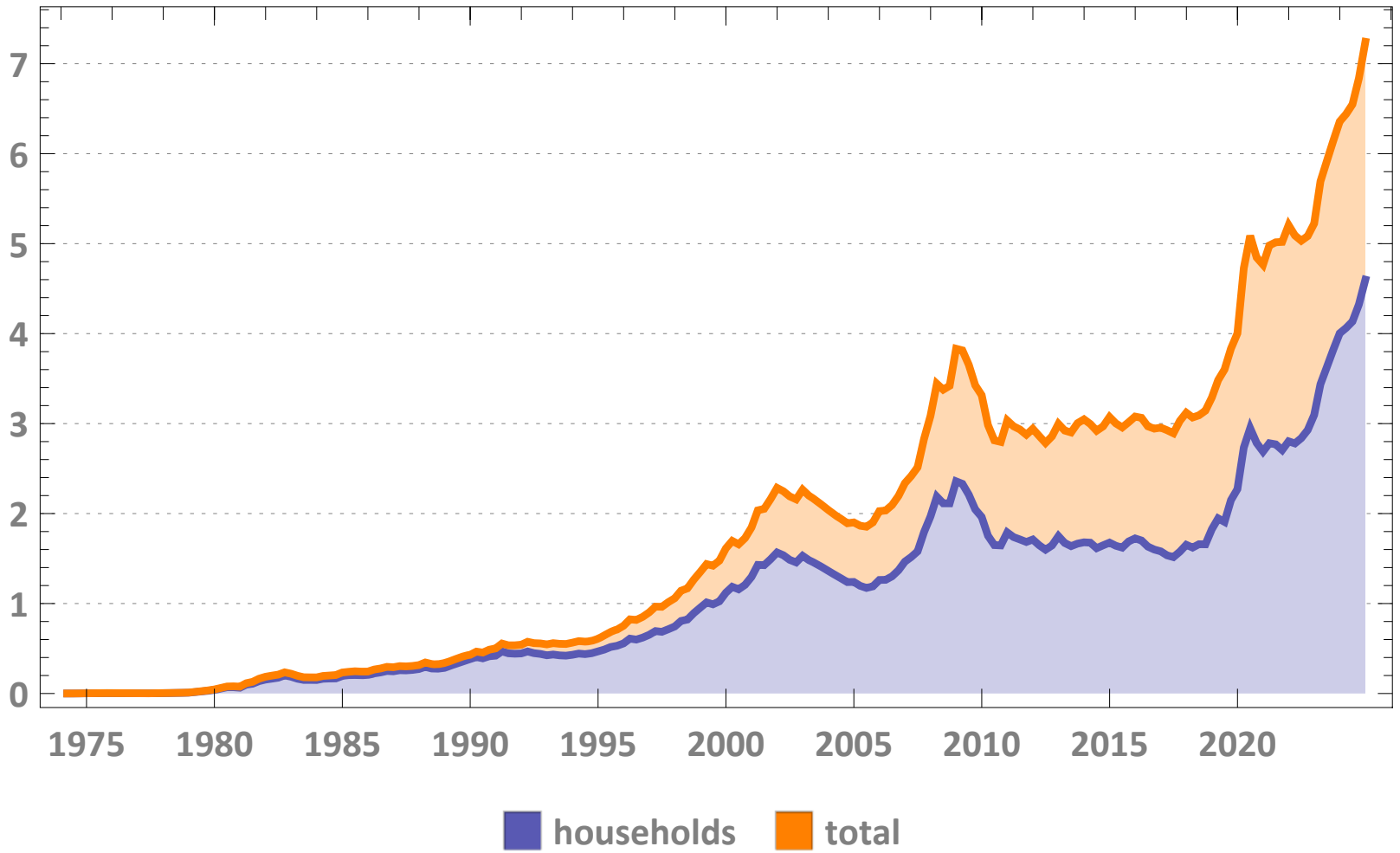
  Retail: households
  Institutional: nonfinancial and financial businesses, institutional investors

- Types of MMMF by investment assets:

  Prime funds: invest in corporate debt, commercial paper, repo
  Government: Treasury debt and repo
  Non-taxable municipal debt

