Banks

Harvard Economics 1011B
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Outline

1. What is the financial system?
2. Diamond and Dybvig (JPE 1983)

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Purpose of a financial system

1. Intermediate between borrowers and savers.
2. Allocate scarce capital to its most efficient use.
3. Efficiently distribute risk.
4. Provide financial services such as payment services and liquidity management.

Liquidity

- Definition: a claim is more liquid the easier and less expensive it is to turn it into cash.
  - A dollar bill is perfectly liquid but worth only \$1.
  - A Picasso is very illiquid but worth millions of dollars.
  - Heuristic test: suppose you had to immediately sell Picasso for cash. What do you think would be the discount relative to an orderly sale?
- Bank deposits are liquid liabilities. Can be used for payments directly or turned into cash by visiting an ATM.
- Houses are illiquid assets.

Traditional banks

Assets	Liabilities
Business loans	Equity
Mortgages	Retail deposits
Securities	Wholesale financing

- Business loans: C&I, M&A, etc.
- Mortgages: loans to households.
- Securities: private and government bonds.
- Equity: Owners' equity.
- Retail deposits: checking and saving deposits withdrawable on demand, and covered by deposit insurance.
- Wholesale financing: short-term and long-term debt (bonds).

Other financial institutions

- Investment banks: no retail deposits, provide financial services such as advising on mergers and acquisitions, and market making. Until Volcker rule in Dodd-Frank could invest on own account.
- Money market mutual funds: retail deposits, no deposit insurance, assets limited to short-term securities.
- Off balance sheet special purpose vehicles: wholly owned subsidiaries created to issue short term debt and invest in illiquid securities without raising capital requirements.
- Hedge fund: raise equity subject to "lock up", issue short-term debt, invest in illiquid assets.
- Life insurers: illiquid liabilities (life insurance contracts) and invest in illiquid assets.
- A bank-like institution is any financial institution which issues liquid liabilities and invests in illiquid assets.

Fragility and runs

- When illiquid assets back liquid liabilities, bank not guaranteed to have sufficient funds on hand to meet redemption requests.
- Fire sale: bank forced to sell assets quickly may not receive full value.
- If cash-on-hand $+$ liquidated assets $<$ redemption requests, bank fails.
- If you think bank might fail, optimal to demand deposits, but this raises risk bank might fail...

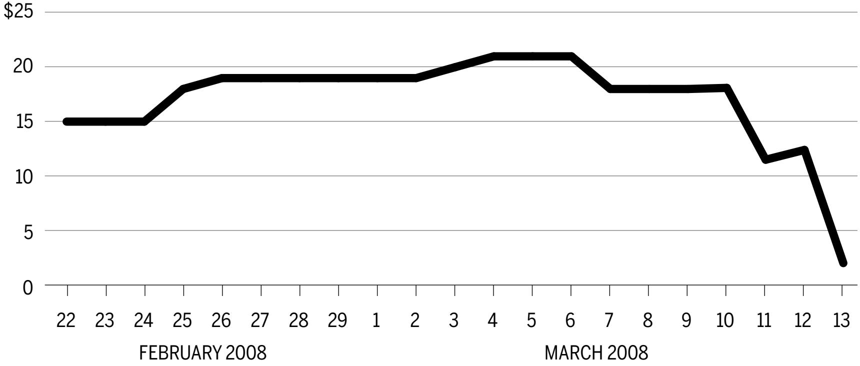
American Union Bank, 1931

Northern Rock, 2007

Bear Stearns Liquidity

In the four days before Bear Stearns collapsed, the company's liquidity dropped by $16 billion.

IN BILLIONS OF DOLLARS, DAILY



SOURCE: Securities and Exchange Commission

EVERY GROCERY STORE, 2020

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Overview

- This will be a very stylized model.
- Idea is to capture two key features of banks:
  1. Iliquid assets and liquid liabilities.
  2. Multiple equilibria: banks subject to runs.
- 3 periods: $t = 0, 1, 2$.
- Agents: depositors, and a bank.
- Welfare criterion: expected utility.

Outline

Depositors (I)

- Continuum of agents indexed by unit interval $[0,1]$.
- What does this mean?
- Suppose a population of size P is divided into N groups (agents). Thus each agent has size P/N.
- Everyone in the same group takes the same action.
- Each individual gets 1 unit to invest:

$$\text{Total deposits} = \sum_{n=1}^{N} P/N = P.$$

- In the limit $N \to \infty$, total deposits still sum to P.
- Order the N agents as $\frac{1}{N}, \frac{2}{N}, \frac{3}{N}, \ldots, \frac{N}{N}$.
- In the limit $N \to \infty$, the agents span the unit interval [0,1].
- Useful to normalize P to 1.

