Macroeconomics A, EI056

Class 11

Financial frictions, panics, and the financial accelerator

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What you will get from today class

- Role and challenges of **financial markets**.
- Two main frictions: **adverse selection** and **moral hazard**.
    - Focus on intuition (extra slides at the end with more details).
- **Financial accelerator**: financial frictions lead to persistent effects of temporary shocks.
- Bank **panics**: self-fulfilling crises and policy response.
- Recent lines of research on bringing finance in macroeconomics.

A question to start

Financial market frictions occur because lenders and borrowers are not well informed.

Making more information available will thus prevent crises and panics.

Do you agree? Why or why not?

FINANCIAL MARKETS :

ROLES AND FRICTIONS

Roles and vulnerabilities

- **Connect** savers and borrowers (funneling of savings), **share risk** between investors with different exposures.
- Best done with **intermediaries** (banks).
  - Borrowers do not have to contact savers individually.
  - **Information** is asymmetric: borrowers know more about the project. The intermediary can specialize in gathering information and monitoring borrowers.
- Central role of **information frictions** makes financial markets inherently fragile.
  - Panics: agents' behavior can create the very problems they fear.
  - Accelerator: shocks interact with information frictions leading to large and persistent effects.

Credit rationing

- Credit markets connect the supply of funds from lenders and the demand from borrowers.
  - With high demand, the **price** (interest rate) should increase to clear the market.
- May not occur. If the market does not clear by price, it clears by a limit in quantities: **rationing** with demand above supply as the market price.
- **Adverse selection**: focus on types of borrowers (not their actions). A high interest rate pushes good borrowers away, only bad borrowers remains.
- **Moral hazard**: focus on actions of borrowers (not their types). A high interest rate induces borrowers to behave in a way that is costly to the lender.

Adverse selection

- **Heterogeneity** of borrowers, with two types: **safe** and **risky**.
  - Each borrower has a project. Payoff can be high or low.
  - **High-low return gap** is moderate for safe borrowers and high for risky borrowers.
- Timing of the loan contract.
  - **Set** interest rate (not a stock with return contingent on project).
  - Borrower repays the loan with interest and keeps the rest...
  - ...or defaults, in which case the lender gets everything.
- Lender sets the interest rate so her expected return is a set value (outside option of investing in a bond).

Structure of payoffs

- Default makes sense only if the project has a low return.
  - The borrower would not choose to default and give the lender everything when the project is successful.
- **Limited liability**: the borrower cannot be forced to pay more than the value of the project.
- Given the interest rate, **borrower**'s payoff is **increasing in risk**.
  - Bad payoff in case of failure has a floor at zero (default).
  - Good payoff in case of success goes to the borrower (loan payment is fixed).
- Lender's payoff mirrors this (gain capped, gets all the marginal loss).

Two effects of the interest rate

- A higher interest rate increases what the lender gets, when the loan gets repaid.
- Additional **selection effect**: a higher interest rate can change the composition of the borrowers' pool.
  - At low interest rates, **both** risky and safe borrowers take a loan.
  - At high interest rate, **only risky** borrowers take the loan. The high interest rate implies that the safe borrower is left with nothing even when the project is successful (project return not that high)
  - **Threshold** interest rate at which safe borrowers drop out.
- Increasing the interest from below the threshold to above is costly for the lender, who loses the best borrowers.
- Instead **ration** credit: not all borrowers get it, or they get only of fraction of what they ask. ▸ Computations

Moral hazard

- **Behavior** of borrowers, who undertake risky projects funded. They repay the loan if the project works, otherwise nobody gets anything.
- Borrower chooses the specific project, the lender cannot check this choice.
    - **Safe** project with high probability of a moderate payoff.
    - **Risky** project (gambling) with low probability of a high payoff.
    - Safe project is better with a higher expected return.
- Low interest rate $\rightarrow$ borrowers choose the safe project.
    - Despite the moderate payoff if successful, borrowers still get good return after paying back the loan.
- **High** interest rate $\rightarrow$ borrowers choose the **risky** project. ▸ Computations
    - Safe project leaves borrowers with little net payoff in case of success.