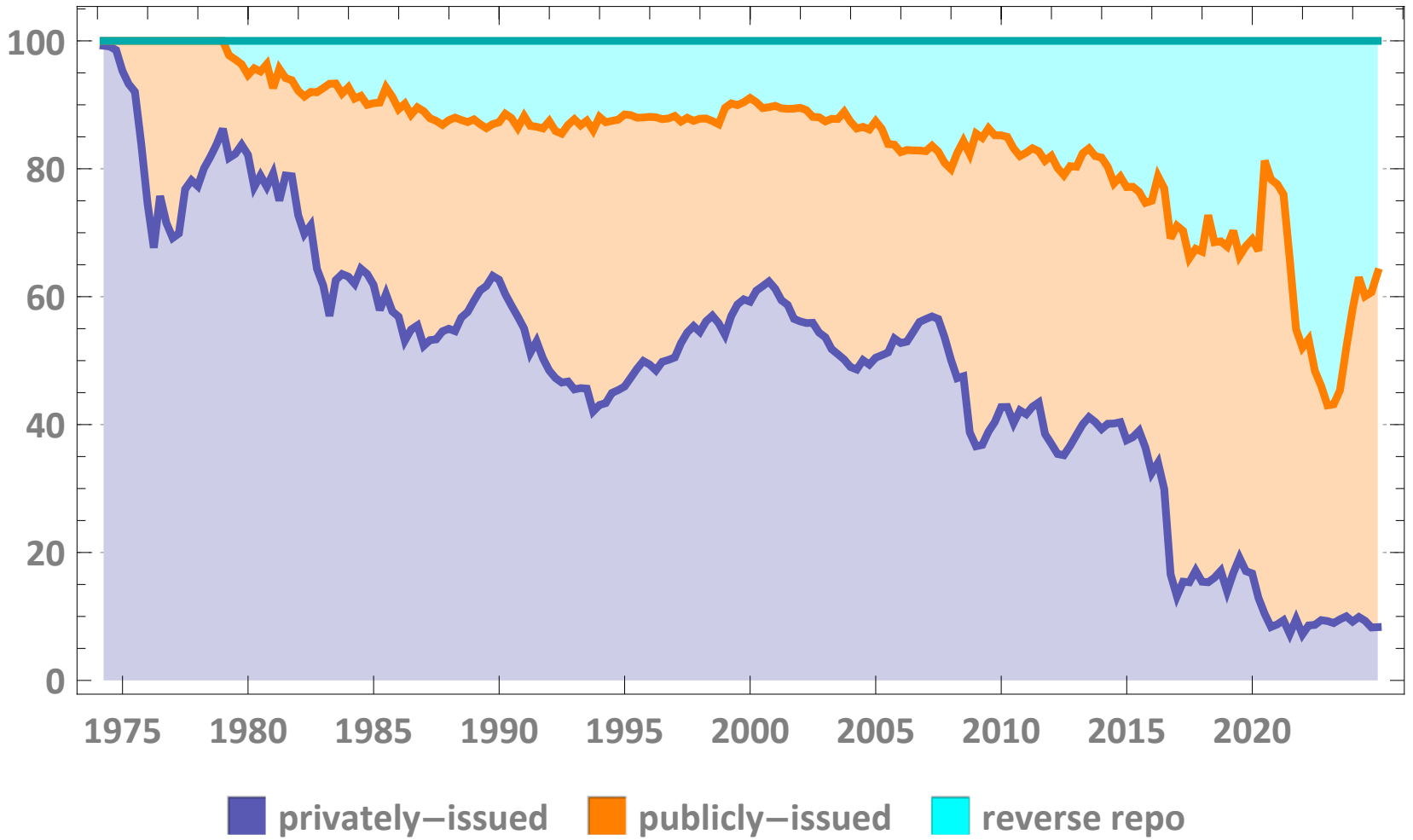
- Prime funds a crucial link in market-based intermediation as investor in short-term debt

Owners of money market fund shares 1974–2024



Value of households' and nonprofit organizations' MMMF shares and total value of MMMF shares, $ trillions, quarterly, Q1 1974 to Q4 2024. *Source*: Federal Reserve Board, Financial Accounts of the United States (Z.1), Table L.206.

Composition of MMMF assets 1974–2024



Share of each asset type in total assets of U.S. money market mutual funds, percent, quarterly, Q1 1974 to Q4 2024. *Source*: Federal Reserve Board, Financial Accounts of the United States (Z.1), Table L.121.

