Monetary Economics

Runs on Banks – Theory

Gerald P. Dwyer

March 2021

Outline

Runs on Banks

- Virtually all theories of runs on banks are variants of Diamond and Dybvig
- Two classes of theories
  - Pure panic
  - Fundamental-based theories
- All empirical evidence points to runs based on fundamentals
- Will just do basic theory
  - Work through Diamond and Dybvig which is available online
  - Pure panic

Literature

- Introduction to theory
  - Franklin Allen and Douglas Gale, Understanding Financial Crises, Oxford: Oxford University Press, 2007. Chapters 1-3.
- Surveys of theory and history of banking arrangements
  - Gerald P. Dwyer and Margarita Samartín, "Theoretical Explanations of Why Banks Promise to Pay Par on Demand." In Transparency, Governance and Markets, edited by Michele Bagella, Leonardo Becchetti and Iftekhar Hasan, pp. 1-20. Amsterdam: Elsevier, 2006.
  - "Why Do Banks Promise to Pay Par On Demand?", Journal of Financial Stability 5 (June 2009), 147-69.

Readings next class

- William J. Crowder,“The Neo-Fisherian hypothesis: empirical implications and evidence?”

Bank Run

- Literature typically generates bank runs with
  - Early and late consumers
  - Illiquid technology
- Similar to, but not identical to Diamond and Dybvig
  - Diamond and Dybvig generate runs by an deposit (insurance) contract alone
  - Papers have this too but are more complex and therefore illiquid technology

The Environment

- Three periods
- One period when decisions are made with no consumption $T = 0$
- One period when consumption can occur $T = 1$
- Second period when consumption can occur $T = 2$
- An endowment economy
  - No production
- Consumers, who get an identical endowment of one unit
- Banks

Technology Available to Consumers

- A technology available to consumers is a storage technology
- One unit of endowment carried over any period yields one unit in the next period
- One unit in period 0 generates one unit in period 1
- One unit in period 1 generates one unit in period 2

Another Technology Available

- A second investment technology available
- One unit of endowment in period 0 can generate
  - One unit in period 1
  - $R > 1$ units in period 2
  - Common in later literature to make this technology available only to banks

Consumers' Preferences

- All consumers are identical in period 0
- Each consumer can be type 1 or type 2
- This is discovered in period 1 and is private information
- Type 1 consumers care only about consumption in period 1, c_1
  - Early or impatient consumers
  - Consumers or depositors
- Type 2 consumers care only about consumption in period 2, c_2
  - Late or patient consumers
  - Consumers or depositors

Consumers' Preferences

- The utility function for each consumer in period 0 is

$$U(c_1, c_2)$$

with

$$U(c_1, c_2) = u(c_1)$$

if the consumer is of type 1 and

$$U(c_1, c_2) = u(c_2)$$

if the consumer is of type 2 – By assumption, a type 2 late consumer does not care about consumption in period 1

Consumers' Preferences

- Type is private information – not observable
- Suppose that utility function u is twice continuously differentiable everywhere with positive first derivatives and negative second derivatives and

$$u'(0) = \infty \text{ and } u'(\infty) = 0$$

- Relative risk aversion coefficient

$$-cu''(c)/u'(c) > 1$$

- A fraction γ of consumers are type 1 and a fraction $1-\gamma$ are late consumers
- There is no aggregate uncertainty: a fraction γ always are type 1 and a fraction $1-\gamma$ are late consumers
  - Law of large numbers implies realization will equal parameter with an infinite number of consumers, at least in this setup
- Consumers maximize expected utility

$$\mathrm{E}\,U(c_1, c_2) = \gamma u(c_1) + (1-\gamma)\,u(c_2)$$

Autarky

- In autarky, a consumer does the best he can with the technology available
- Use investment technology with

$$\mathrm{E}\,U(c_1, c_2) = \gamma u(c_1 = 1) + (1-\gamma)\, u(c_2 = R)$$

Pareto Optimal Solution

- Consumers have the expected utility function

$$\mathrm{E}\, U(c_1, c_2) = \gamma u(c_1) + (1-\gamma)\, u(c_2)$$

- Maximize expected utility subject to resource constraint
- Resource constraints per capita are

$$\gamma c_1 = L \text{ and } (1-\gamma)\, c_2 = (1-L)R$$

where L is the amount withdrawn from the technology in period 1 for the early consumers

