Bank Runs, Deposit Insurance, and Liquidity

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Outline

Introduction

Diamond, Douglas W., and Philip H. Dybvig. 'Bank Runs, Deposit Insurance, and Liquidity'. Journal of Political Economy 91, no. 3 (1 June 1983): 401–19. https://doi.org/10.1086/261155.

- 2022 Nobel Memorial Prize in Economic Sciences

1. Abstract
2. Context, Motivation and Literature

Dybvig (2017):

"The key message is: banks tend to be fragile because of the services they provide and in particular people don't know when they are going to want their money out. Giving people an option to take their money out when they want it (that's providing liquidity) also tends to make the bank unstable. Because if people are worried about the bank's ability to give them their money back, then banks will be unstable. [...] If everybody does take their money out, then the bank will fail because they will not be able to cover all the withdrawals."

Introduction

Abstract

- **The economic role of banks:** transformation of illiquid assets into liquid liabilities.
- **Liquidity** is welfare-enhancing.
- An undesirable equilibrium: **bank run**.

The illiquidity of assets provides the rationale both for the existence of banks and for their vulnerability to runs.

Introduction

Abstract

- Goal: determining **optimal bank contracts** to prevent runs
- 3 propositions:
  - Suspension of convertibility
  - Government deposit insurance
  - Liquidity injection
- Results and policy implications

Introduction

Context

- 1981: No bank run in the United States since the Great Depression and the creation of the Federal Deposit Insurance.
- Deregulation and dire financial condition of savings and loans.
- Original idea: modelling banking using game theory.

Introduction

Literature

Diamond: "The financial sector was not really modelled yet in mainstream economics."

- Characterizing the liquidity of assets: Patinkin (1965), Tobin (1965), Niehans (1978).

"Theory neglected to explain why bank contracts are less stable than other types of financial contracts or to investigate the strategic decisions that depositors face."

- Friedman and Schwartz (1963), Fisher (1911)

Outline

The Diamond-Dybvig Model of Bank Runs

The 3 key ideas demonstrated by the model:

1. **Banks issuing demand deposits** can improve on a competitive market by **providing better risk sharing** among people who need to consume at different random times.
2. The demand deposit contract providing this improvement has **an undesirable equilibrium (a bank run)** in which all depositors panic and withdraw immediately, including even those who would prefer to leave their deposits in if they were not concerned about the bank failing.
3. **Bank runs cause real economic problems** because even "healthy" banks can fail, causing the recall of loans and the termination of productive investment.

Model: Investment Technology

- one homogeneous good, 3 periods: T = 0, 1, 2.
- a continuum of agents, each one receives 1 unit of endowment at T=0.
- a storage technology with no cost: store 1 unit at T = k , get 1 unit at T = k+1.
- productive technology:

$$\begin{array}{ccc} T=0 & T=1 & T=2 \\ -1 & 0 & R>1 \\ & 1 & 0 \end{array}$$

Model: Uncertainty

We introduce liquidity shocks with 2 types of agents:

- type 1 (impatient): invest at T=0 and consume at T=1
- type 2 (patient): invest at T=0 and consume at T=2

$$U(c_1, c_2; \Theta) = \begin{cases} u(c_1) & \text{if agent is of type 1 in state } \Theta \\ \rho u(c_1 + c_2) & \text{if agent is of type 2 in state } \Theta \end{cases}$$

with $\rho R > 1$
All agents are identical at T=0, types are revealed at T=1

- Denote the probability of being type 1: t
- Ex ante, all agents have the same expected utility:

$$U = tu(c_1) + (1 - t)\rho u(c_1 + c_2)$$

The Bank's Role in Providing Liquidity

Baseline Case 1: Competitive equilibrium

- Agents hold goods directly
- Allows for a competitive market in which claims on future goods are traded at T = 0
- No public information lead to uncontingent contracts:

period 0 and 1 prices of consumption at time 1 $c_1 = 1$
period 0 and 1 prices of consumption at time 2 $c_2 = 1/R$

- NO TRADE

The Bank's Role in Providing Liquidity

Baseline Case 1: Competitive Allocation

- $c_1^2 = c_2^1 = 0$
- $c_1^1 = 1$ and $c_2^2 = R$

Assume $U = \ln c$

Expected utility under competitive equilibrium becomes:

$$E[U] = t\ \ln 1 + (1-t)\rho\ \ln R$$
$$= (1-t)\rho\ \ln R$$

The Bank's Role in Providing Liquidity

Baseline Case 2: Social Planner

The social planner can observe agents realized types.