Rationing and solutions

- Lender does not want to set the interest rate too high.
  - A high rate induces borrowers to gamble, which reduces the lender's expected payoff.
  - Lender limits the amount of loans to each borrower, or randomly pick some borrowers (credit rationing).
- **Two costly solutions** for moral hazard.
- **Monitoring**: check what the borrower does (even randomly), at a cost.
  - Cost is passed to the borrowers through a higher cost of credit.
  - Some productive projects aren't funded.
- **Collateral**: borrower needs to put some of her own money
  - Something to loose in case of failure (harder to gamble your own money than the money of other people).
  - Good projects by poor borrowers are not funded.

FINANCIAL ACCELERATOR

Frictions and the financial accelerator

- Frictions in credit markets can lead temporary shocks to have persistent effects.
- Start with the mechanism in partial equilibrium. Investment done by **entrepreneurs**, who need to borrow (partially) with limited liability.
- Entrepreneurs with a **risky project**.
  - Success: κ_2 units of **capital** with probability π_2.
  - Failure: $\kappa_1 < \kappa_2$ units (for simplicity $\kappa_1 = 0$) . Expected payoff $\kappa = \pi_2 \kappa_2$.
- **Heterogeneous ability** to run the project among entrepreneurs.
  - ω: index of **inability** uniformly distributed between 0 and 1. Efficient entrepreneurs have a low ω.
- Cost of project is $x(\omega)$, with $x' > 0$. Each entrepreneur has funds S, even the best needs to borrow $(S < x(0))$.

Efficient allocation

- **Lender freely observes** the result of the project. Repayment depends on it.
  - Repayment r_2 in case of success and r_1 in case of failure.
  - Expected return equal to outside option r.
- **Ability threshold** ω^*. Only efficient entrepreneurs $(\omega < \omega^*)$ undertake projects. The other ones lend.
- Marginal entrepreneur indifferent: expected project return equal to return of investing the cost in the bond:

$$\kappa = rx\left(\omega^*\right)$$

Asymmetric information

- Lender **does not freely** see the return on the project. She can see it at an **auditing cost** $\bar{c}$.
- Optimal contract: 1) borrower announces the return on the project, 2) payment to the lender lower in case of failure.
  - **Incentive to lie** and announce failure (and pay little) in case of success.
- No audit if success is announced (no borrower wrongly claims success). Lender gets $\kappa_2 - P_2$, the borrower gets P_2.
- **Random audit if failure** is announced, with probability p.
  - Truly a failure: lender gets $-\bar{c}$, the borrower nothing (we can show it is optimal).
  - Not actually failure, lender takes everything: $\kappa_2 - \bar{c}$.
  - If no audit (probability $1 - p$) lender gets zero and the borrower the rest (i.e. nothing if she truly failed).

Optimal contract (1)

- Maximize the borrower's expected payoff $\pi_2 P_2$ (assuming she tells the truth), with constraint that the lender gets expected return r:

$$(1-\pi_2)\,p\,(-\bar{c}) + \pi_2\,[\kappa_2 - P_2] = r\,[x\,(\omega) - S]$$

- **Incentive compatibility constraint**: borrowers tells the truth in case of success (gets P_2). Lying means she gets κ_2 if not audited and zero if audited.

$$P_2 = (1-p)\,\kappa_2$$

- With lender's expected return constraint, the objective is negatively affected by the probability of costly audit:

$$\pi_2 P_2 = \kappa - r\,[x\,(\omega) - S] - (1-\pi_2)\,p\bar{c}$$

Optimal contract (2)

- Probability of audit computed from the borrower's expected payoff and the incentive compatibility constraint:

$$p = \frac{r\left(x\left(\omega\right) - S\right)}{\pi_2 \kappa_2 - \left(1 - \pi_2\right)\bar{c}}$$

- **Audit more likely** when:
  - **Large loan** $x\left(\omega\right) - S$: borrower has little own funds (low S) or is not efficient (ω is high).
  - **Limited extra payoff** in case of success (κ_2 is small), cost of being caught lying is low.
- High probability of audit is bad news: more resources are used in auditing cost, instead of being consumed or invested.