Defining liquidity

Private liquidity creation

Liquidity risk and runs

- Measuring a market participant's liquidity risk
- Bank liquidity risk
- Banking and insurance liquidity
- Liquidity risk in insurance
- Runs and intermediary failures

Definition of funding liquidity risk

- The risk that creditors either withdraw credit or change the terms on which it is granted
- $\rightarrow$Positions have to be unwound and/or are no longer profitable.
- Also called **balance sheet risk**
- Related term is **rollover risk**
  - Short-term debt cannot be refinanced
  - Or can be refinanced only on highly disadvantageous terms
- **Example**: intermediaries forced to take greater liquidity risk following Lehman bankruptcy
  - Even if able to roll over borrowing today, uncertainty about tomorrow
- Leads to undesired asset liquidations, market liquidity risk event

Funding liquidity metrics

Stock measures compare liquid asset holdings to short-term liabilities

Liquidity gap within maturity buckets: liquid assets net of firm's less stable funding or **volatile liabilities**

- Banks: exclude wholesale short-term funding, **nonoperating deposits**
- Insurance: exclude **guaranteed investment contracts** (GICs), policyholder deposits apt to be surrendered

Flow measures: projections of out- and inflows of cash and other liquid assets over specific time horizon

- Often combined with stock measures

Cash flow mismatch: difference between estimated inflows and outflows of cash over specified future horizon

Liquidity coverage ratio: stock of liquid assets divided by a measure of cash outflow

- Key ratio for Basel liquidity regulation

Data on market liquidity

- Available data includes
  - Bid-ask spreads
  - Turnover volume
  - Amount outstanding of securities
  - Order books
- But few useful risk measures
- Volatility based bid-ask spread risk measure
  - Expected transactions cost is the **half-spread** or **mid-to-bid spread**
  - Volatility of the half-spread a measure of transaction cost risk
- Even if accurate, not that useful!

Liquidity-adjusted VaR

- VaR estimate adjusted for "time to escape"
- Exploit square-root-of-time rule, requiring:
  - Estimate days T to liquidate without adverse price impact
  - Estimate of 1-day VaR
- Assume position liquidated in equal parts each day
  - Trader faces 1-day holding period on entire position, 2-day holding period on $\frac{T-1}{T}$ of the position, etc.
  - Sequence of position sizes $1, \frac{T-1}{T}, \frac{1}{T}, \ldots, \frac{T-2}{T}$
  - Multiplying VaR by $\sqrt{T}$ overestimates risk
- Rather, adjust VaR by

