Monetary Economics

Lecture 18: bank runs

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This lecture

• Bank runs, part one: Liquidity transformation, etc.
  ◦ Diamond and Dybvig “Bank runs, deposit insurance, and liquidity” *Journal of Political Economy*, 1983

• Securitised banking and the run on repo
  ◦ Gorton and Metrick “Securitized banking and the run on repo” NBER working paper, 2009

Readings available from the LMS
This lecture

1- The Diamond-Dybvig model of bank runs

   - tension between efficient risk-sharing/liquidity provision and exposure to a run

2- Securitised banking and the run on repo

   - repo transactions
   - increased repo “haircuts” as a form of modern bank run
Diamond-Dybvig model

Q. Why are bank liabilities more liquid than their assets?

A. Issuing liquid liabilities allows for efficient risk-sharing. Investors who may need liquidity prefer to invest in bank rather than hold illiquid asset directly.

Q. Why are banks subject to runs?

A. Coordination failure. Implementing efficient risk-sharing with liquid liabilities only one equilibrium. Also another equilibrium where investors panic and run to withdraw deposits.
Diamond-Dybvig model

- Three dates \( \{0, 1, 2\} \)

- Unit mass of ex ante identical investors, single bank

- Each investor has endowment 1 to invest at date \( T = 0 \)

- Type of investor revealed at date \( T = 1 \)
  - fraction \( t \) are *impatient*, consume at \( T = 1 \) only
  - fraction \( 1 - t \) are *patient*, consume at either \( T = 1 \) or \( T = 2 \)
    - individual realized type is *private information*, but aggregate fraction \( t \) is known

- CRRA preferences \( U(c) \) with coefficient \( \sigma \geq 1 \)
Asset structure

• Each asset described by pair of returns \((r_1, r_2)\), known
  \[\Rightarrow\] liquidity risk, not asset return risk

• Examples

  (i) illiquid asset
  
  \[1 = r_1 < r_2 = R\]

  (ii) liquid asset
  
  \[1 < r_1 < r_2 < R\]
Optimal insurance (risk-sharing) contract

Maximize ex ante expected utility

\[ tU(c_1) + (1 - t)U(c_2) \]

subject to resource constraint

\[ tc_1 + (1 - t)\frac{c_2}{R} \leq 1 \]

and incentive compatibility constraint

\[ U(c_1) \leq U(c_2) \]

(patient types will not want to mimic impatient types)
Optimal insurance contract

- Lagrangian

\[ L = tU(c_1) + (1-t)U(c_2) + \lambda \left[ 1 - tc_1 - (1 - t) \frac{c_2}{R} \right] + \eta \left[ U(c_2) - U(c_1) \right] \]

- First order conditions

\[ c_1 : \quad tU'(c_1) - \lambda t - \eta U'(c_1) = 0 \]

and

\[ c_2 : \quad (1 - t)U'(c_2) - \lambda (1 - t) \frac{1}{R} + \eta U'(c_2) = 0 \]
Optimal insurance contract

• Guess and verify incentive constraint is slack ($\eta = 0$)

• If so, with CRRA utility we have

$$U'(c_1) = U'(c_2) R \quad \Leftrightarrow \quad c_2 = c_1 R^{1/\sigma} > c_1$$

\[ \therefore U(c_2) > U(c_1), \text{ verifies incentive constraint is slack} \]

• Now use resource constraint to solve for $(c_1^*, c_2^*)$

$$c_1^* = \frac{1}{t + (1 - t) R^{1/\sigma}} \geq 1$$

$$c_2^* = \frac{R^{1/\sigma}}{t + (1 - t) R^{1/\sigma}} \leq R$$

\[ \Rightarrow \text{ These contingent payments provide optimal insurance given the resource and incentive constraints} \]
Optimal insurance contract: example

- Numerical example: $t = 0.25$, $R = 2$, $\sigma = 2$ (from Diamond 2007)

- Gives

\[ c_1^* = \frac{1}{0.25 + 0.75 \times 2^{-0.5}} = 1.28 > 1 \]
\[ c_2^* = \frac{2^{0.5}}{0.25 + 0.75 \times 2^{-0.5}} = 1.81 < 2 \]
Implementing the optimal contract with deposits

- Bank takes deposits (liquid liabilities) and invests them in project (illiquid asset) with payoff $R$ at date $T = 2$

- **Deposit contract**
  - take deposit of 1 at time $T = 0$
  - pay $r_1$ to investors who withdraw at $T = 1$ (early)
  - pay $r_2$ to investors who withdraw at $T = 2$ (late)

- Check *feasibility*
  - at $T = 1$, fraction $t$ make withdrawal get $r_1$
  - bank needs to liquidate $t \times r_1$ funds
  - remaining $1 - t \times r_1$ funds earn $R$, divided amongst patient investors

$$r_2 = \max \left[ 0, R \frac{1 - tr_1}{1 - t} \right]$$
Implementing the optimal contract with deposits

- **Sequential service constraint**

\[ r_2 = \max \left[ 0, R \frac{1 - tr_1}{1 - t} \right] \]

- Now take \( r_1 = c_1^* \) from the optimal insurance contract. Rearrange the resource constraint to get

\[ c_2^* = R \frac{1 - tc_1^*}{1 - t} > c_1^* > 0 \]

- Therefore we can set

\[ r_2 = \max [0, c_2^*] = c_2^* \]

⇒ We can implement the optimal insurance contract with deposits
• **Good news**

  – implementation of optimal insurance is a Nash equilibrium of deposit game

• **Bad news**

  – bank runs are also a Nash equilibrium

  – all investors can panic and try to withdraw early, not just impatient types but patient types too
Bank runs

