Monetary Economics

Lecture 18: bank runs

Chris Edmond

2nd Semester 2014

This lecture

- Bank runs, part one: Liquidity transformation, etc.
  - ◇ Diamond and Dybvig "Bank runs, deposit insurance, and liquidity" *Journal of Political Economy*, 1983
  - ◇ Diamond "Banks and liquidity creation: a simple exposition of the Diamond-Dybvig model" FRB Richmond *Econ. Quarterly*, 2007
- 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

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

$\therefore$ $U(c_2) > U(c_1)$, verifies incentive constraint is slack

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

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

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

$\Rightarrow$ 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*

$$r_2 = \max \left[0,\ R \frac{1 - t r_1}{1 - t} \right]$$

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

$$c_2^* = R \frac{1 - t c_1^*}{1 - t} > c_1^* > 0$$

- Therefore we can set

$$r_2 = \max \left[0,\ c_2^* \right] = c_2^*$$

$\Rightarrow$ 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

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

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

- 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 *credible* promise to *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

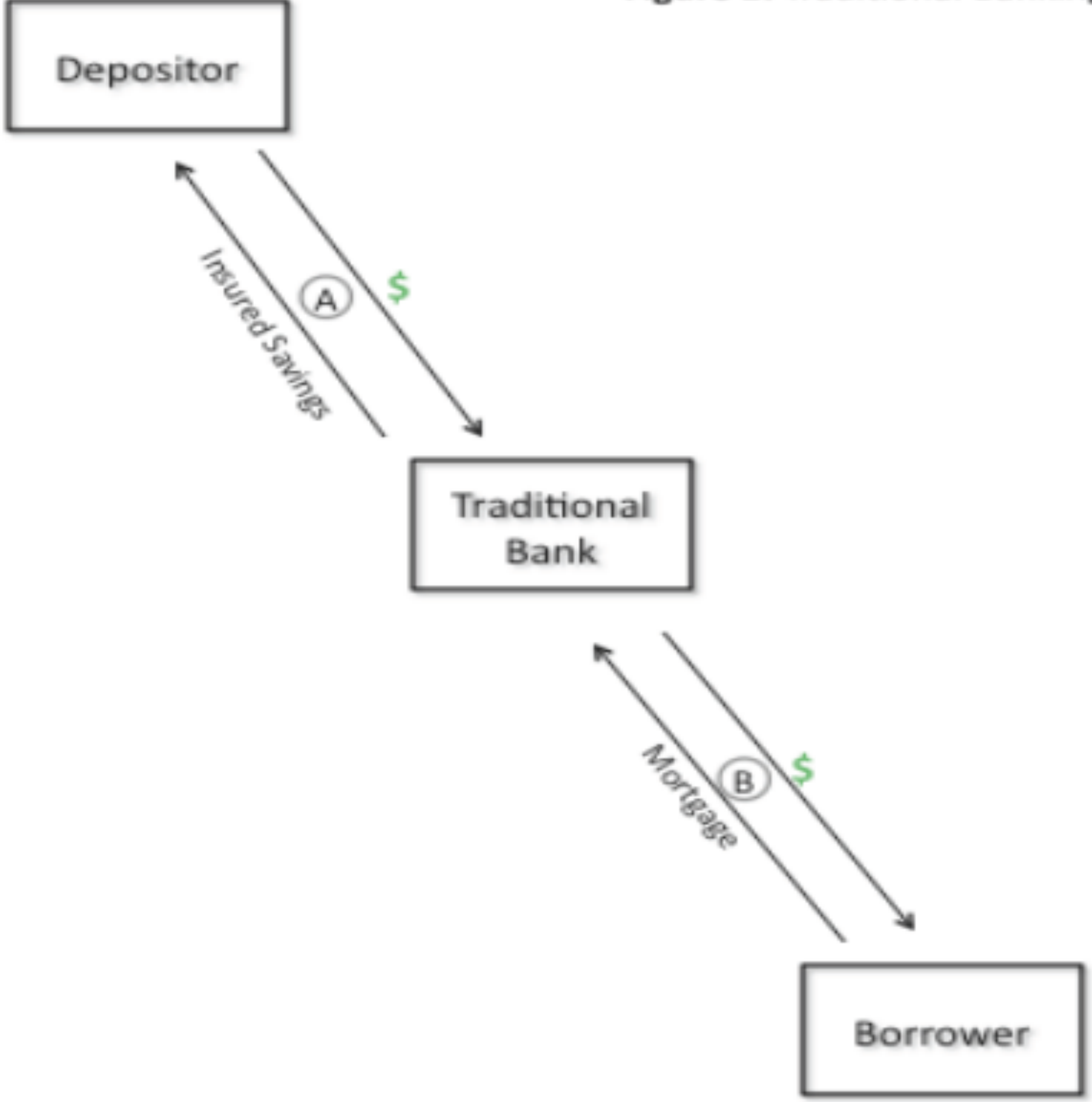
- Government promise to pay (r_1, r_2), backed by tax powers
- Avoids potential problems of suspending convertibility
- Rule-based deposit insurance also avoids time inconsistency problems of discretionary "*bailouts*"
- In practice, often supplemented by *lender-of-last-resort* facilities from central 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

