ECON 747 – LECTURE 13:
FINANCIAL INTERMEDIATION, BANKS AND BANK RUNS

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MOTIVATION

- In the models we studied so far, lending/borrowing occurs directly between agents
  - E.g. households lend to entrepreneurs
- We now turn to considering an explicit role of financial intermediation
- The interaction between distressed financial intermediaries and real economic outcomes is of key interest to macroeconomists

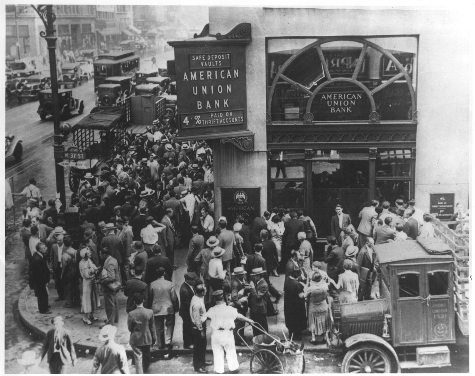
OVERVIEW OVER THIS PART

1. Banks as providers of liquidity insurance and the presence of bank runs
   - Diamond and Dybvig (1983)
2. Financial intermediaries in DSGE models
   - Agency costs and bank capital: Gertler and Karadi (2011)
   - Combining financial accelerator effects and bank runs: Gertler and Kiyotaki (2015)

BANKS

- Banks transform maturity: create liquid deposits, finance illiquid assets (loans)
- Banks provide liquidity insurance (focus today)
- Banks carry out delegated monitoring

BANKS



- Banks may be subject to runs ...

THE DIAMOND-DYBVIG MODEL OF BANK RUNS

MOTIVATION

- Main idea of Diamond and Dybvig (1983)
  - Bank deposit contract delivers equilibrium that improves on an exchange market
  - This explains why banks can attract deposits, although they may be subject to runs
- Setting with asymmetric information and liquidity demand

SETTING

- Three periods, $T = 0, 1, 2$
- One homogeneous good
- Production technology:
  - Requires 1 unit of input in period 0
  - Can be ‘interrupted’ in period 1
  - If interrupted: gives 1 unit in period 1, 0 units in period 2
  - If not interrupted: gives 0 units in period 1, $R > 1$ units in period 2

PRODUCTION TECHNOLOGY

- Timeline:

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

- Potential interpretation: transaction costs associated with selling a bank's asset before maturity

STORAGE TECHNOLOGY

- Alternatively, agents can store ("hoard") goods between periods at no costs
- Storage is not publicly observable

PREFERENCES AND ENDOWMENTS

- Continuum of ex ante identical consumers
- In period 1, each consumer learns her type
- Type is private information
- Two types
  - Type 1: only likes consumption in $T = 1$
  - Type 2: only likes consumption in $T = 2$
- Fraction t of consumers is type 1
- Each consumer is endowed with 1 unit of the good in $T = 0$

STORAGE USE

- No agent would want to use storage between periods 0 and 1
- The reason is that production technology does just as well
- Type 1 consumers would never store between periods 1 and 2 either, as they want to consume everything in period 1
- If type 2 consumers were to receive any additional goods in period 1 they would store all of them until period 2

GOOD RECEIVED

- Denote c_T as goods received in period T
- Goods received can be stored or consumed
- c_T is a publicly observed variable
- A type 2 consumer's consumption in period 2 is therefore

$$c_1 + c_2$$

UTILITY FUNCTION

- This implies state dependent utility function (with the state private information)

$$U(c_1, c_2) = \begin{cases} u(c_1) & \text{if consumer is type 1} \\ \rho u(c_1 + c_2) & \text{if consumer is type 2} \end{cases}$$

  with $R^{-1} < \rho \leq 1$

- $u(\cdot)$ satisfies standard assumptions, features relative risk aversion > 1

COMPETITIVE EQUILIBRIUM

- First consider equilibrium in which agents hold goods directly
- Allow for competitive market in which claims on future goods are traded in $T = 0$
- There is no public information on which contracts can be conditioned
- This gives uncontingent contracts in which prices are determined as follows:
  - Period-0 price of period-1 consumption $= 1$
  - Period-0 and period-1 prices of period-2 consumption $= 1/R$
- There is no trade!