DEPOSITORS (II)

- Continuum of agents indexed by unit interval $[0,1]$.
- Agents of type p (patient) or type i (impatient), with preferences:

$$U(c_1, c_2; i) = u(c_1^i),$$
$$U(c_1, c_2; p) = u(c_1^p + c_2^p).$$

- Interpret: impatient types only get utility from period 1 consumption. Patient types get utility from consumption in 1 and 2. Preferences generate a demand for period 1 liquidity by impatient types.
- Let α denote the fraction of depositors who are impatient.
- Depositors do not know their type in period 0 but learn their type in period 1.
- Functional form:

$$u(x) = \frac{x^{1-\frac{1}{\sigma}} - 1}{1 - \frac{1}{\sigma}}, \quad \sigma < 1.$$

Investment

- All depositors have 1 unit of output to invest in period 0.
- Unit mass of depositors $\Rightarrow$ total investment in period 0 will be 1.
- There is one technology. It transforms 1 unit of period 0 output into 1 unit of period 1 output or $R > 1$ units of period 2 output:

$$\text{1 unit in period 0} \Longrightarrow \begin{cases} 1, & \text{project ended in period 1} \\ R > 1, & \text{project ended in period 2} \end{cases}.$$

- Note: decision of whether to end project in period 1 is made in period 1. By assumption of continuum, any fraction in $[0,1]$ can be liquidated in period 1.
- Interpretation: in period 0 bank makes secured loans to firms to buy new equipment. In period 1, bank can demand early repayment of loan, in which case firm sells equipment and returns to bank the original loan amount. Or, in period 2 the firm produces additional output using the equipment and can return to bank a sum exceeding the original loan amount.

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   - Setup
   - Types of equilibria

Autarky

- Suppose individuals cannot trade or interact.
- In period 1, individuals learn their type.
- Consumption choice is immediate:

$$\begin{aligned} \text{Type}=i \Longrightarrow \qquad & c_1 = c_1^i = 1, \qquad & c_2 = c_2^i = 0, \\ \text{Type}=p \Longrightarrow \qquad & c_1 = c_1^p = 0, \qquad & c_2 = c_2^p = R. \end{aligned}$$

- Expected utility in period 0:

$$\begin{aligned} E_0[U] &= \alpha U(c_1, c_2; i) + (1-\alpha) U(c_1, c_2; p) \\ &= \alpha u(c_1^i) + (1-\alpha) u(c_1^p + c_2^p) \\ &= \alpha u(1) + (1-\alpha) u(R). \end{aligned}$$

Social optimum

- A benevolent and omnipotent *social planner* would withdraw an amount $1-x$ from investment at $t=1$ to maximize expected utility:

$$\max_x \alpha u(c_1^i) + (1-\alpha) u(c_1^p + c_2^p)$$

s.t.

$$\begin{aligned} \alpha c_1^i + (1-\alpha) c_1^p &= 1-x, \\ (1-\alpha) c_2^p &= Rx. \end{aligned}$$

- You should immediately see that the optimal $c_1^p = 0$.
- Impose $c_1^p = 0$ and consolidate the budget constraints:

$$\max_{c_1^i, c_2^p} \alpha u(c_1^i) + (1-\alpha) u(c_2^p)$$

s.t.

$$\alpha c_1^i + (1-\alpha)\frac{c_2^p}{R} = 1.$$

Social optimum

- Let λ denote Lagrange multiplier on budget constraint:

$$\mathscr{L} = \alpha u(c_1^i) + (1-\alpha)u(c_2^p) + \lambda\left[1 - \alpha c_1^i - (1-\alpha)\frac{c_2^p}{R}\right].$$

- FOC:

$$u'(c_1^i) = \lambda,$$
$$u'(c_2^p) = \lambda/R,$$
$$\Longrightarrow \left(\frac{c_1^i}{c_2^p}\right)^{-\frac{1}{\sigma}} = R \Longrightarrow c_2^p = R^\sigma c_1^i.$$