Pareto Optimal Solution

- Consumers have the expected utility function

$$\mathrm{E}\, U(c_1, c_2) = \gamma u(c_1) + (1-\gamma)\, u(c_2)$$

- Maximize expected utility subject to resource constraint
- Resource constraints per capita are

$$\gamma c_1 = L \text{ and } (1-\gamma)\, c_2 = (1-L)R$$

where L is the amount withdrawn from the technology in period 1 for the early consumers

- The constraint is

$$(1-\gamma)\, c_2 = (1-L)R$$

Pareto Optimal Solution

- Consumers have the expected utility function

$$\mathrm{E}\,U(c_1, c_2) = \gamma u(c_1) + (1-\gamma)\, u(c_2)$$

- Maximize expected utility subject to resource constraint
- Resource constraints per capita are

$$\gamma c_1 = L \text{ and } (1-\gamma)\, c_2 = (1-L)R$$

where L is the amount withdrawn from the technology in period 1 for the early consumers
- The constraint is

$$(1-\gamma)\, c_2 = (1-L)R$$

$$(1-\gamma)\, c_2 = (1-\gamma c_1)R$$

Pareto Optimal Solution

- Consumers have the expected utility function

$$\mathrm{E}\, U(c_1, c_2) = \gamma u(c_1) + (1-\gamma)\, u(c_2)$$

- Maximize expected utility subject to resource constraint
- Resource constraints per capita are

$$\gamma c_1 = L \text{ and } (1-\gamma)\, c_2 = (1-L)R$$

where L is the amount withdrawn from the technology in period 1 for the early consumers

- The constraint is

$$(1-\gamma)\, c_2 = (1-L)R$$

$$(1-\gamma)\, c_2 = (1-\gamma c_1)R$$

$$R - R\gamma c_1 - (1-\gamma)\, c_2 = 0$$

Pareto Optimal Solution

- Consumers have the expected utility function

$$\mathrm{E}\,U(c_1, c_2) = \gamma u(c_1) + (1-\gamma)\,u(c_2)$$

- Maximize expected utility subject to resource constraint
- Resource constraints per capita are

$$\gamma c_1 = L \text{ and } (1-\gamma)\,c_2 = (1-L)R$$

where L is the amount withdrawn from the technology in period 1 for the early consumers

- The constraint is

$$(1-\gamma)\,c_2 = (1-L)R$$

$$(1-\gamma)\,c_2 = (1-\gamma c_1)R$$

$$R - R\gamma c_1 - (1-\gamma)\,c_2 = 0$$

In terms of reductions from the original resource value of one

$$1 - \gamma c_1 - R^{-1}(1-\gamma)\,c_2 = 0$$

Pareto Optimal Solution

- Maximization of

$$\gamma u(c_1) + (1-\gamma)\, u(c_2)$$

subject to

$$R - R\gamma c_1 - (1-\gamma)\, c_2 = 0$$

implies that

$$\begin{aligned} \gamma u'(c_1) - \lambda\gamma R &= 0 \\ (1-\gamma)\, u'(c_2) - \lambda (1-\gamma) &= 0 \end{aligned}$$

which can be rewritten as

$$u'(c_1) - Ru'(c_2) = 0$$

Pareto Optimal Solution

- Have

$$\begin{aligned} u'(c_1) - Ru'(c_2) &= 0 \\ \frac{u'(c_2)}{u'(c_1)} &= R^{-1} \end{aligned}$$