- Denote type i's period-T consumption by c_T^i
- Competitive allocation is
  - $c_1^1 = 1$, $c_2^1 = 0$
  - $c_1^2 = 0$, $c_2^2 = R$

OBSERVABLE TYPES

- Suppose types were publicly observable
- Agents write insurance contract in period 0
- Ex ante, each agent does not know which type she will become in period 1
- Curvature in $u(\cdot) \Rightarrow$ ex ante, agent would be better of with c_1^1 bigger, c_2^2 smaller

OBSERVABLE TYPES

- The contract satisfies:

$$c_2^{1*} = c_1^{2*} = 0 \tag{1}$$

$$u'(c_1^{1*}) = \rho u'(c_2^{2*})R \tag{2}$$

$$tc_1^{1*} + (1-t)\frac{1}{R}c_2^{2*} = 1 \tag{3}$$

INSURANCE CONTRACT WITH OBSERVABLE TYPES

- Equation (1): type-1 does not consume in period 2; type-2 does not consume in period 1
- Equation (2): marginal utility is in line with marginal "productivity"
- Equation (3): resource constraint

- Since $\rho R > 1$ and risk aversion > 1, equations (1), (2), (3), imply that

$$c_1^{1*} > 1$$
$$c_2^{2*} < R$$
$$c_2^{2*} < c_1^{1*}$$

- A formal proof can be found in Diamond and Dybvig (1983)

BACK TO PRIVATE INFORMATION CASE

- Can such an insurance contract be achieved with *unobservable* types?
- Yes: banks can provide such insurance
- The idea is that banks provide liquidity, guarantee a return when an investor cashes in before maturity
  - This is what risk sharing requires
- Banks provide insurance via a demand deposit contract

DEMAND DEPOSIT CONTRACT

- Bank promises each consumer who withdraws funds in period 1 a fixed claim of r_1 per unit of the good deposited
- *Sequential service constraint*:
  - Withdrawals are served in random order until the bank runs out of available assets
  - Payoff to a given agent depends only on agent's place in line and not on information about agents behind her in the line
- Assume that bank is mutually owned and liquidated in $T = 2$:
  - Agents not withdrawing get a pro rata share of the bank's remaining assets

- Denote V_1 the period-1 payoff per unit deposit withdrawn

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

f_j is the number of withdrawals before agent j as a fraction of total deposits

DEMAND DEPOSIT CONTRACT: PAYOFFS

- Suppose bank promises $r_1 = 2$, so that $r_1^{-1} = 0.5$
- Suppose bank has collected one unit of deposit from 100 people, so it can pay out a maximum of 100 in withdrawals
- If 49 people withdraw, bank is ok: $f_j = \frac{49}{100} < r_1^{-1} = 0.5$
  - Each consumer gets r_1
- If 51 people withdraw, bank runs out of assets
  - First 50 consumers get r_1, 51st consumer gets 0

DEMAND DEPOSIT CONTRACT: PAYOFFS

- Denote V_2 the period-2 payoff per unit deposit not withdrawn

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

where f is the total number of withdrawals as a fraction of total deposits

DEMAND DEPOSIT CONTRACT: PAYOFFS

- In the same example, suppose 49 consumers have withdrawn:

$$\max\left\{R\frac{1-r_1 f}{1-f}, 0\right\} = \max\left\{R\frac{1-0.49*2}{1-0.49}, 0\right\} \approx 0.039R$$

- Suppose 51 consumers have withdrawn

$$\max\left\{R\frac{1-r_1 f}{1-f}, 0\right\} = \max\left\{R\frac{1-0.51*2}{1-0.51}, 0\right\} = 0$$

CONSUMPTION ACHIEVED

- Denote w_j the fraction of deposits that a given consumer j withdraws
- Consumption of type 1 agent:
$$w_j V_1(f_j, r_1)$$
- Consumption of type 2 agent:
$$w_j V_1(f_j, r_1) + (1 - w_j) V_2(f, r_1)$$