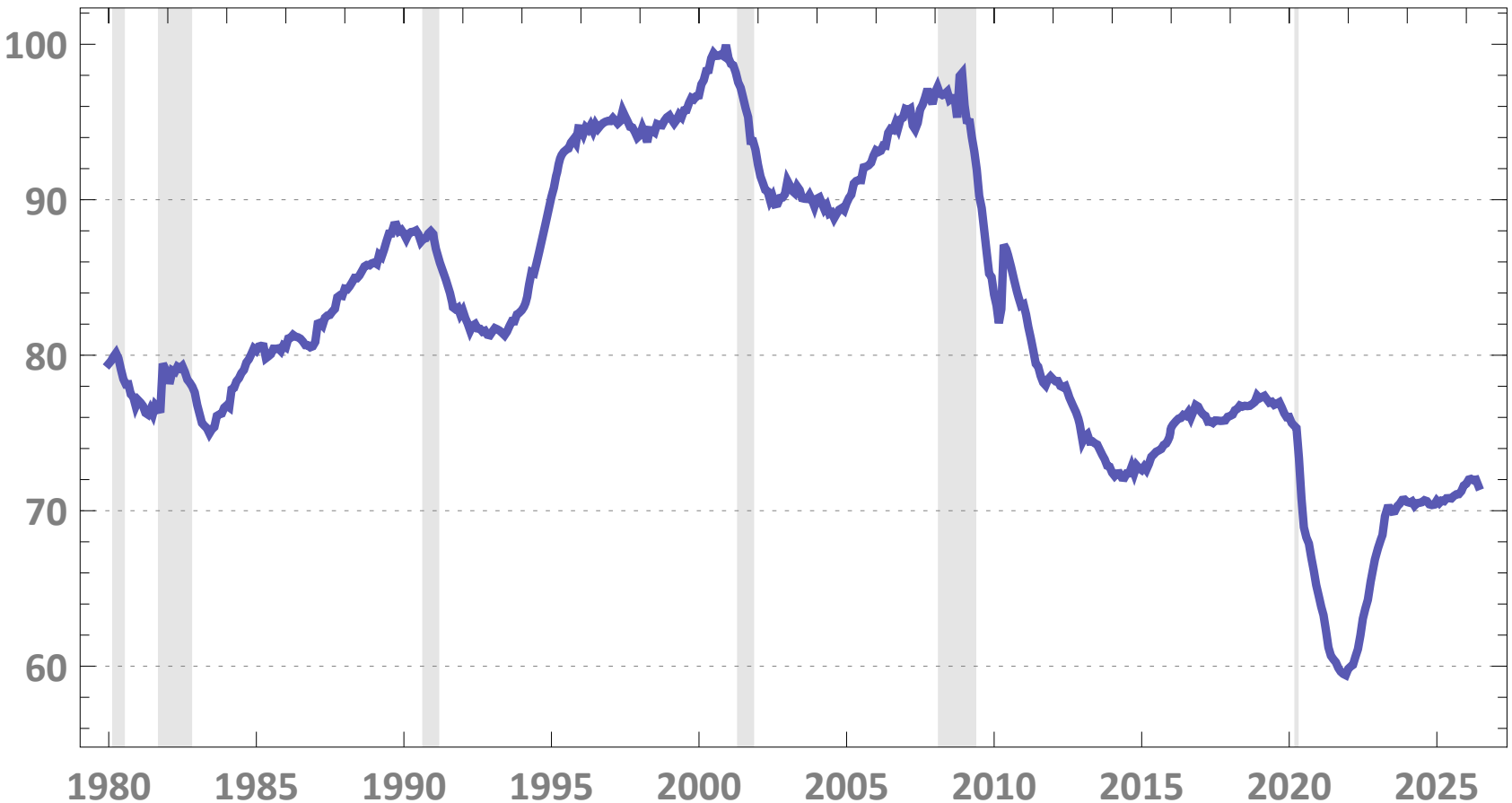
$$\sqrt{1+\left(\frac{T-1}{T}\right)^2+\cdots+\left(\frac{1}{T}\right)^2}=\sqrt{\frac{(1+T)(1+2T)}{6T}}$$