- Suppose some fraction $f$ withdraw at date $T = 1$
- Return at date $T = 2$ then depends on $f$

$$r_2(f) = \max \left[ 0, R \frac{1 - fr_1}{1 - f} \right]$$

- Impatient types always withdraw, so $f \geq t$
- Patient types withdraw if

$$r_2(f) < r_1 \iff f \geq f^* \equiv \frac{1}{r_1} \frac{R - r_1}{R - 1}$$

[note $f^* < 1 \iff r_1 > 1$]

- If $r_1 > 1$ (deposit contract), two Nash equilibria in pure strategies
  (i) $f = t$ and $r_2(t) = c_2^*$ as above, and (ii) $f = 1$ and $r_2(1) = 0$
Suspension of convertibility

- In this game, can prevent bank runs by \textit{credible} promise to \textit{suspend convertibility} (of deposits for cash)

- If bank can credibly commit to pay no more than first $t$ of depositors, then no incentive for patient types to withdraw early
  - an “off-the-equilibrium-path” threat, not used in equilibrium

- Problems
  - difficult to be credible (suspension is a discretionary choice), time-consistency problem
  - not so easy if aggregate mass $t$ is stochastic
Deposit insurance

- Government promise to pay \((r_1, r_2)\), backed by tax powers

- Avoids potential problems of suspending convertibility

- Rule-based deposit insurance also avoids time inconsistency problems of discretionary "bailouts"

- In practice, often supplemented by lender-of-last-resort facilities from central bank
  - discount window loans, etc
  - public liquidity
Traditional banking in practice

- Lend long (mortgages, bank loans) to borrowers

- Raise funds from investors through demand deposits, these funds can be withdrawn any time

- Bank holds assets (mortgages, bank loans) on its balance sheet

- Small fraction of deposits retained as reserves

- Deposit insurance in the United States:

  Since 1933, FDIC guarantees deposits at commercial banks. Regulates capitalisation of member banks. Deposits insured to cap of $100k (now temporarily increased to $250k)

- Lender-of-last-resort: prime loans from the Federal Reserve
Source: Gorton and Metrick (2009)
Modern securitised banking

- Deposit insurance capped, so of less value to institutional investors

- Instead of demand deposits, raise funds in the market for sale and repurchase agreements, “repo” for short. And other similar forms of short term finance

- Instead of deposit insurance, investors protect funds by taking collateral
Repo transactions

- Borrower (say, bank) raises funds by selling security at spot price to investor who provides cash. Borrower agrees to repurchase security at future date (perhaps tomorrow) at forward price

- Effectively, security is collateral for a cash loan from the investor

- *Repo rate* is interest rate implied by difference between spot and forward prices. If spot is $s_t$ and forward is $f_t$, repo rate is the forward premium

$$\frac{f_t - s_t}{s_t}$$

**Example:** if forward price is $f_t = 11$ and spot price is $s_t = 10$, then repo rate is $(11 - 10)/10 = 1\%$

- If repurchase happens, repo rate is riskless (both prices known at $t$)
Haircuts

- *Credit risk*. If repurchase does not happen (borrower defaults), investor keeps security. But may not be able to recover face value, implying loss to investor.

- As protection against credit risk, amount of loan typically less than market value of collateral.

**Example**: if asset has market value 100 and amount of loan is 95, then *haircut* (initial margin) is $(100 - 95)/100 = 5\%$.

- No consequences ex post if borrower repays, but ex ante limits amount of funds borrower can raise against inventory of securities.
Modern securitised banking

- Mortgages and loans securitised
- Funds raised from investors via repo, collateralised by securities
- Outputs of securitisation process are also inputs in the form of collateral to repo financing
Source: Gorton and Metrick (2009)
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New information: ABX indices

• ABX indices: from 2006, measures of subprime tranche risk

• A relatively liquid, transparent market price for subprime risk
  – generally, securitised products do not trade in public markets

• Beginnings of significant concern about values of securitised products exposed to subprime
New information: ABX indices

To buy protection against default, pay upfront fee of $100 – ABX price. Previous sellers of CDS suffer losses as index falls. Source: Brunnermeier (2009).
“Run on repo”

- Massive “withdrawal” of repo finance in the form of large increases in haircuts (margin calls)

- As haircuts increase, banks have funding shortfall

  **Example:** bank raises $95 via repo with $100 collateral (5% haircut). As haircut rises to 15%, bank can only raise $85 funds, now shortfall of $10

- May be unable to meet new margin if highly levered

- **Systemic crisis:** all investors raise haircuts on all borrowers (most institutions both investors and borrowers at same time). Massive de-leveraging as banks try to sell assets to bridge shortfalls
Repo haircut index

Repo-haircut index is equally-weighted average haircut for nine asset classes. Source: Gorton and Metrick (2009).
Repo haircuts and adverse selection

- Collateral is offered at market prices. Thus value of collateral is changing, e.g., day-to-day.

- These haircuts do not reflect concern about value of collateral per se (i.e., to large extent do not reflect payoff risks).

- Instead, reflect concern about adverse selection, to protect investor against being left holding a lemon if borrower defaults on repo.

- By contrast, haircut on corporate bonds increased $\approx 5-10\%$. 
Repo haircuts on different market segments

Source: Gorton and Metrick (2009b)
Next lecture (after the break)

- Macroeconomics with financial market frictions, part one


  ◦ Brunnermeier, Eisenbach and Sannikov “Macroeconomics with financial frictions: a survey,” NBER working paper 2012
     section 1, sections 2.1–2.2

  ◦ Bernanke, Gertler and Gilchrist “The financial accelerator in a quantitative business cycle framework,” Handbook of Macroeconomics, 1999

Readings available from the LMS