

# Topic 8 : Bank Run, Systemic Risk and Deposit Insurance

Diamond(2007), Bank and Liquidity Creation: A Simple Exposition of the Diamond-Dybvig Model, Federal Reserve Bank of Richmond Economic Quarterly

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## Introduction

- Fractional reserve banking is a system in which banks retain only a portion of deposits as cash reserve.
- Banks make loans that cannot be sold quickly at a high price.
- Banks issue demand deposits that allow depositors to withdraw at any time.
- Banks engage in maturity mismatch (or liquidity mismatch).
- In normal times, fractional reserve banking usually works properly.
- Banks can predict quite correctly the amount of withdrawals due to large scale borrowing. (The bank can use statistical data to predict the amount of withdrawals. Banks obtain deposits from many depositors. The pattern of withdrawal becomes quite predictable.)
- Demand for cash of each depositor is unlikely to be perfectly correlated or coordinated. Most of the time it is likely to be inversely correlated. Interbank markets provide liquidity to the banks.

- This mismatch of liquidity will cause problems for a bank when too many depositors attempt to withdraw at once.
- The situation is referred to as “a bank run”.
- A bank run happens in an unusual situation. Depositors want to withdraw large amount of money not because they need to spend but because they are panicking.
- Liquidity problem → Bankruptcy, Financial crises.
- Negative spillovers effect → Many banks suffer runs at the same time.

"First, it would have resulted in the immediate cessation of operations at one bank, and would have led to the suspension of operations at [Cyprus's] second big bank, and that would have finally led us to the complete collapse of the banking system," said Mr. Anastasiades, who has been in office for just over two weeks.

Source: Wall Street Journal, March 18, 2013, *Cyprus Head Tries to Rally Support*

- “Systemic risk” is the risk of collapse of an entire financial system.
- To find the way to prevent “a bank run”, financial crises, we have to make understand why banks are subject to runs.

- Diamond and Dybvig (1983) develop a model to explain why banks are subject to runs.
- The model has been widely used. There are many interesting contribution that builds on Diamond and Dybvig (1983).
- This topic focuses on narrative and numerical examples given by Diamond(2007) to understand the ideas in Diamond and Dybvig(1983).
- Why do we need deposits to be highly liquid? ⇒ The demand for liquidity
- How do banks create liquidity to meet the demand? ⇒ Bank liquidity creation
- Why are banks subject to runs? ⇒ Bank runs
- How to prevent banks from runs? ⇒ Suspension of Convertibility and Deposit insurance

## The Demand for Liquidity

Consider an economy where

- There are 3 dates, date 0, date 1 and date 2.
- “Primary investment” costs 1 in date 0, and yields 1 if cashed in date 1  $R > 1$  if cashed at date 2.
- Let  $R = 2$ .
- Each investor begins with 1 to invest on date 0.
- Investors face an uncertain horizon to hold the asset. Each will need to consume either at date 1 or 2.
- However, as of date 0, an investor does not know at which date he will need to consume. In other words, they are facing with liquidity risk.
- “Type 1” : an investor who needs to consume at 1.
- “Type 2” : an investor who needs to consumer at 2.
- For this example, this means an investor will consume only at 1 if of type 1, and only 2 if of type 2.

- At date 0, an investor does not know which type he will be, but each investor has a probability of  $\pi$  of being type 1 and  $1 - \pi$  of being type 2.
- Suppose that  $\pi = \frac{1}{4}$  and that there are 100 investors in the economy. 25 will be type 1 and 75 will be type 2 but it is not known at date 0 which investors will be of each type.
- Type 1 investors will have utility  $U(c_1)$ . Type 2 investors will have utility  $U(c_2)$ .
- $c_1$  denotes consumption at date 1 and  $c_2$  denotes consumption at date 2.
- The utility function  $U(c)$  is the same for both types, but the date on which an investor will consume depends on his type.
- Both types are risk averse.
- Here, suppose  $U(c) = 1 - \frac{1}{c}$ .