- For example, for $T=5$ multiply overnight VaR by 1.48

Bank liquidity measurement

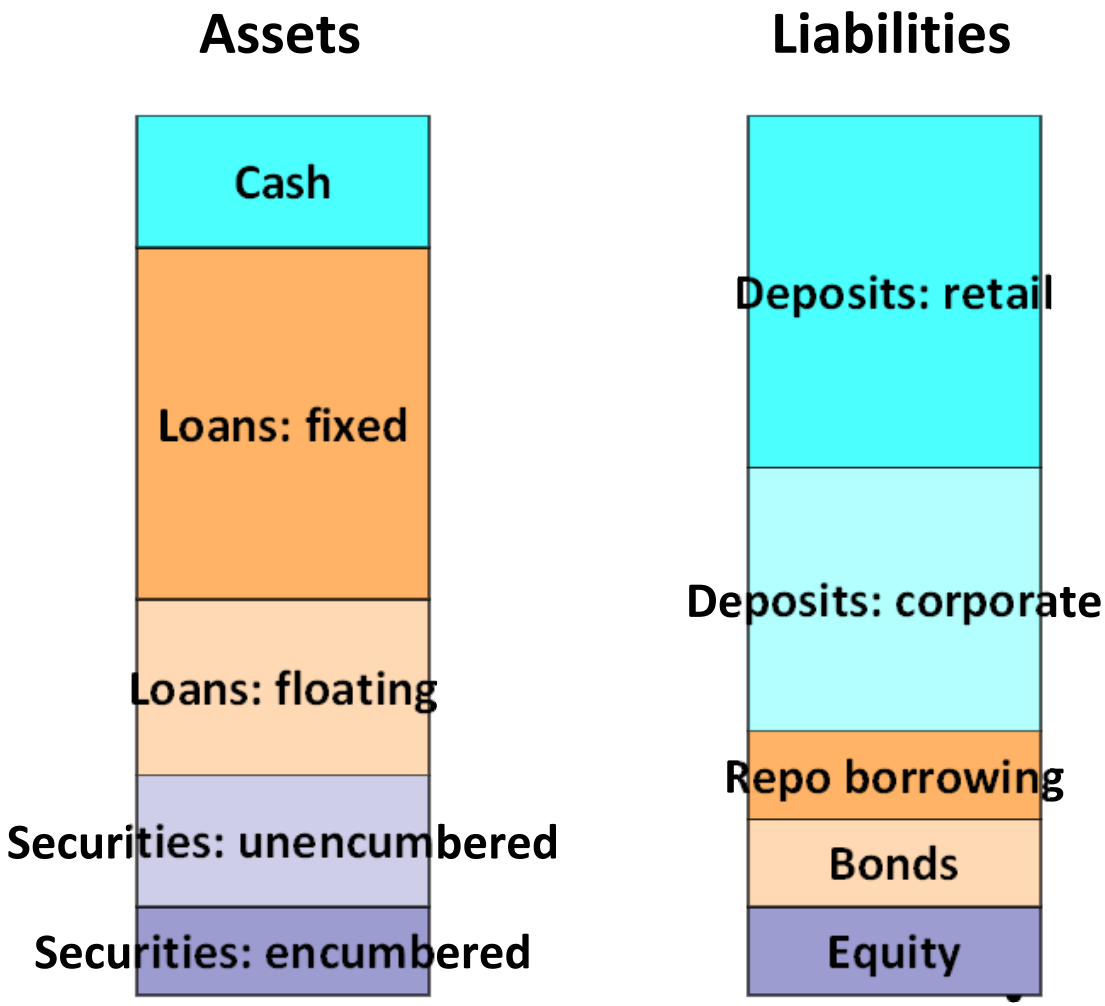
- Randomness in in- and outflows of liquidity
- Sudden or unforeseen need to borrow liquidity potentially costly
- Liquidity buffer
- Loan-to-deposit ratio
  - Indicates extent to which illiquid loans are funded by liquid deposits.
- Cash flow projections
  - Includes contingent cash flows, e.g. derivatives, credit lines
  - Liquidity term structure

Loan-to-deposit ratio of U.S. banks 1979–2026



Ratio of loans and leases in bank credit to deposits, all commercial banks, seasonally adjusted, percent, monthly Dec. 1979 to May 2026. Vertical shading represents NBER recession dates. *Source*: Federal Reserve Board, H.8 data release.

Schematic bank balance sheet



Bank balance sheet and cash flows

	size	rate	tenor	duration	cash flow
Assets					
Cash	1 500	2.50	0.10	0.10	9.38
Loans: fixed	4 000	7.50	10.00	5.00	75.00
Loans: floating	2 000	5.00	4.00	0.10	25.00
Securities: unencumbered	1 500	4.00	10.00	7.00	15.00
Securities: encumbered	1 000	4.00	10.00	7.00	10.00
Liabilities					
Deposits: retail	4 000	1.00	0.00	0.00	-10.00
Deposits: corporate	3 000	4.00	0.50	0.10	-30.00
Repo borrowing	1 000	3.00	0.00	0.00	-7.50
Bonds	1 000	4.50	10.00	7.00	-11.25
Equity	1 000	2.50	NA	NA	-6.25