Figure 1: Traditional Banking



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

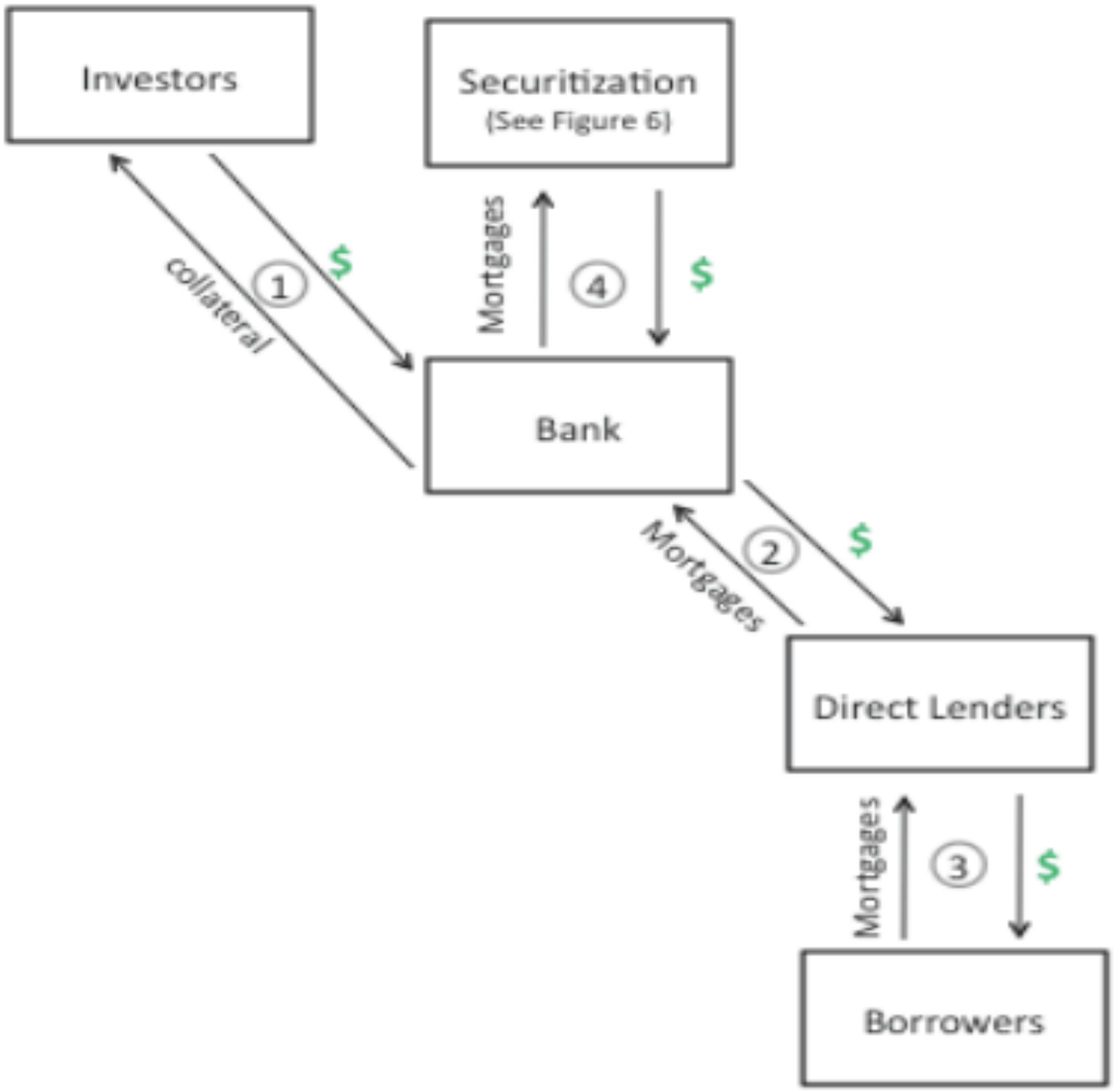
  EXAMPLE: if asset has market value 100 and amount of loan is 95, then *haircut* (initial margin) is $(100 - 95)/100 = 5\%$