EQUILIBRIUM WITH DEPOSIT CONTRACT

- The contract offered by the bank satisfies self-selection constraints
  - See the paper for a formal discussion
  - A few more remarks on the (non)-optimality of this contract below
- Consider pure strategy Nash equilibria
- There are two equilibria
  1. Risk sharing equilibrium
  2. Bank run equilibrium

RISK SHARING EQUILIBRIUM

- The demand deposit contract can achieve the full information risk sharing arrangement described above
- We can verify this by setting:

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

- Type 1 consumers choose $w_j = 1$, type 2 consumers $w_j = 0$
- This leads to

$$V_1(f_j, r_1) = c_1^{1*}$$
$$V_2(f, r_1) = c_2^{2*}$$

BANK RUN EQUILIBRIUM

- Importantly, second equilibrium arises in this setting
- If agents anticipate that many others withdraw in period 1, the optimal response is to set $w_j = 1$, even for type 2 consumers
- The reason is that with many consumers withdrawing, the face value of deposits becomes bigger than the banks assets after liquidation

BANK RUN EQUILIBRIUM

- This equilibrium exists for all $r_1 > 1$
- If $r_1 = 1$, there are no runs because

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

- In this case the bank would just mimic the equilibrium with direct asset holding
- *A deposit contract that is not subject to runs cannot provide liquidity services!*

BANK RUN EQUILIBRIUM: DISCUSSION

- The bank run equilibrium implies an allocation that is worse for all agents than without the deposit contract
  - Bank run equilibrium gives risky return with mean 1
  - Holding assets directly gives riskless return of at least 1
- Bank runs reduce efficiency because all production is interrupted at $T = 1$

BANK RUN EQUILIBRIUM: DISCUSSION

- Why would anyone deposit anticipating a run?
- As long as the anticipated probability of a run is low, agents will deposit some of their wealth, as the risk sharing equilibrium improves upon holding assets directly

BANK RUN EQUILIBRIUM: DISCUSSION

- What can move the economy from the good equilibrium to the bank run equilibrium?
- It could be a commonly observed fundamental variable in the economy, such as a bad earnings report
- It could also be a "sunspot"
  - Remember the discussion in the previous lecture
- This is the reason why banks are very concerned about maintaining confidence

BOTTOM LINE

- This model rationalizes formally why banks can attract deposits even if the perceived probability of a bank run may be positive

EXTENSIONS

- Diamond and Dybvig (1983) also consider:
  - Possibility of *suspension of convertibility*
  - Stochastic withdrawals: t is random variable
  - Government deposit insurance

SOME QUALIFIERS ON THE CONTRACT

- Subsequent research has pointed out that the existence of bank runs in this setting is an artifact of a suboptimal contract
  - E.g. when suspension is introduced, there is no run equilibrium
- Peck and Shell (2003) show that a bank run equilibrium exists in a class of optimal contracts
- Andolfatto and Nosal (2020) study a version of Diamond-Dybvig with fixed costs of banking, in which bank runs occur under an optimal contract

DSGE MODELS WITH FINANCIAL INTERMEDIATION

GERTLER-KARADI

- We start with Gertler and Karadi (2011)
- Main idea of this paper:
  - Build model in which intermediaries face endogenous balance sheet constraints
    - Lender net worth becomes important
    - No 'bank runs' in their setting
  - Study unconventional monetary policy

IDEA OF GERTLER-KARADI IN A NUTSHELL

- Financial intermediaries
  - Raise funds from households
  - Give loans to firms
- The central bank
  - Raises funds from households
  - Gives loans to firms

IDEA OF GERTLER-KARADI IN A NUTSHELL

- Financial intermediaries
  - Raise funds from households $\rightarrow$ subject to friction
  - Give loans to firms $\rightarrow$ efficient
- The central bank
  - Raises funds from households $\rightarrow$ riskless bonds, no friction
  - Gives loans to firms $\rightarrow$ inefficient

GERTLER-KARADI: AGENTS

- Households
- Financial intermediaries
- Firms that produce intermediate goods
- Government / central bank
- Capital producers
  - Make intertemporal decisions
- Retailers
  - Carry the nominal rigidities (remember BGG)

SO HOW DOES THE FRICTION WORK?