- $R > 1$ implies

$$\frac{u'(c_2)}{u'(c_1)} < 1$$

- By diminishing marginal utility,

$$c_2 > c_1$$

Pareto Optimal Solution and Autarky

- How are these solutions related to autarky values of 1 and R?
- Note that

$$u'(c_1) = Ru'(c_2)$$

- Interesting solution will be $c_1 > 1$ and $c_2 < R$
- A necessary condition for $c_1 > 1$ and $c_2 < R$ is that

$$u'(1) > Ru'(R)$$

  so that increasing c_1 and reducing c_2 moves the consumptions toward the equilibrium. A sufficient condition is that $cu'(c)$ be decreasing in c, which is equivalent to saying that relative risk aversion is greater than one, i.e.,

$$-cu''(c)/u'(c) > 1$$

- Consumers insure against being early consumers
  - Receive more than autarky in early period
  - Receive less in later period but still more than in early period

$$1 < c_1 < c_2 < R$$

Banking Solution

- An infinite number of banks
- No costs of operating bank
  - Constant returns to scale in investment technology
- Bank can convert one unit of endowment into one unit in period 1 and either
  - One unit in period 2 using storage technology
  - $R > 1$ units using the banks' technology
- Perfect competition and no impediment to maximizing the utility of the representative consumer
- Banks implement the consumption allocation in the Pareto optimal solution

A Problem with the Banking Solution

- At $T = 1$, banks pay out $c_1 > 1$
- Suppose that some consumers believe that some other late consumers might withdraw early, i.e. in period 1
  - Then the amount left in period 2 will be less than the promised consumption
  - The amount left in period 2 may be less than the amount promised in $T = 1$
- Optimal solution can be to withdraw early
  - Nothing to present a consumer from doing this since being early or late is private information
  - Sequential service implies that some late consumers get more than one unit in the run
  - Early consumers who arrive at the bank too late may not get even one unit
- Called a "panic run" because the only reason for withdrawing early is the thought that others might withdraw

Problem with This Simple Model

- Really have shown there are two equilibria
- One equilibrium with banks because everyone believes that everyone else will withdraw by type
- Another equilibrium with no banks in period $T = 0$ because everyone believes that, in period one, some late consumers will withdraw early

Risky Technology

- An example of a risky technology available to banks
- Now, one unit of the second technology yields
  - 1 unit at $T = 1$
  - 0 units with probability p and R^h units with probability $1 - p$ at $T = 2$
    - Call outcome at $T = 2$ with 0 the *low state*
    - Call outcome at $T = 2$ with R^h the *high state*
  - Assume that $\mathrm{E}\, R = p \cdot 0 + (1 - p) \cdot R^h > 1$
- Question of when the result for $T = 2$ is known
- To have a run at $T = 1$, must become known by depositors at $T = 1$
  - Therefore, outcome for investment at banks becomes known at $T = 1$

Result of Learning in High State

- Events in High State
- Depositors find out that they will receive R^h if they wait
- It is implied by earlier analysis that late consumers will wait
- Therefore, no run

Result of Learning in Low State

- Events in Low State
- Depositors find out that they will receive 0 if they wait
- Each depositor can receive c_1 now because the bank cannot tell the difference between early and late consumers
- Therefore, everyone wants to withdraw at $T = 1$

How Does A Run Work?

- How does a run work?
- Everyone tries to withdraw at $T = 1$ and bank has promised to pay out c_1 units to everyone
- Bank does not have enough assets to pay everyone $c_1 > 1$
- Under assumptions at the moment, banks have enough assets to pay everyone 1
- How handle payments?
  - Sequential service constraint
    - Some get c_1 units
    - Some get nothing
  - Suspend payments because bank knows a run will happen
    - All depositors get the same amount, 1

Summary

- The Diamond-Dybvig model is a simple model with a banking system
- The banking system
  - Takes an asset and produces higher returns by holding it longer
  - Makes households better off
  - Is illiquid early on
  - Is subject to runs

Summary

- The Diamond-Dybvig model is a simple model with a banking system
  - No credit risk
  - Run is a "pure panic" run and not fundamental
  - No moral hazard from deposit insurance

Summary

- There have been many elaborations of this simple model
- Most important: fundamental runs due to a risky technology
- This produces a model with runs and some of issues in real runs
- Also can introduce equity capital into the model
- Also can introduce more time periods