- Chooses $c_1^2 = c_2^1 = 0$
- Fraction of projects liquidated early: tc_1^1
- Fraction of projects led to maturity: $1 - tc_1^1$ and each yields R

The planner's resource constraint becomes:

$$c_2^2 = \frac{(1 - tc_1^1)R}{1 - t} \tag{1}$$

Baseline Case 2: Social Planner

Expected utility becomes:

$$E[U] = t\ \ln c_1^1 + (1-t)\rho[\ln(1-tc_1^1) + \ln R - \ln(1-t)]$$

Notice:

$$\left.\frac{\partial E[U]}{\partial c_1^1}\right|_{c_1^1 = c_1^{1\text{Autarchy}}} = (1-\rho)t > 0$$

$$\text{and } \frac{\partial^2 E[U]}{\partial {c_1^1}^2} < 0$$

The planner wants to maximise the expected utility of the representative agent, so it will transfer some resources from type 2 to type 1 agents.

The Bank's Role in Providing Liquidity

Baseline Case 2: Social Planner

We look for the optimal level of c_1^1 and c_2^2.

$$E[U] = t \ln c_1^1 + (1-t)\rho[\ln(1-tc_1^1) + \ln R - \ln(1-t)]$$

FOC:

$$\frac{\partial E[U]}{\partial c_1^1} = 0$$
$$\frac{t}{c_1^{1*}} + \frac{(1-t)\rho}{1-tc_1^{1*}}(-t) = 0$$
$$c_1^{1*} = \frac{1}{t+(1-t)\rho} \quad > 1$$

And:

$$c_2^{2*} = \rho R t + (1-t)\rho \quad < R$$

Note that if $c_2^{2*} < c_2^{2\text{Autarchy}}$, it is still greater than c_1^{1*}.

The Bank's Role in Providing Liquidity

The optimal insurance contract under publicly observable types:

- $$c_1^{2*} = c_2^{1*} = 0 \tag{2}$$
  (Those who can, delay consumption.)
- $$u'(c_1^{1*}) = \rho R u'(c_2^{2*}) \tag{3}$$
  (Marginal utility in line with marginal productivity)
- $$t c_1^{1*} + \left[(1-t) c_2^{2*}/R\right] = 1 \tag{4}$$
  (Resource constraint)

Can such insurance contract be achieved with unobservable types? (We reintroduce private information.)

The Bank's Role in Providing Liquidity

Proposition: Banks can achieve the optimal insurance contract.

"By providing liquidity, banks guarantee a reasonable return when the investor cashes in before maturity, as is required for optimal risk sharing."

The Demand Deposit Contract:

$$\begin{array}{ccc} T=0 & T=1 & T=2 \\ -1 & 0 & r2 < R \\ & r1 > 1 & 0 \end{array}$$

The demand deposit contract with $r_1 = c_1^1$ can achieve the full-information optimal risk sharing as an equilibrium where type 1 withdraw at T=1 and type 2 wait until T=2 for c_2^2.

The Bank's Role in Providing Liquidity

The sequential service constraint

"A bank's payoff to any agent can depend only on the agent's place in line and not on future information about agents behind him in line."

The Demand Deposit Contract: Payoffs

$$V_1(f_j, r_1) = \begin{cases} r_1 & \text{if } f_j < r_1^{-1} \\ 0 & \text{if } f_j \geqslant r_1^{-1} \end{cases}$$

$$V_2(f, r_1) = \max\{R(1 - r_1 f)/(1 - f), 0\}$$

Where

- V_i is the period i payoff per unit deposit withdrawn
- f_j is the number of withdrawals before agent j as a fraction of total deposits
- f is the total number of demand deposits withdrawn as a fraction of total deposits.

The Bank's Role in Providing Liquidity

The Demand Deposit Contract: Consumption

- Consumption of type 1 agent:

$$w_j V_1(f_j, r_1)$$

- Consumption of type 2 agent:

$$w_j V_1(f_j, r_1) + (1 - w_j) V_2(f, r_1)$$

Where w_j is the fraction of deposits that a given consumer j withdraws.

Proposition: Risk Sharing Equilibrium

There is an equilibrium in which the demand deposit contract can achieve the full information optimal equilibrium.