- If there is no bank, all investors have just only one choice, to invest in “Primary Investment”.
  - Type 1 will liquidate his investment at date .... and get .....
  - Type 2 will liquidate his investment at .... and get .....
  - Type 1 will consume  $c_1 = \dots\dots$
  - Type 2 will consume  $c_2 = \dots\dots$
  - At date 0, an investor does not know his type. He expects to consume ..... if he is type 1 (with probability  $\pi$ ) and expects to consume ..... if he is type 2 (with probability  $(1 - \pi)$ ).
  - The investor’s expected utility is given by

$$\begin{aligned}
 \dots U(\dots) + \dots\dots U(\dots\dots) &= \dots U(\dots) + \dots\dots U(\dots\dots) \\
 &= \\
 &= \qquad\qquad\qquad 0.375
 \end{aligned}$$

- “Primary investment”, with 1 unit invested at date 0, it will worth  $R = 2$  at date 2, but only 1 at date 1.
- Suppose that there is another asset (so-called “Deposit”) The deposit contract in which 1 unit invested at  $T = 0$ , it will worth  $d_2 = 1.813$  at date 2, but only  $d_1 = 1.28$  at date 1.
- Which one would an investor prefer?
- The expected utility from holding the “Deposits” is

$$\dots U(\dots) + \dots U(\dots) = 0.391 > 0.375.$$

- Therefore, an investor prefer ..... (“Deposits”, “Primary investment”)

- Liquid asset offers a small loss when liquidated early.
- Illiquid asset is the one in which the proceeds available from physical liquidation or a sale on some date are less than its payoff on some future date.
- $\frac{\text{payoff on date 1}}{\text{payoff on date 2}}$  is used to measure the level of liquidity of an asset.
- Given that payoff on date 1 always less than payoff on date 2. The ratio is always ..... one. The lower the ratio is, the ..... liquid is the asset.
- “Deposits” : 1.28 at date 1 and 1.813 at date 2.
- “Primary Investment” : 1 at date 1 and 2 at date 2.
- Hence, “Deposits” is ..... liquid than “Primary investment”.
- An investor prefer the ..... liquid asset.

- “Deposits” offers 1.28 with 0.25 probability and 1.813 with 0.75 probability. “Primary asset” offers 1 with 0.25 probability and 2 with 0.75 probability.
- Expected return on “Primary Asset” is equal to  $0.25 \times \dots + 0.75 \times \dots = 1.75$ .
- Expected return on “Deposits” is equal to  $0.25 \times \dots + 0.75 \times \dots = 1.68 < 1.75$ .
- If the investor were risk-neutral, he would prefer “.....”.
- Investors are risk-averse. It is possible that they are willing to give up some expected return to get more liquid asset (to reduce their liquidity risk).

## Bank Liquidity Creation

- Suppose initially there is only “Primary investment” available in the economy. If 1 unit invested at date 0, it will worth  $R = 2$  at date 2, but only 1 at date 1.
- A bank can provide the more liquid asset (“Deposits”) by offering demand deposits.
- Assume that there is only one bank without equity (for simplicity).
- At date 0, the bank receives \$1 from each of the 100 investors. Then, the bank invests all they have got in “Primary investment” at date 0.
- Suppose in return for a deposit of 1 at date 0, the bank offers to pay  $d_1 = 1.28$  to those who withdraw at date 1 or to repay  $d_2 = 1.813$  to those withdraw at date 2.
- $d_1$  can be thought of as the return on short-term deposits and  $d_2$  can be thought of as the return on long-term deposit.

- At date 1, the bank's entire portfolio is worth \$.....
- Suppose 25 depositors withdraw 1.28 each, then ..... of "Primary Investment" must be liquidated.
- ..... of "Primary Investment" will remain until date 2, when they worth ..... each at date 2.
- On date 2, there remain ..... depositors, each will receive

$$\frac{\text{the value of the bank's entire portfolio at date 2}}{\text{the number of depositors remains at date 2}} =$$

$$= 1.813$$

- Therefore, a bank can provide the more liquid asset (“Deposits”), which has a smaller loss from early liquidation than is available from holding the illiquid asset (Primary Investment) directly.
- At date 0, depositors now can get 1.28 with probability 0.25 and 1.813 with probability 0.75 if they deposit their funds at the bank.
- Depositors prefer bank “Deposits” to “Primary investment”.
- It is an equilibrium for 25 depositors to withdraw at date 1, because if all depositors expect 25 to withdraw at date 1, only type 1 depositors will withdraw because the 75 type 2 depositors prefer 1.813 available at date 2 to the 1.28 available at date 1.
- It can be mathematically proved that this “Deposits” is optimal. It maximises the utility of all depositors. (See the Note on the optimal level of liquidity at the end of this lecture presentation for the proof, if you are interested. Questions are welcome.)