Inclusion in a macroeconomic model

- **Investment** linked to **net worth of entrepreneurs**.
  - Shocks to entrepreneurs' wealth affect investment, persistent effect.
- Production of the consumption good with labor, capital and **productivity** θ:

$$y_t = \theta_t f(k_t)$$

  - Random θ_t, **no persistence**: θ_t tells nothing about $E_t \theta_{t+1}$
- Overlapping generations (2 periods). Young people work in production of the consumption good.
- A fraction $1 - \eta$ are risk neutral lenders: consume in both periods, can store goods with a return r (lend only at expected return r).
- η agents are **entrepreneurs**.
  - Save all their wage income: $S_t = w_t L$. Lend it at r or invest in a project that produces capital, return κ_2 or 0 as before.
  - Cost of running the project, $x(\omega)$, as before.
  - q: **price of capital** in terms of consumption good.

Efficient allocation

- Efficient benchmark with no information problems.
- Only efficient entrepreneurs ($\omega < \omega^*$) undertake their project. Marginal entrepreneur is indifferent between the project or lending:

$$rx\left(\omega^*\right) = \pi_2 \kappa_2 E_t q_{t+1} = \kappa E_t q_{t+1}$$

- **Investment** is equal to the number of projects: $i_t = \omega^* \eta$.
- **Capital accumulation** reflects investment and expected return:

$$k_{t+1} = \kappa \omega^* \eta \Rightarrow \omega^* = \frac{k_{t+1}}{\kappa \eta}$$

Capital supply and demand

- **Capital supply** reflects the marginal entrepreneur. Higher expected price of capital makes projects worth undertaking :

$$\kappa E_t q_{t+1} = rx\left(\omega^*\right) = rx\left(\frac{k_{t+1}}{\kappa\eta}\right)$$

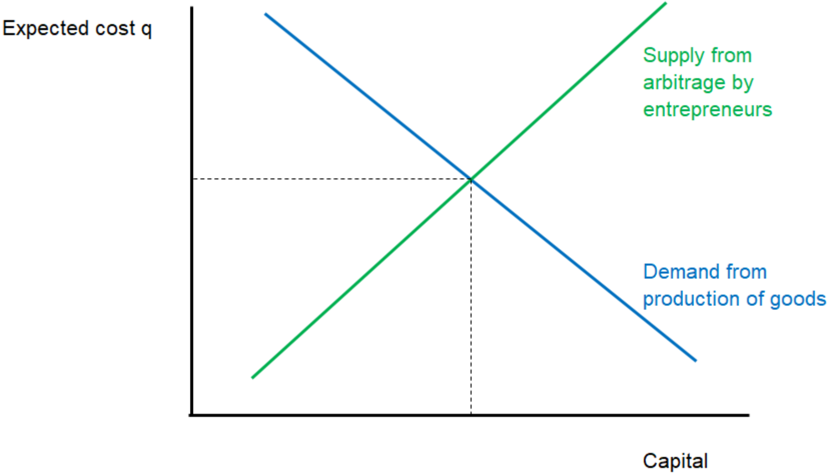
- **Capital demand** from optimization in the production of the consumption good. Marginal return = cost:

$$E_t q_{t+1} = f'\left(k_{t+1}\right) E_t \theta_{t+1}$$

- Productivity **shocks have no effects**: $E_t \theta_{t+1}$ is not affected by θ_t.

First-best capital market

- Neither supply or demand are shifted by θ_t.