In the optimal equilibrium, type 1 withdraws at T = 1 and type 2 waits until T = 2 to get c_2^2

To verify this, we set

- $f = t$
- $r_1 = c_1^{1*}$

Consumption of type 1 agent: $V_1(f_j, r_1) = c_1^{1*}$
Consumption of type 2 agent: $V_2(f, r_1) = c_2^{2*}$

The Bank's Role in Providing Liquidity

Proposition: Bank run 1

There is a second equilibrium where all agents panick and withdraw at T=1.

- If agents anticipate that many other withdraw at $T = 1$, their optimal response is to set: $w_j = 1$, they all withdraw at $T = 1$ (even type 2).
- This is because the face value of deposits becomes larger than the liquidation value of the bank's assets.
- Thus, bank runs are a **Nash Equilibrium**.

The Bank's Role in Providing Liquidity

Proposition: Bank run 2

"The "transformation" of illiquid assets into liquid assets that is responsible both for the liquidity service provided by banks and for their susceptibility to runs."

This equilibrium exists for all $r_1 > 1$.
If $r_1 = 1$:

$$V_1(f_j, r_1) < V_2(f, r_1) \quad \forall f_j$$

In this case, there cannot be a bank run: the bank mimics the equilibrium with direct asset holding.

In other words, a deposit contract that is not subject to runs cannot provide liquidity services.

The Bank's Role in Providing Liquidity

Proposition: Bank run 3

Bank runs have direct negative consequences on the economy.

In the bank run equilibrium, the allocation is worse than the one provided under direct asset holding.

- Holding assets directly gives riskless return of at least 1.
- Bank run equilibrium gives risky return with mean 1.
- All production is interrupted at T=1 when it is optimal for some to continue until T = 2.

To sum up, bank runs ruin the risk sharing between agents and take a toll on the efficiency of production because all production is interrupted.

The Bank's Role in Providing Liquidity

Bank run: Discussion

What if we consider outcomes must match anticipation?

- Agents will choose to deposit at least some of their wealth in the bank even if they anticipate a positive probability of a run, provided that the probability is small enough.

Thus, the selection between the bank run equilibrium and the good equilibrium could depend on some commonly observed random variable in the economy (bad earnings, government reports, other bank runs, or even sunspots).

Proposition: Bank run 4

Banks with pure demand deposit contracts will be very concerned about **maintaining confidence** because the good equilibrium is very fragile.

Suspension of Convertibility

In order to prevent the deposit contract from collapse, we need to reduce the risk of bank runs. One of the simplest ideas is to limit withdrawals when $T = 1$.

$$V_1(f_j, r_1) = \begin{cases} r_1 & \text{if } f_j \leqslant \hat{f} \\ 0 & \text{if } f_j > \hat{f} \end{cases}$$

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

where the expression for V_2 assumes that $1 - \hat{f} r_1 > 0$, i.e. $\hat{f} < r_1^{-1}$. Each agent will choose his equilibrium action even if he anticipates that other agents will choose non-equilibrium or even irrational actions.

Stability of the contract

When $f = t$, there is a dominant strategy equilibrium.

Optimal Contracts with Stochastic Withdrawals

We now allow the fraction of type 1's to be an unobserved random variable, $\tilde{t}$.

- The payments of those who withdraw at $T = 1$ are $V_1(f_j)$.
- The payments of those who withdraw at $T = 2$ are $V_2(f)$.

Let's check whether banks which are subject to the constraint of sequential service can achieve the NE that optimal risk sharing is consistent with self-selection.
We use the full-information optimal risk sharing to show the shortcomings of suspension of convertibility. Now, $\tilde{t} = t$ and $c_1^{2*} = c_2^{1*} = 0$.

Optimal Contracts with Stochastic Withdrawals

Proposition

Bank contracts (which must obey the sequential service constraint) cannot achieve optimal risk sharing when t is stochastic and has a non-degenerate distribution.

Proof.

1. We assume that the payment for $f_j \in [0, t]$ is a feasible function of t, $V_1(t)$. For two possible values of $\tilde{t}$, t_1 and t_2, $V_1(t_1) \neq V_1(t_2)$. It contradicts an unconstrained optimum.
2. For all possible realizations of $\tilde{t} = t$, $V_1(f_j)$ is constant $(\forall f_j \in [0, t])$. This implies that $c_1^1(t)$ is constant. Then then equation of (3) and (4) cannot be satisfied at the same time.

Thus, optimal risk sharing is inconsistent with sequential service. □

The proposition implies that no bank contract, including suspension convertibility, can achieve the full-information optimum.