- Every period, intermediaries turn into households with probability θ
- Their balance sheet is given by

$$Q_t S^p_{j,t} = N_{j,t} + B_{j,t}$$

  - Looks familiar?
- $S^p_{j,t}$ are loans, that is, financial claims on firms which earn return $R_{k,t+1} \geq R_{t+1}$
- The superscript 'p' makes clear that these are provided by private intermediaries

SO HOW DOES THE FRICTION WORK?

- Denote $V_{j,t}$ the continuation value of an intermediary
- Assume that each period, an intermediary can divert a fraction λ of funds available from the project and consume them
- This is actually a limited enforcement/moral hazard friction
- It turns out that in this setting it plays out similar to a CSV friction

SO HOW DOES THE FRICTION WORK?

- For households to be willing to provide $B_{j,t}$ to an intermediary, the following incentive constraint must be satisfied:

$$V_{j,t} \geq \lambda Q_t S_{j,t}$$

- $V_{j,t}$ depends on intermediary net worth $N_{j,t}$

SO HOW DOES THE FRICTION WORK?

- Using an appropriate expression for $V_{j,t}$ (I omit the details), derive the following relationship between loans given out by intermediaries and their net worth

$$Q_t S^p_{j,t} = \phi_t N_{j,t}$$

where ϕ_t is a composite term that depends positively on $R_{k,t+1} - R_{k,t+1}$

  - Looks familiar?

- This is a linear relationship which can be aggregated conveniently across j (just as in BGG1999)

- Total credit to firms is given by

$$S_t = S_t^p + S_t^g$$

where S_t^g are assets intermediated by the central bank

- To conduct credit policy, the central bank can issue riskless bonds, but has to incur an efficiency cost of τ per unit of credit supplied

GERTLER-KARADI: EXPERIMENTS

- Study IRFs to a variety of shocks, compare to model without financial frictions
- One of those shocks is a capital quality shock, which generates dynamics similar to the Great Recession
- Study the dynamics with / without aggressive central bank credit intermediation
- Study interaction with a zero lower bound (ZLB) on the nominal interest rate

GERTLER-KARADI: IRFS

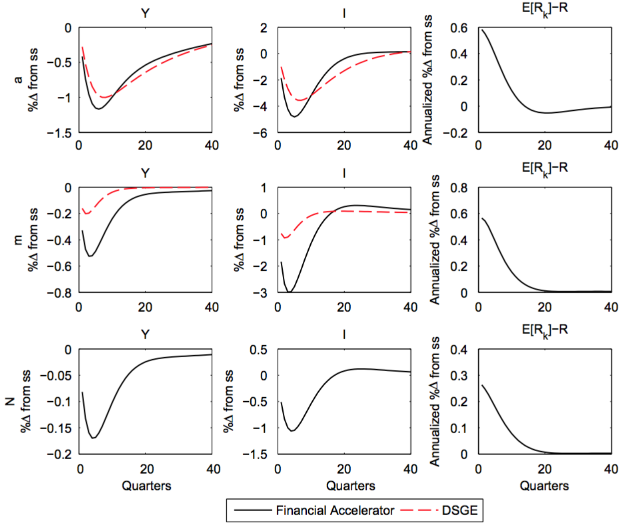


Fig. 1. Responses to Technology (a), Monetary (m) and Wealth (w) Shocks.