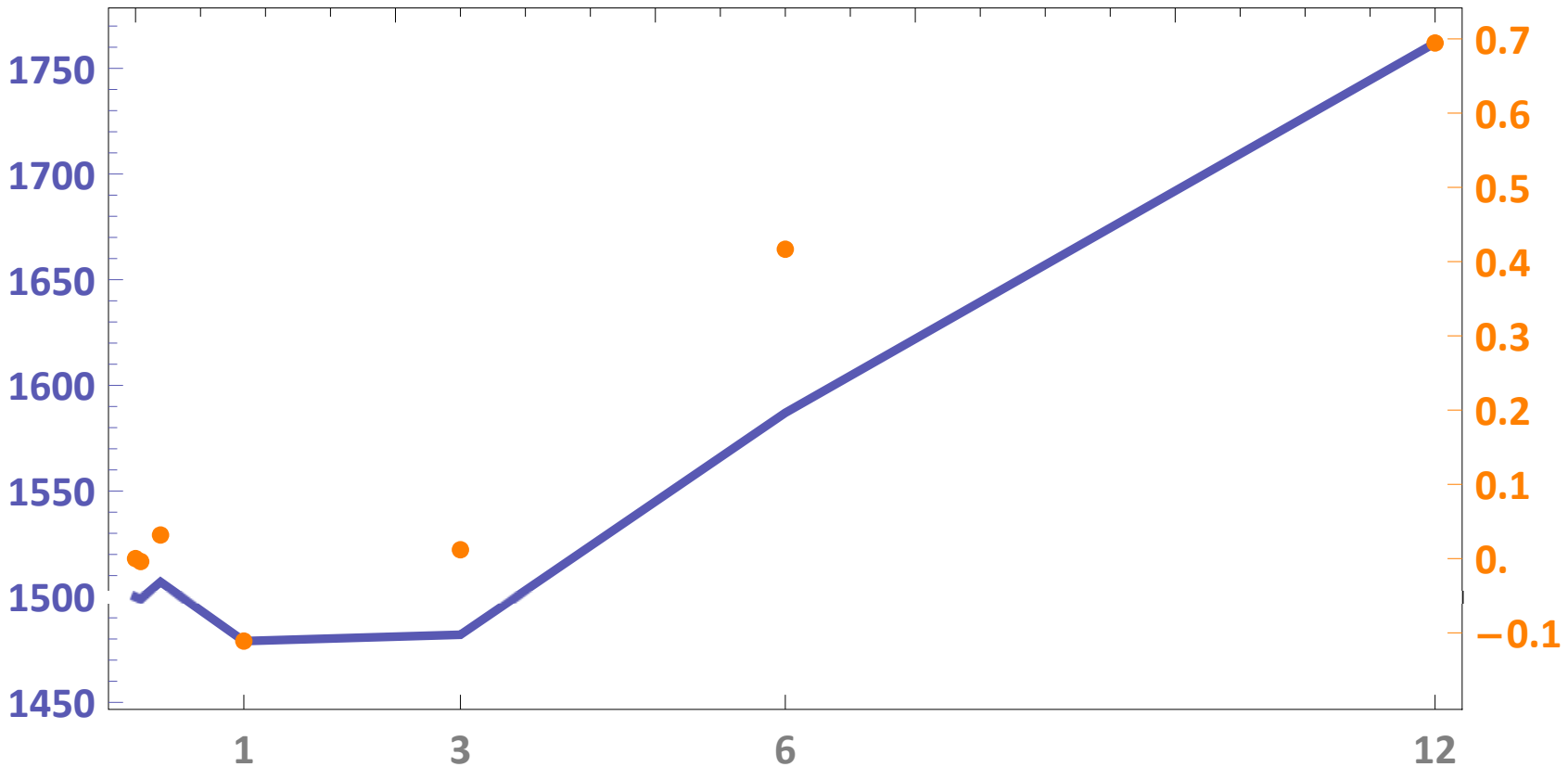
Maturities in years; cash flows at a quarterly rate.

Near-term bank liquidity term structure

period	maturity	inflows	outflows	cash balance
Intraday	0	3	3	1 500
1 day	0.0040	1	2	1 499
1 day to 1 week	0.0192	15	7	1 507
1 week to 1 month	0.0833	30	58	1 479
1 month to 3 months	0.2500	75	72	1 482
3 months to 6 months	0.5000	175	70	1 587
6 months to 1 year	1.0000	290	115	1 762

Cash flows at a daily rate.

Short-term bank cash flows and cash balance



Purple plot (left axis): bank's cash balance; orange points (right axis): cash in- and outflows at a daily rate.

The insurance business

- Business is driven largely by liability side of balance sheet
  - Policies generate liabilities arising from probability and severity of future claims
- Asset side responds
  - Insurance premiums invested in portfolio of assets designed to meet claims and generate excess return over cost of equity
  - Duration of investment portfolio generally matched to that of insurance reserves

Schematic balance sheet:

<table>
<tr><th>Assets</th><th>Liabilities</th></tr>
<tr><td rowspan="2">Duration-matched
investment portfolio $95</td><td>Insurance reserves $70</td></tr>
<tr><td rowspan="2">Capital: common equity $30</td></tr>
<tr><td>Liquidity reserve $5</td></tr>
</table>