Government Deposit Insurance

- The deposit insurance should guarantee that the promised return will be paid to all withdraws.
- There are two different types of guarantee: a real value or nominal insurance.

Proposition

Demand deposit contracts with government deposit insurance achieve the unconstrained optimum as a unique Nash equilibrium (in fact, a dominant strategies equilibrium) if the government imposes an optimal tax to finance the deposit insurance.

Government Deposit Insurance

We still assume the optimal risk sharing that $c_1^1 = c_1^1*$, $c_2^2 = c_2^2*$ and $c_2^1 = c_1^2 = 0$. Consider the proportionate tax as a function of f, $\tau : [0,1] \to [0,1]$ given by

$$\tau(f) = \begin{cases} 1 - \frac{c_1^{1*}(f)}{r_1} & \text{if } f \leqslant \bar{t} \\ 1 - r_1^{-1} & \text{if } f > \bar{t} \end{cases}$$

where $\bar{t}$ is the greatest possible realization of $\tilde{t}$. Denote the after-tax proceeds by $\hat{V}_1(f)$, given by

$$\hat{V}_1(f) = \begin{cases} c_1^{1*}(f) & \text{if } f \leqslant \bar{t} \\ 1 & \text{if } f > \bar{t} \end{cases}$$

Any tax collected in excess of that needed to meet withdrawals at $T=1$ is plowed back into the bank. This implies that the after-tax proceeds, per dollar of initial deposit, of a withdrawal at $T=2$, denoted by $\hat{V}_2(f)$, are given by

$$\hat{V}_2(f) = \begin{cases} \frac{R[1-c_1^{1*}(f)f]}{1-f} = c_2^{2*}(f) & \text{if } f \leqslant \bar{t} \\ \frac{R(1-f)}{1-f} = R & \text{if } f > \bar{t} \end{cases}$$

$\forall f \in [0,1]$, $\hat{V}_2(f) > \hat{V}_1(f)$, which means no type 2 agents will withdraw at $T=1$ no matter what they expect others to do. $\forall f \in [0,1]$, $\hat{V}_1(f) > 0$, which means all type 1 agent will withdraw at $T=1$.

Government Deposit Insurance

Now, we know the dominant strategy equilibrium is $f = t$. Evaluate at a realization t,

$$\hat{V}_1(f = t) = c_1^{1*}(t) \tag{5}$$

and

$$\hat{V}_2(f = t) = \frac{[1 - c_1^{1*}(t)t]R}{1 - t} = c_2^{2*}(t) \tag{6}$$

and the optimum is achieved.

- When t is non-stochastic, deposit insurance can be provided costlessly.
- When t is stochastic, only if the government impose a suitable tax, bank runs won't happen no matter how twisted the $\tilde{t}$ is.
- The aim of government policy is to prevent a bad equilibrium rather than a policy to move an existing equilibrium.

Outline

Conclusions and Implications

- This paper justify that the government should take tax and provide deposit insurance. They think there is a potential benefit from government intervention into banking markets.
- However, they analyze an economy with a single bank and ignore that the liquidity risk will share between banks. e.g. “inter-bank lending”..

We should be wary of moral hazard.

- It will be terrible if the government (or the lender) is always willing to help banks escape from runs.
  - No punishment to bankers.
  - Distort the expectation.

The final aim of government insurance should be to help bank operate healthily.

Outline

Historical Perspective

- For the policy maker. They offer an explanation for the logic of the bank run hazard. Bank runs lead to the early recovery of bank loans, which leads to the stagnation of production and turns into real losses.
- Some flows. When they argue that runs can occur in healthy banks, they refer to their assumption that bank runs depend entirely on independent random factors, e.x. Sunspot. In fact, there is a strong correlation between bank runs and the poor performance of the bank.
  - Cass, D. and Shell, K., 1983. Do sunspots matter?. Journal of political economy, 91(2), pp.193-227.
- Bank runs under optimal contracts
  - Peck and Shell (2003), Andolfatto and Nosal (2020)

Outline

Critiques

- The precise source of agents' desire for liquidity is not critical to the possibility of a run.
  - Holmström and Tirole (1998), Diamond and Rajan (2001), Dang, Gorton, and Holmström (2015)
- Bank runs can take various forms.
  - Gorton and Metrick (2012), He and Xiong (2012)
- Liquidity vs solvency runs
- Logarithmic utility: expected utility in the run equilibrium is infinitely negative.
  - Diamond's and Dybvig's answer
- The other roles of banks

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