# Bank Runs

- Banks can create liquidity by offering deposits that are more liquid than their assets.
- If only the proper depositors withdraw, it works out very well.
- However, creating this liquidity subjects the bank to bank runs.
- Recall: It is an equilibrium for 25 depositors to withdraw at date 1, because if all depositors expect 25 to withdraw at date 1, only type 1 depositors will withdraw because the 75 type 2 depositors prefer 1.813 available at date 2 to the 1.28 available at date 1.
- The equilibrium for 25 depositors to withdraw at date 1 will occur when all depositors expect that “the others” will choose the option that is the best for them.
- There are multiple equilibria.
- There is more than one “self-fulfilling” prophecy about who withdraws at date 1.

- There are 100 depositors.  $d_1 = 1.28$  and  $d_2 = 1.81$ . Consider these following three cases.

1. Suppose that all depositors forecast that everybody else will withdraw at date 1.

- Each depositor forecasts that 99 depositors will withdraw at date 1.
- At date 1, the bank's entire portfolio is worth \$.....
- 99 depositors withdraw ..... each, then ..... of "Primary Investment" must be liquidated.
- The bank will fail at date 1 because it does not have enough asset to repay its liability.
- Then, everybody will withdraw at date 1.

2. Suppose that all depositors forecast that 79 will withdraw at date 1.
- 79 depositors withdraw ..... each, then ..... of “Primary Investment” must be liquidated.
  - The bank will fail at date 1 because it does not have enough asset to repay its liability.
  - Then, everybody will withdraw at date 1.

3. Suppose that all depositors forecast that 27 depositors will withdraw at date 1.

- Each depositor forecasts that 27 depositors will withdraw at date 1.
- At date 1, the bank's entire portfolio is worth \$.....
- 27 depositors withdraw ..... each, then ..... of "Primary Investment" must be liquidated.
- The bank will not fail at date 1.
- ..... of "Primary Investment" will remain until date 2, when they worth ..... each at date 2.
- On date 2, there remain ..... depositors, each will receive 
$$\frac{\text{the value of the bank's entire portfolio at date 2}}{\text{the number of depositors remains at date 2}} =$$
$$= 1.79$$

- Type 2 investors will withdraw at date 2. There are no bank runs.

- “Bank runs are a common feature of the extreme crises that have played a prominent role in monetary history. During a bank run, depositors rush to withdraw their deposits because they expect the bank to fail. In fact, the sudden withdrawals can force bank to liquidate many of its assets at a loss and to fail. In a panic many bank failures, there is a disruption of monetary system and a reduction in production.”
- Bank runs disrupt production because they force banks to call in loans early.

- When does a bank runs occur?
- Type 2 depositors choose whether to withdraw at date 1 according to their prediction.
- Bank runs occur when type 2 depositors fear about it.
- There are two possible equilibrium beliefs
  - Bank runs
  - No bank runs
- Bank runs occurs when type 2 depositors expect that the return on date 2 is lower than the return on date 1. ( $r_2 < r_1$ )
- There is no bank runs when type 2 depositors expect that return on date 2 is higher than or equal to the return on date 1. ( $r_2 \geq r_1$ )

- There are many “good” equilibria where there are no bank runs. (for example, all depositors forecast that 25, 27 depositors will withdraw at date 1.)
- There are many “bad” equilibria where there are bank runs. (for example, all depositors forecast that 99, 79 depositors will withdraw at date 1.)
- Moving away from a good equilibrium requires a large change in belief.
- For example, a newspaper story that the bank is performing poorly could cause a run even if many knew that it was inaccurate, because those who know it is inaccurate can believe that the other will decide to withdraw based on the story.

“Greek depositors withdrew €700 million (\$898 million) from the country’s banks on Monday, fueling fears of a bank run amid the growing political disarray.”

Wallstreet Journal, 2012

40% losses Depositors in Cypriot banks with more than 100,000 euros could see 40% of their funds converted into bank shares, while those with less than 100,000 euros will not lose any funds - but face limits on what funds they can access.

BBC, 27 March 2013

## Suspension of Convertibility

- Bank suspends withdrawals of deposits.
- In this simple model, a bank can suspend convertibility of deposits to cash in order to stop a run.
- The bank does not allow more than 25 depositors to withdraw.
- Then, no matter how many depositors attempt to withdraw at date 1, a type 2 depositor will get  $d_2 = 1.81$  at date 2.
- As a result, the depositors would never panic and a run would never start.
- In the days before deposit insurance, banks regularly suspended convertibility to stop runs.
- Many people are worse-off when suspension of convertibility actually occurs. They actually need to withdraw the money to pay their bills.
- Each depositor's type is his own private information.
- Suspension of convertibility is costly.