Comparing banking and insurance businesses

- Liquidity generally not in the forefront for insurance
  - Banks' core functions related to liquidity creation
  - Insurers core functions related to coverage of future claims, liquidity risk incidental
- Insurer liabilities tend to be long-term rather than short-term
  - But susceptible to **adverse development:** underestimate of future claims
- Relative absence of liquidity creation activities in insurance
  - Policy holder claims far less liquid than deposits
  - But some short-term funding sources vulnerable to run-like behavior
  - Insurer "using its balance sheet" to fund future claims payments, generate return on equity
- Insurance companies less reliant on wholesale funding
- Insurance companies generate liquidity via inflow of premium payments, analogues to interest income

Asset-liability management in banking and insurance

- **Asset-liability management** (ALM): monitoring and control of the maturity and liquidity structures of assets and liabilities
- ALM metrics:
  - Fixed-income analytics: duration, convexity
  - Stress scenarios
  - Cash-flow profiles
- Banks more heavily focused on cash flows, ensuring liquidity at all times
  - Banks manage a mismatch of maturity and liquidity structures as a core function
  - Short-term, liquid liabilities against longer-term, illiquid assets
- Insurers more heavily focused on matching duration, ensuring assets invested at longest durations consistent with liability duration
  - Insurance companies endeavor to match the maturity and liquidity structures
  - Extremely long-term–but also illiquid—liabilities present challenge and opportunity

Liquidity stress events for insurers

- What shocks jeopardize liquidity, as opposed to solvency?
- Early surrender of life products
- Redemption of GICs, other bank-like liquidity products
  - Termination of reinsurance contracts
- Collateral calls on collateralized securities funding and on derivatives transactions
- Reaching for yield increases risk that any funding liquidity risk event will lead to market liquidity risk event
- Triggers:
  - Run on insurer: idiosyncratic credit downgrade (GA Life, AIG), insolvency fears (Executive Life of New York)
  - Market risk event: economic downturn and systematic credit downgrade (AIG), sharp rise in interest rates, derivatives cash call
  - Surge in claims, e.g. natural disaster cluster

Early surrender of life products

- Rising interest rates make minimum guaranteed rates in annuity products uncompetitive, may make early surrender optimal
- Bad combination: low surrender charge and low minimum guaranteed rate
- Inverse: low interest rate environment, high guaranteed rate$\rightarrow$solvency/capital problem
- May require sale of assets to fund redemption
- Fire sale: market liquidity risk event
- Interest-rate sensitivity of annuities, esp. variable annuities
- Surrender—access to accumulated cash value—and optionality
- Hard to model: lack of experience of low interest rate environments

Bank runs and the fragility of banking

- Bank keeps **reserves** of liquid assets
  - Ensure bank can meet unexpected cash withdrawals by depositors
  - Cash and readily-marketable securities, esp. high-quality short-term commercial paper and government debt→market liquidity risk
- **Bank run** or **panic:** near-simultaneous attempt by many depositors to withdraw deposits out of fear bank's reserves may be depleted
- Why are fractional-reserve banks fragile?
  - Sequential service constraint together with par redemption
  - Controversial: fragility of deposits enhances credibility of banks' credit monitoring
- Multiple equilibria: all can run or all can stay
- Demand deposits only work in "good," no-run equilibrium
- Applies to market-based intermediation as well
- Solutions: ample or 100 percent reserves, clearinghouses, deposit insurance, lender of last resort

