

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

# 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 **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:
  - 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
- → **Information-insensitive** debt
  - Perceived to be (relatively) free of asymmetric information problems
  - Low credit and liquidity risk, legally-sanctioned reliance on ratings
  - → 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 → 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

**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 (→information-insensitive assets)  
**Liquidity** or **noise 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 (→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 ((→) “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

# The commercial banking business

- **Depository institutions** carry out both maturity and liquidity transformation
- 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
- Provide liquidity via transactions accounts, **lines of credit** or **loan commitments**
- Effect settlement, clearing of payments, offset of debts
  - Pay one debt with another (the ledger)
- Loan underwriting and **delegated monitoring**
- Synergies among deposits, loan commitments, term loans
  - Deposits, loan commitments supported by same stock of liquid assets
  - But potential high correlation of redemptions, draws under stress conditions
  - Term loans, commitments require underwriting
- Synergies among deposits, term loans and payment systems

# 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 (→runs)

## Schematic balance sheet of a commercial bank

Assets	Liabilities
Liquidity reserve: cash and government bonds \$15	Capital: common equity \$10
5-year corporate loans \$85	Deposits \$80
	Longer-term borrowing \$10

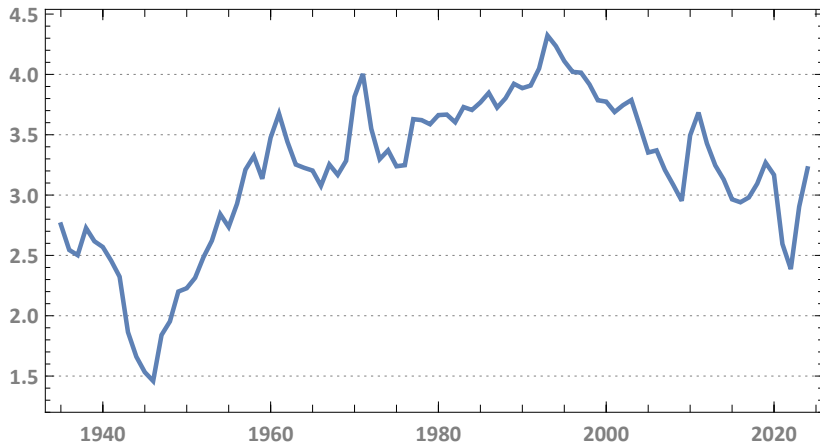
# Net interest margin

- 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  $\Rightarrow$  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 (→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 (→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
  - (→)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
  - →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
- →**Safety trap**: safe-asset shortage induces recession under unconventional monetary policies

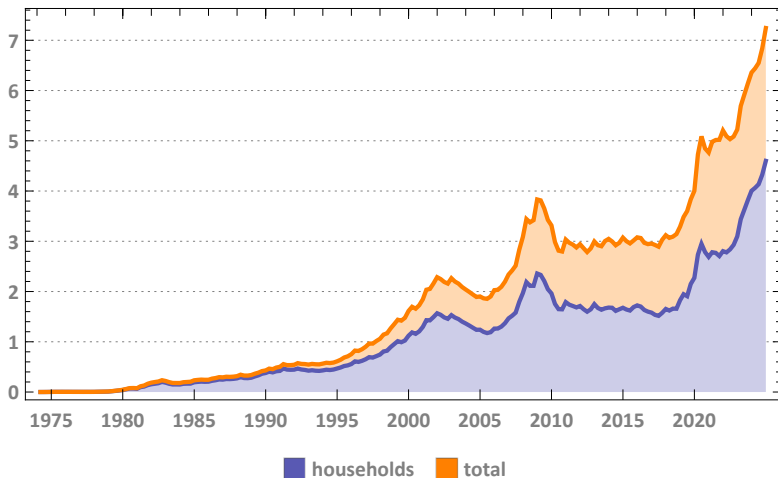
## Advent of money market mutual funds

- 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

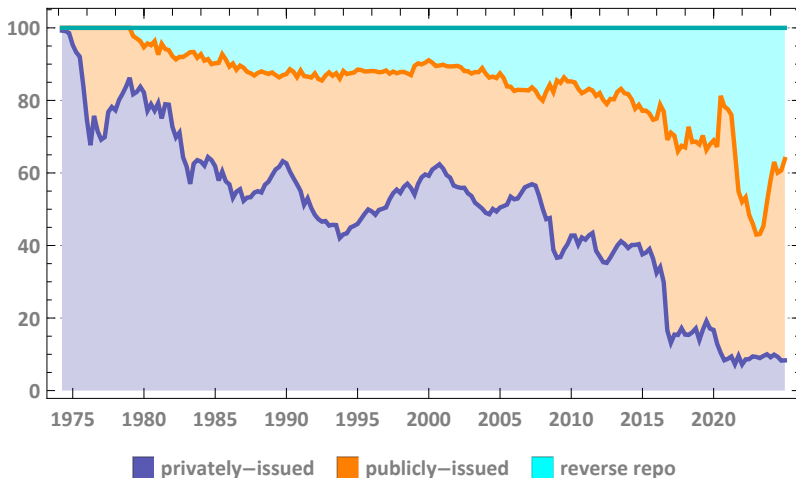
- Types of MMMF by share ownership:
  - Retail:** households
  - Institutional:** nonfinancial and financial businesses, institutional investors
- Types of MMMF by investment assets:
  - Prime funds:** invest in corporate debt, commercial paper, repo
  - Government:** Treasury debt and repo
  - Non-taxable** 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

- 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
- → 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  $1, \frac{T-1}{T}, \frac{1}{T}, \dots, \frac{T-2}{T}$
  - Multiplying VaR by  $\sqrt{T}$  overestimates risk
- Rather, adjust VaR by

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

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

## 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:

Assets	Liabilities
Duration-matched investment portfolio \$95	Insurance reserves \$70
Liquidity reserve \$5	Capital: common equity \$30

# 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→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

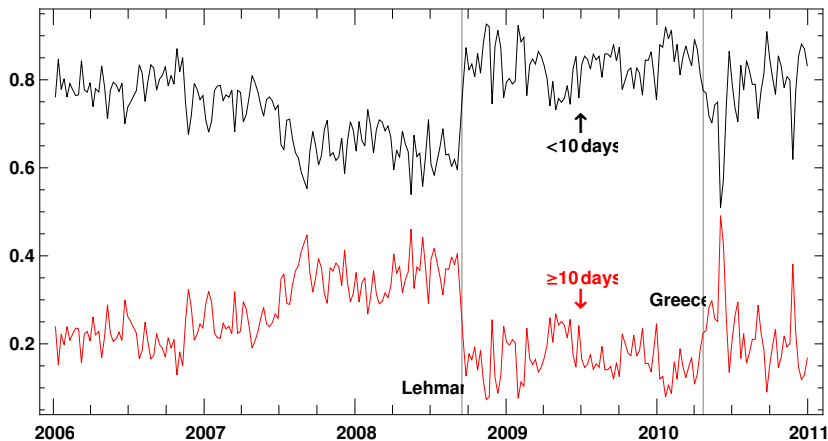
# Liquidity risk in the aggregate

- 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/](http://www.federalreserve.gov/releases/cp/).