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

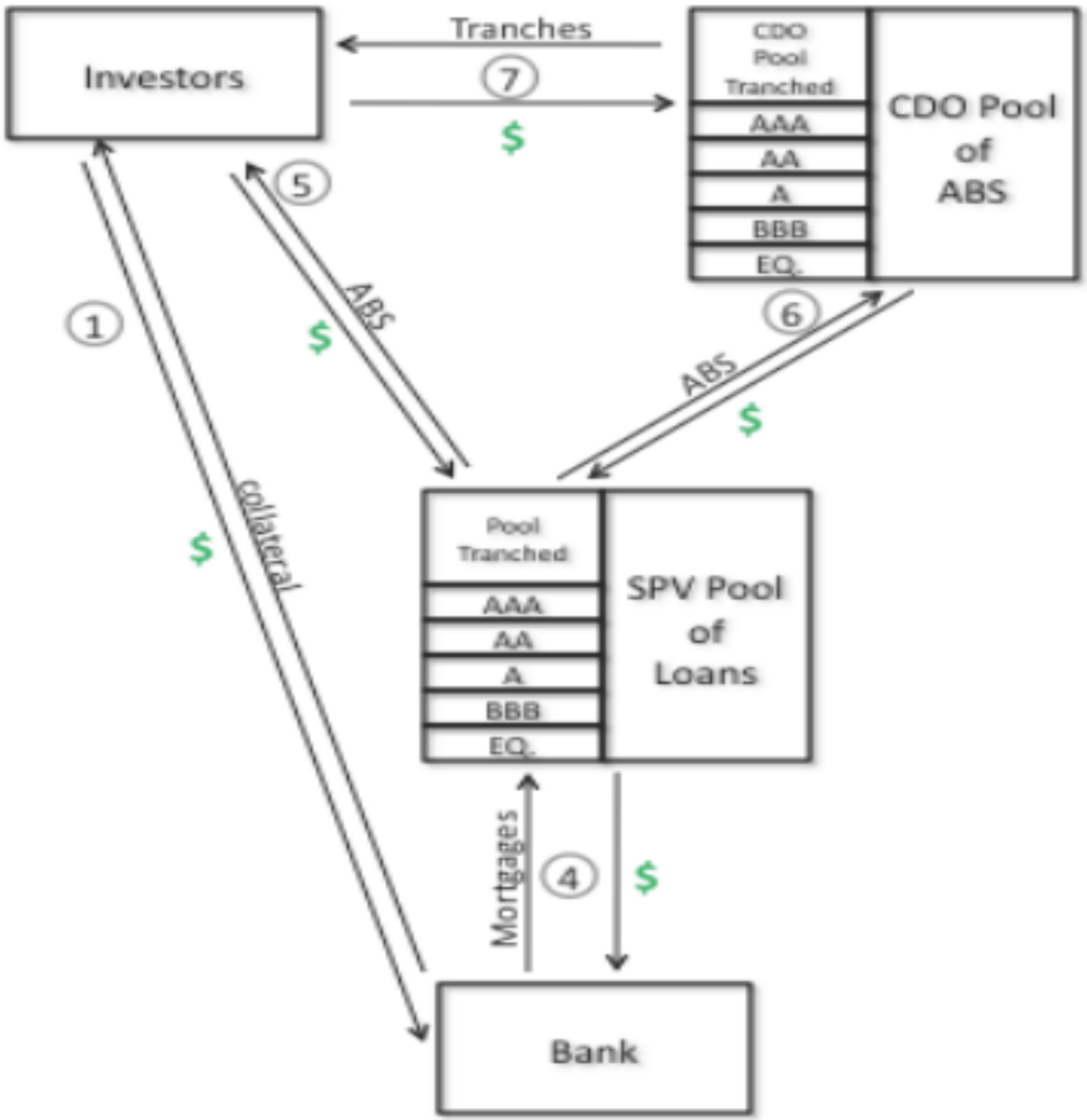
Modern securitised banking

- 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