- Substitute into budget constraint:

$$1 = \alpha c_1^i + (1-\alpha)R^{\sigma-1}c_1^i,$$
$$\Longrightarrow c_1^i = \frac{1}{\alpha + (1-\alpha)R^{\sigma-1}} > 1,$$
$$c_2^p = \frac{R^\sigma}{\alpha + (1-\alpha)R^{\sigma-1}} = \frac{R}{\alpha R^{1-\sigma} + (1-\alpha)} < R.$$

Comparison

- Autarky:

$$c_1^i = 1,$$
$$c_2^p = R.$$

- Social optimum (note $*$ notation for optimum):

$$(c_1^i)^* = \frac{1}{\alpha + (1-\alpha)R^{\sigma-1}} > 1,$$
$$(c_2^p)^* = \frac{R^\sigma}{\alpha + (1-\alpha)R^{\sigma-1}} = \frac{R}{\alpha R^{1-\sigma} + (1-\alpha)} < R.$$

- Intuition: $\sigma < 1$ means utility function exhibits substantial curvature. Agents face risk of wanting to consume early before projects have matured. Social optimum provides some insurance against needing to consume early and thus having relatively low consumption.

Bank

- Suppose a bank accepts deposits at $t = 0$ and invests on behalf of the depositors.
- Agents can choose to withdraw their deposits at date $t = 1$, receiving gross interest rate r_1.
- Agents who choose to leave their deposits until date $t = 2$ receive *pro rata* share of assets in $t = 2$.
- Immediate: impatient agents will all withdraw and consume at $t = 1$.
- Patient depositors are more interesting.

No-run outcome

- Suppose $r_1 = (c_1^i)^*$, and patient depositors all wait to withdraw in $t = 2$.
- By construction, $c_1^i = r_1 = (c_1^i)^*$, $c_1^p = 0$.
- This is the same period 1 allocation as in the social optimum. Therefore the period 2 allocation must also be the same.
- We have proved the result that the presence of a bank can move the economy from autarky to the social optimum.
- But there is another possibility...

Run outcome

- Assume a *sequential service constraint*: bank services withdrawals in order they arrive as long as funds last.
- Let $V_1(f_j, r_1)$ be the dollar payoff if you withdraw in period 1 and f_j depositors have already withdrawn, f the total fraction of depositors who withdraw, and V_2 the dollar payoff if you withdraw in period 2:

$$V_1(f_j, r_1) = \begin{cases} r_1, & f_j r_1 < 1 \\ 0, & f_j r_1 \geq 1 \end{cases},$$

$$V_2(f, r_1) = \max\left\{ \frac{R(1 - r_1 f)}{1 - f}, 0 \right\}.$$

- If $f = \alpha$ and $r_1 = (c_1^i)^*$, then we have social optimum.
- If $r_1 = 1$, then $V_2(f, 1) = \max\{R, 0\} = R$ and patient types will never withdraw in period 1. But then having banks is no better than autarky.

Run outcome

- Assume $r_1 > 1$.
- Suppose you turn out to be patient but believe that $f = 1/r_1$.
- If $f = 1/r_1$, then bank has all resources withdrawn at $t = 1$, making $V_2(1/r_1, r_1) = 0$.
- Then even though you are patient, it is rational for you to try to withdraw at date 1.
- If everyone tries to withdraw at date 1, the bank will run out of resources and fail.
- Result: first-best bank equilibrium is inherently fragile. It depends on the confidence of patient depositors that the bank will not fail, which is a self-fulfilling prophecy.

Market remedies

1. Suspension of convertibility: temporarily halt withdrawals.
   - Common in the U.S. before the founding of the Fed.
   - Can be government mandated: *Corralito* in Argentina in 2001; U.S. banking holiday in 1933.
   - Sometimes necessary, rarely sufficient.
2. Interbank market: bank experiencing a run can borrow from other banks.
   - Common in the U.S. before founding of the Fed. Famous example is panic of 1907 ended by J.P. Morgan.
   - But what happens when there is a run on the whole system?

Policy responses

1. Deposit insurance.
   - FDIC insures deposits up to $250,000 (up to $100,000 before 2008).
   - No need to run if patient because no risk of losing access to deposit.
   - But large corporations have deposits much larger than $250,000.
   - Doesn't help with non-traditional banks.
2. Lender of last resort.
   - Central bank can provide liquidity to bank experiencing run.
   - Bagehot (*Lombard Street*): lend freely against good collateral and at a penalty rate.
3. Confidence fairy.
   - Roosevelt fireside chat after 1933 banking holiday.
   - Modern stress tests.

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