GERTLER-KARADI: IRFS

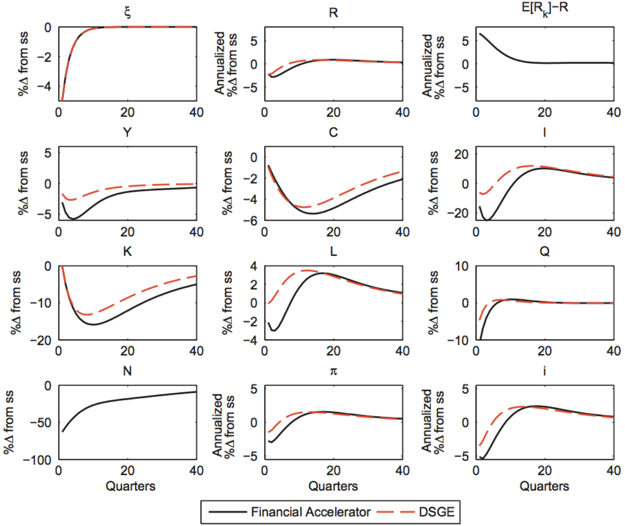


Fig. 2. Responses to a Capital Quality Shock.

GERTLER-KARADI: IRFS

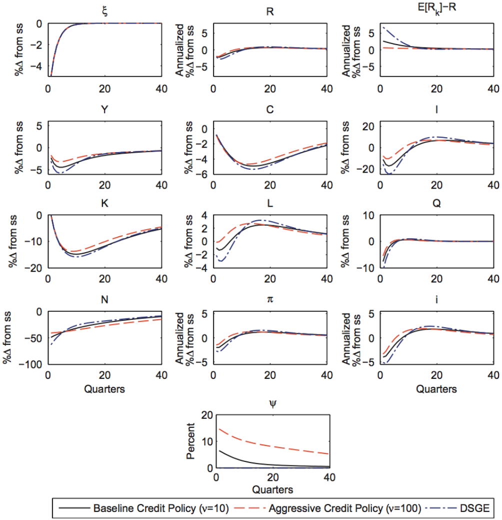


Fig. 3. Responses to a Capital Quality Shock with Credit Policy.

GERTLER-KARADI: IRFS

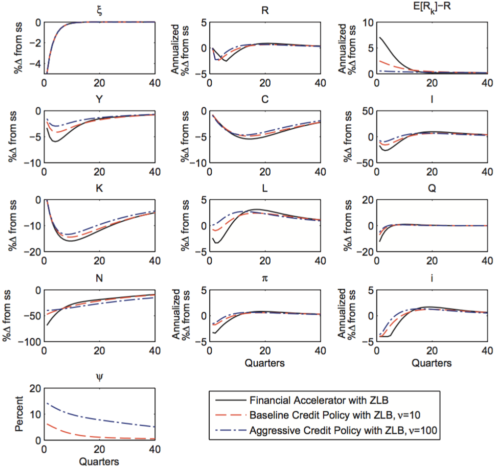


Fig. 5. Impulse responses to the capital quality shock with the zero lower bound (ZLB) with and without credit policy.

GERTLER-KARADI: MAIN INSIGHT

- As central bank is not balance sheet constrained during a recession, the net benefits from central bank intermediation can justify intervention in credit markets

GERTLER-KIYOTAKI

- We now turn to Gertler and Kiyotaki (2015)
- The idea of this paper is to build a DSGE model which incorporates:
  1. Endogenous balance sheet constraints for financial intermediaries **and**
  2. The possibility of bank runs
- "Gertler-Karadi meets Diamond-Dybvig"
- Motivation: in the Great Recession both of these forces appeared to be at play ...

MODEL INGREDIENTS

1. Agency friction in the flow of funds between households and financial intermediaries
   - Similar to Gertler and Karadi (2011)
2. Liquidity mismatch between financial intermediaries' liabilities and assets
   - Not quite the same as Diamon-Dybvig, more in the spirit of Cole and Kehoe (2000)'s "self-fulfilling debt crises"
   - See next slide