Figure 2: Securitized Banking



Source: Gorton and Metrick (2009)

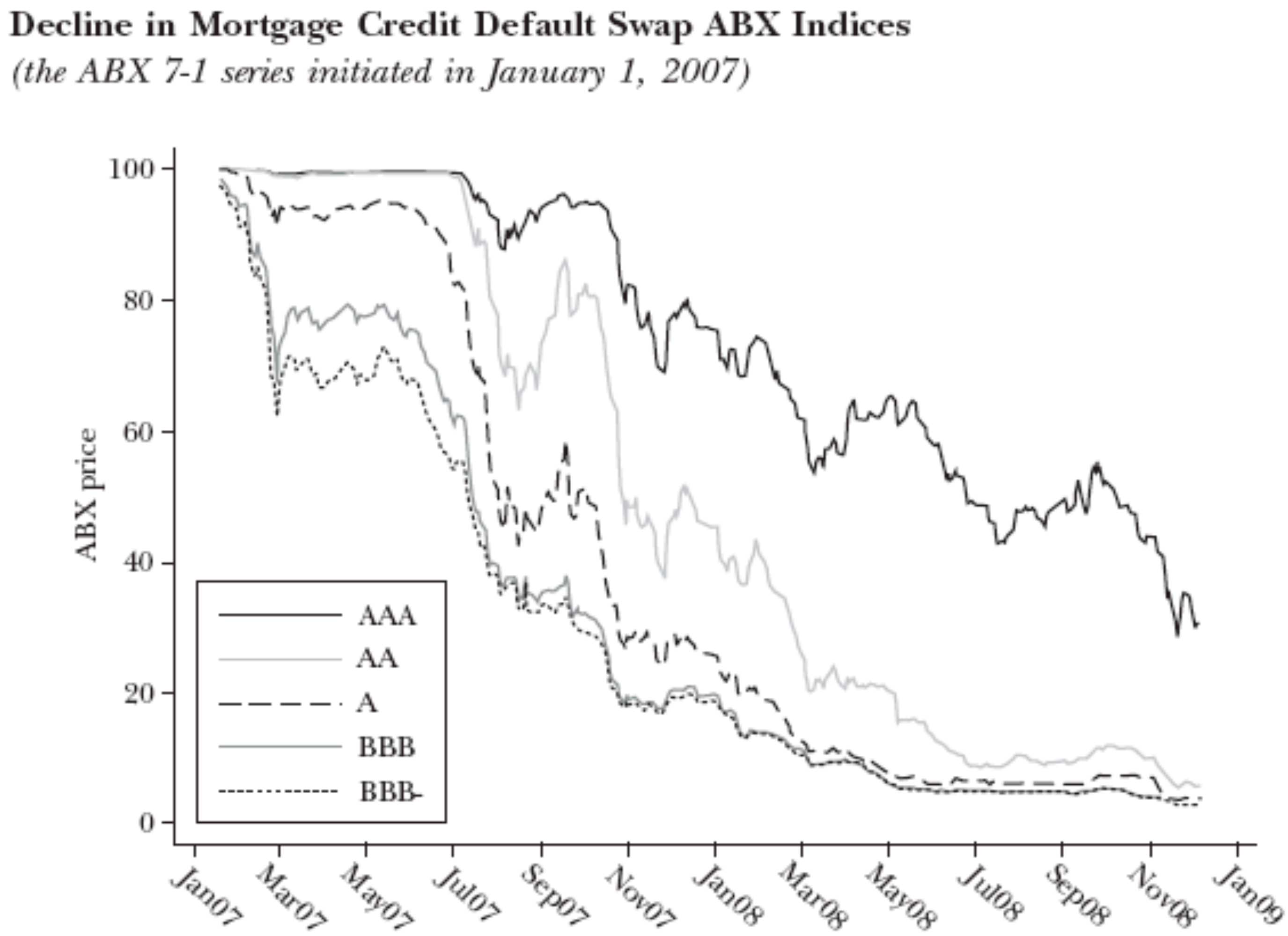


Source: Gorton and Metrick (2009)