Nervous depositors in Cyprus rushed to ATMs Saturday to drain their accounts following a bailout agreement with international creditors that includes a levy on all the country's bank accounts

Lines formed at many ATMs as people scrambled to pull their money out after word that the €10 billion (\$12.96 billion) rescue package. ...

European officials said people with less than €100,000 in their accounts will have to pay a one-time tax of 6.75%, those owning more money will lose 9.9%. Cypriot bank officials said that depositors can access all their money except the amount set by the levy.

But that hardly assuaged people who continued to withdraw cash from ATMs until the machines ran out, unsure what or how much would be taxed. Officials said that withdrawing funds on Saturday wouldn't reduce anyone's levy.

The country's cooperative banks also shut their doors after depositors scurried in hopes of protecting their savings. ...

Wallstreet Journal, March 16, 2013

## Won't the bank holiday stop that?

Bank holidays have a fun sounding name, but they are really quite harmful. When you tell people they can't have their money, it makes it very hard for an economy to return to normal. We tried bank holidays a few times in the Great Depression and it only made things worse. One reason to have deposit insurance is to prevent bank runs, but partial deposit insurance is ineffective if it does not cover 100%. You will run on your bank if you think you will lose 100% of your deposits, and you will also run if you think you will lose 10%.

Source: CNN, March 18, 2013, *Bank run expert: Cyprus' plan was 'absurd'*,

“We were in the Stone Age, and now we’re entering the 19th century,” he said in this village near the capital, Nicosia, after visiting his branch of the Bank of Cyprus, which opened Thursday for the first time since March 15. He cursed the strict new controls that for at least the next week will give him access to only a tiny portion of his money and stop him from cashing checks freely or using his bank to pay suppliers who use different ones.” ....

Source: Edgy Calm as Banks in Cyprus Reopen, *New York Times*, March 28, 2013

# Deposit Insurance

- An alternative way to stop and prevent bank runs is deposit insurance.
- Deposit insurance can be defined as a promise to pay the amount promised by the bank no matter how many depositors withdraw.
- In the example, this is a promise of 1.28 to those who withdraw at date 1 and 1.81 to those who withdraw at date 2.
- How can this accomplished if everyone withdraws?
- The only way is to take some resources from those who run and withdraw.

- The government can collect taxes, which is an ability to take resources.
- A survey by the World Bank states that “Almost all countries actually have financial safety nets in place which include explicit and implicit deposit insurance..”
- Deposit insurance may induce moral hazard problems. Banks undertake excessive risk. Depositors are still willing to deposit their money into risky banks.

## Note on the optimal level of liquidity

- What is the optimal level of  $d_1$  and  $d_2$  that will maximise the ex ante expected utility of each investor at date 0?
- $c_1 = d_1$  and  $c_2 = d_2$

$$\text{Max}_{d_1, d_2} \pi U(d_1) + (1 - \pi)U(d_2)$$

$$\text{subject to } d_2 \leq \frac{(1 - \pi d_1) R}{1 - \pi}$$

- The optimal values satisfy

$$\begin{aligned} \pi U'(d_1) + (1 - \pi)U'(d_2) \frac{(-\pi)R}{1 - \pi} &= 0 \\ \frac{U'(d_1)}{U'(d_2)} &= R \end{aligned}$$

- $U(c) = 1 - \frac{1}{C}$ .  $U'(C) = \frac{1}{C^2}$ .  $R = 2$ .
- Then  $\left(\frac{d_2}{d_1}\right)^2 = 2$ ,  $\frac{d_2}{d_1} = \sqrt{R}$ .
- $\frac{d_2}{d_1} \approx 1.4142$ . (1)
- $d_2 = \frac{(1 - 0.25d_1)2}{0.75}$ .
- $0.75d_2 = (1 - 0.25d_1)2$ . (2)

- Substitute (1) into (2) and get

$$\begin{aligned}\frac{0.75}{1.4142}d_1 &= 1 - 0.25d_1 \\ d_1 &= \frac{1}{0.78034} \approx 1.28\end{aligned}$$

- Substitute  $d_1 = 1.28$  into (1).  $d_2 = 1.4142 \times 1.28 \approx 1.81$ .