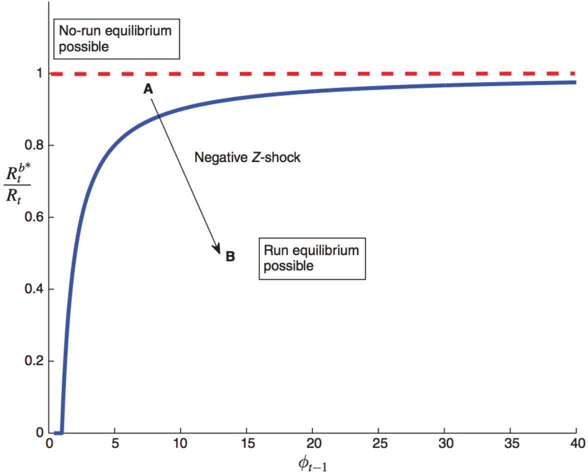
LIQUIDITY MISMATCH

- Part of the economy's capital is operated by household, part is operated by financial intermediaries
- Capital does not fully depreciate
- Households are less efficient at operating capital, they need to pay a quantity of final goods to operate it
- This means that the intermediary operates an asset that is imperfectly liquid
- At the same time, deposits are short term and fully callable

MULTIPLE EQUILIBRIA

- As we have seen in Diamond-Dybvig, bank runs arise as an equilibrium in addition to an equilibrium without a run
- In Diamond-Dybvig, whenever $r_1 > 1$, there exists such multiplicity of equilibria
- Here: the presence of a second (bank run) equilibrium arises endogenously, depending on the condition of the intermediary balance sheet

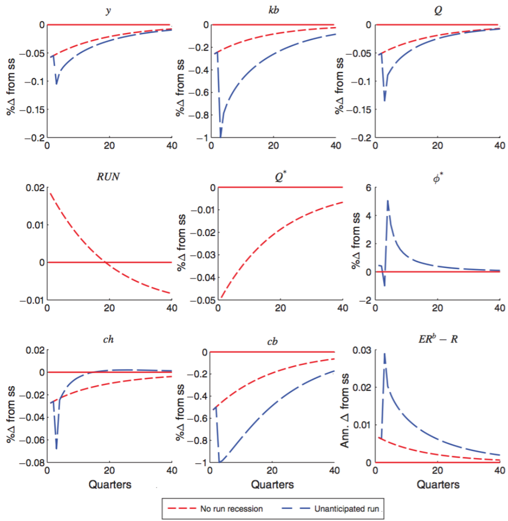
GERTLER-KIYOTAKI: EQUILBRIA



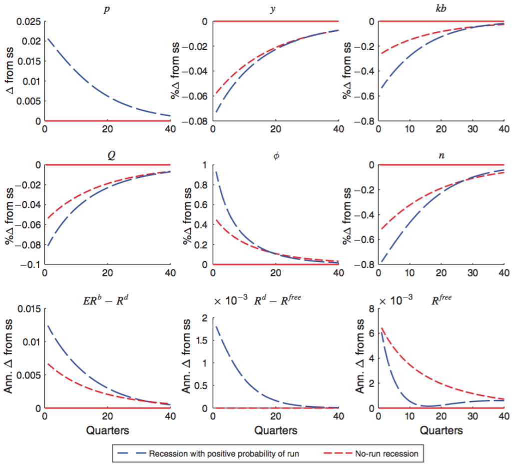
GERTLER-KIYOTAKI: EXPERIMENTS

- Investigate the presence of both anticipated and unanticipated banks runs, studying situations in which the bank run does or does not actually occur

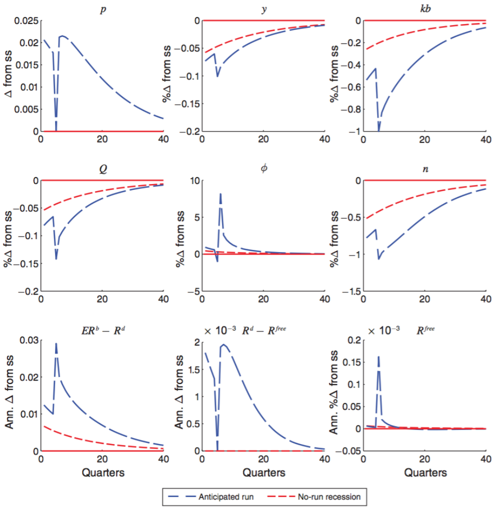
GERTLER-KIYOTAKI: IRFS



GERTLER-KIYOTAKI: IRFS



GERTLER-KIYOTAKI: IRFS



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