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)

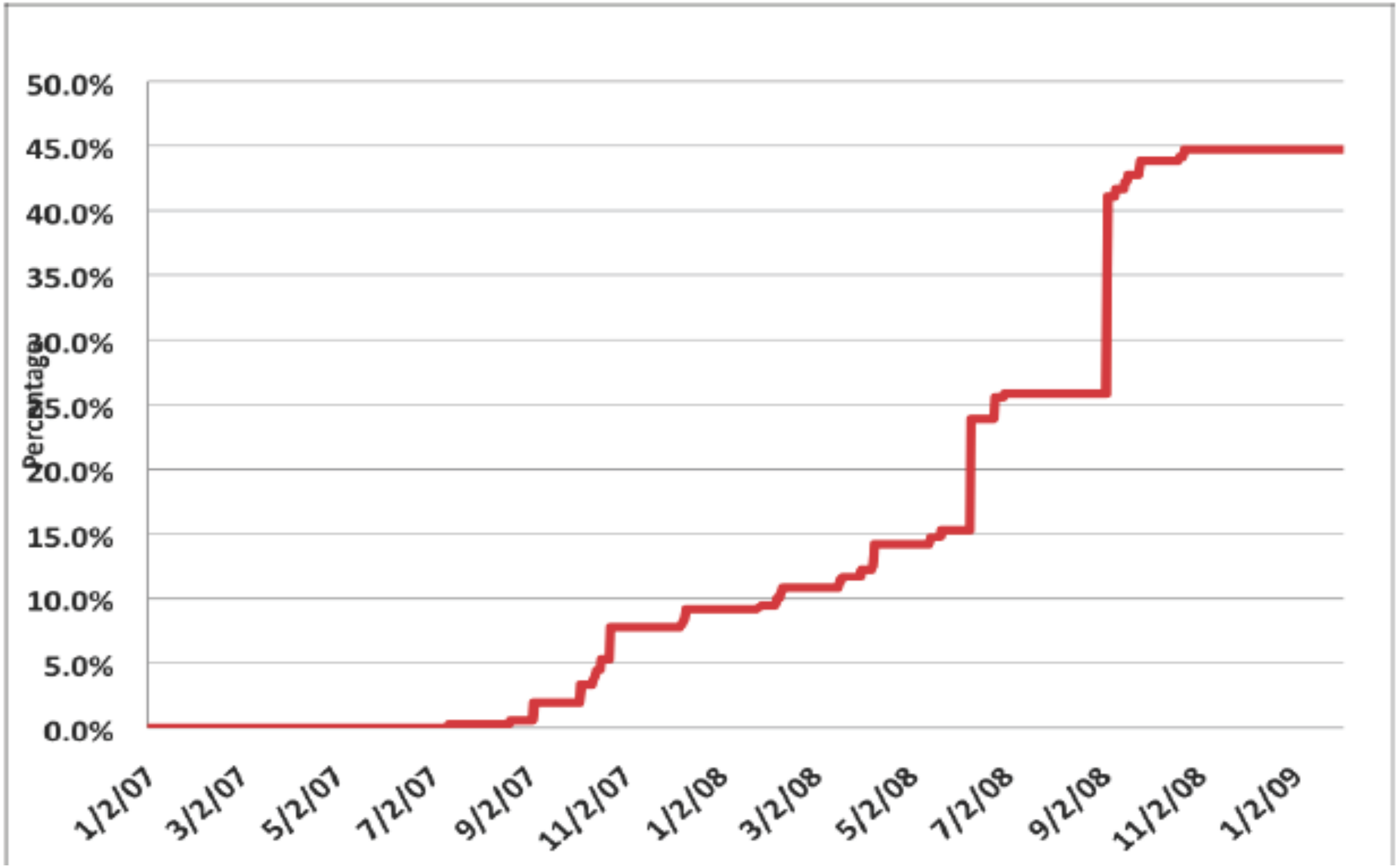
- As haircuts increase, banks have funding shortfall