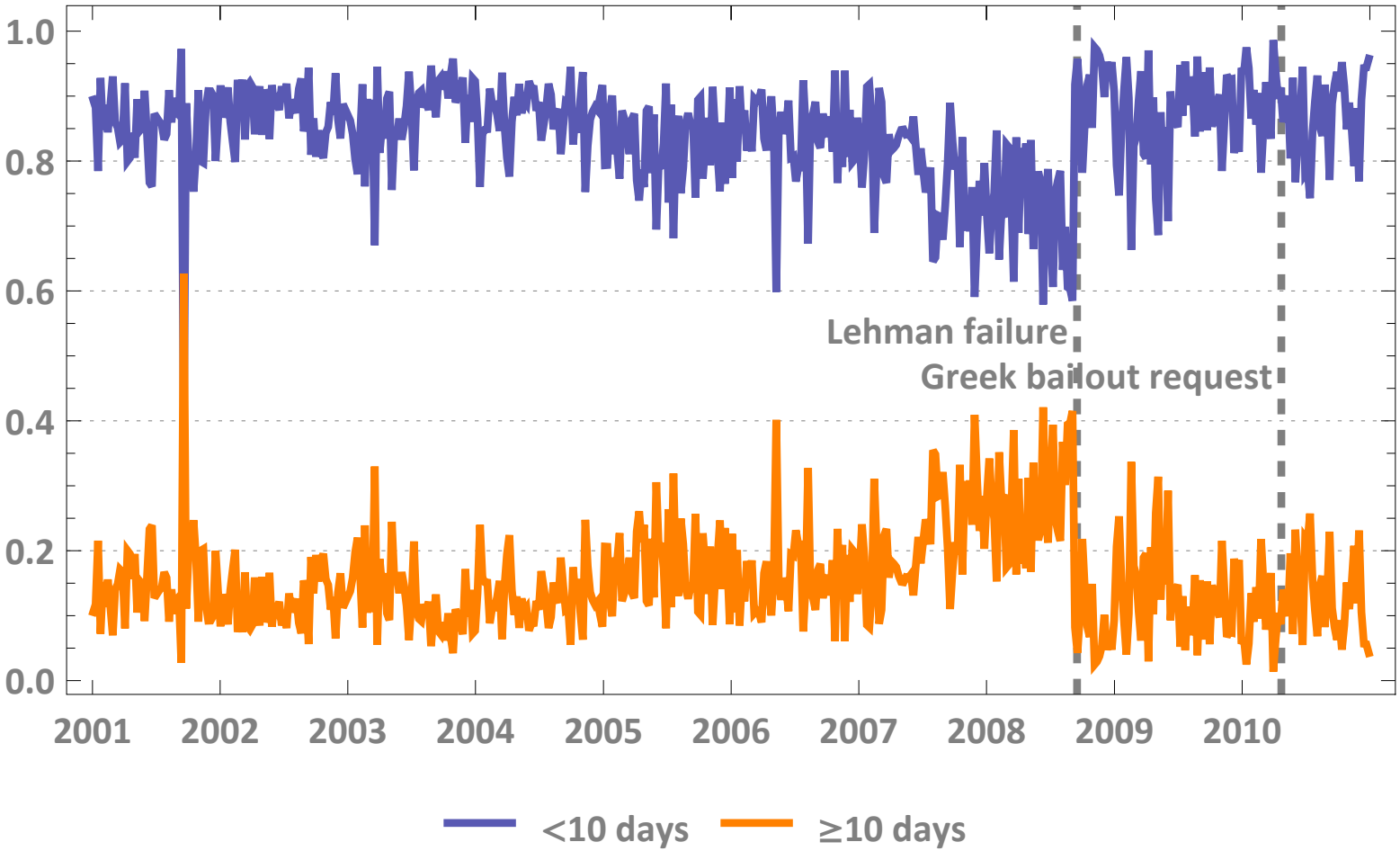
Liquidity risk in the aggregate

- Potential for liquidity risk events of individual intermediaries to affect others
- **Short-term wholesale funding** (STWF) a focus since global financial crisis
  - Regulatory term for short-term credit
  - Extended by intermediaries—banks, institutional investors, MMMFs—rather than households
  - Includes large deposits, MMMF assets, cash borrowed via repo
- Rapid growth in STWF up to global financial crisis

Conditions for a run

- Extensive maturity and liquidity transformation
- Features of financial contracts:
  - On-demand redemption (zero maturity)
  - Par redemption
  - Sequential service constraint ("first-come first-served")
  - Failure to pay, including temporary suspension, triggers bankruptcy
- Typically—and historically—banks
- But apply also to money market mutual funds
  - Rule 2a-7: maintain "stable net asset value" per share via amortized cost method of valuation and penny-rounding
  - Sequential service constraint: capital redemption
- Survival depends on liquidity but can be overcome by strong suspicion of insolvency
- Increase in **liquidity preference**, demand for cash related to risk aversion, uncertainty

AA financial commercial paper 2006–2010



Shares of amount issued of AA financial commercial paper with original maturities of 1–9 days (black plot), and maturities of 10 days or more (red plot), weekly. *Source*: Federal Reserve Board, available at `www.federalreserve.gov/releases/cp/`.