  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

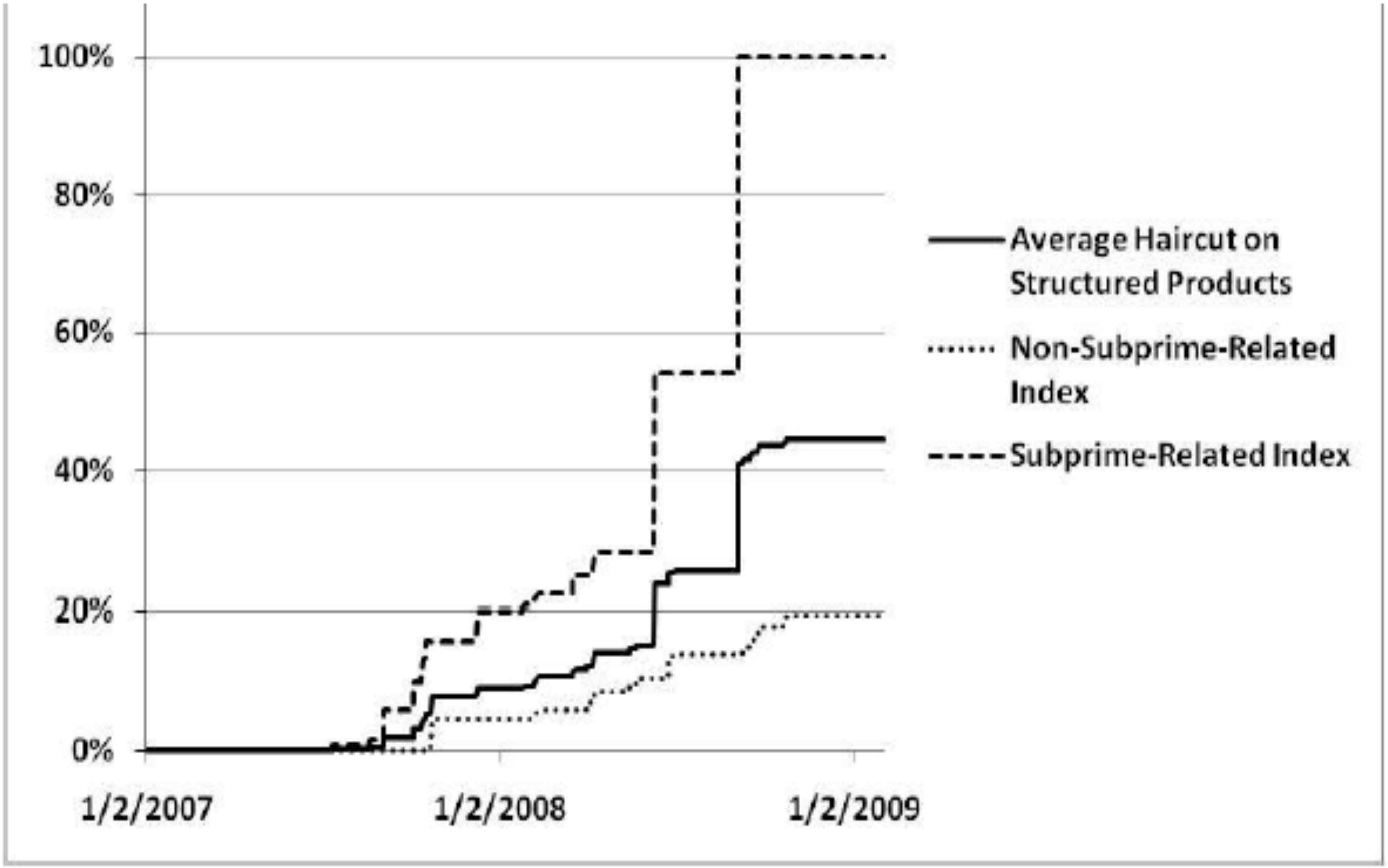


Repo-haircut index is equally-weighted average haircut for nine asset classes.
Source: Gorton and Metrick (2009).

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

- Agency costs. Costly state verification. Amplification and propagation of shocks.

  ◇ 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