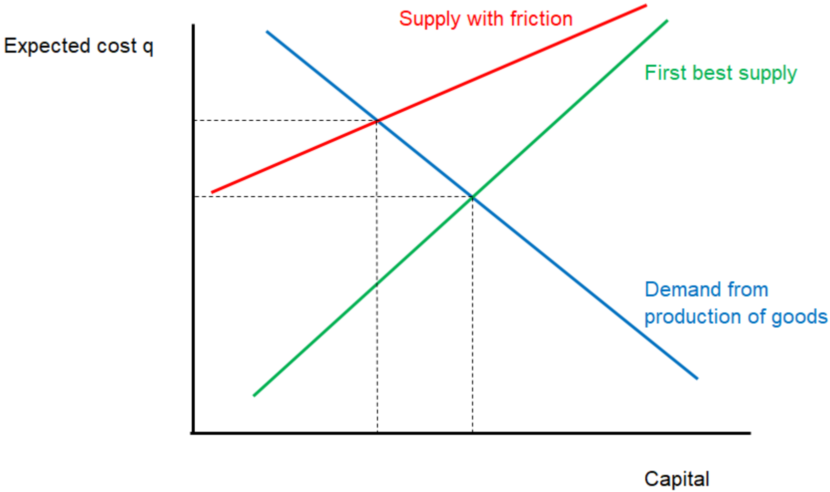


Equilibrium with financial friction

- Lender can only see the return of the project at an **auditing** cost $\bar{c}$ units of capital.
- Entrepreneur announces the result. If she claims failure, audit with probability $p(\omega)$. Lender gets expected return r, and the entrepreneur tells the truth.
- Higher probability of monitoring when **net worth S is low**.
  - Entrepreneur with little equity pays a lot to the lender in case of success, and gets nothing in case of failure.
  - **Strong incentive to lie** and claim failure, offset by a high probability of monitoring.
- Capital supply below $k_{t+1} = \kappa\omega^*\eta$, as auditing is costly.
  - Auditing **consumes capital**, reduces capital accumulation.
  - Marginal entrepreneur in frictionless allocation does not find it profitable to undertake her project.
- At given expected price of capital, the **supply of capital is limited**. Capital demand is not affected.

Capital market with friction

- Supply lies about the frictionless supply (higher cost of a given amount of capital).

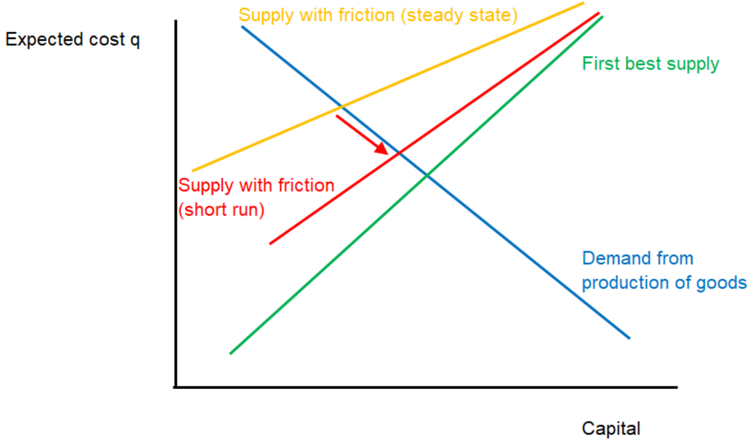


Impact of a productivity shock

- One-period **increase in productivity** θ_t (without frictions, no effect on investment).
- Higher wages in period t, entrepreneurs are **wealthier**.
- Higher net worth leads to **less costly auditing**.
  - Capital supply moves closer to the frictionless supply.
  - **Higher capital** k_{t+1} goes up.
- Higher capital k_{t+1} **boosts wages** in period $t+1$, second round.
  - Entrepreneurs young at time $t+1$ are wealthier than in the steady-state (but not as much as entrepreneurs young at time t).
- Less need for auditing than in the steady state (but more than in period t).
  - Capital supply moves back only partially.
  - Capital k_{t+2} higher than in the steady state (but smaller than k_{t+1}).
- Gradual return to the steady state: temporary shocks have **persistent effects**. Net worth of entrepreneur is a **new state variable**.

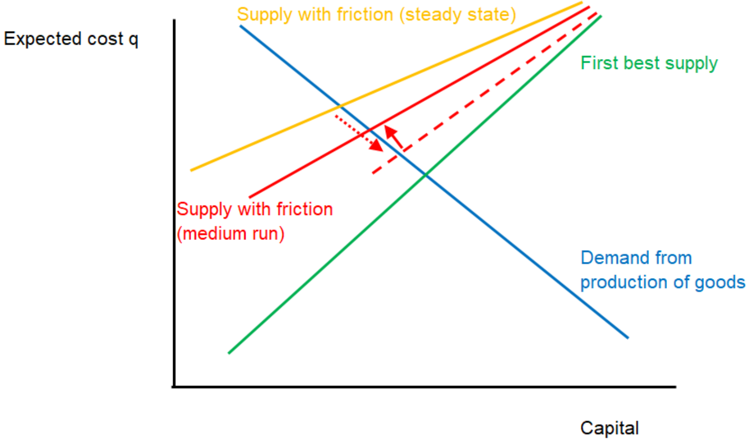
Initial effect of higher productivity

- Shifts supply towards the frictionless line
- Higher productivity raises wages, and make borrowers more creditworthy going into period $t+1$.



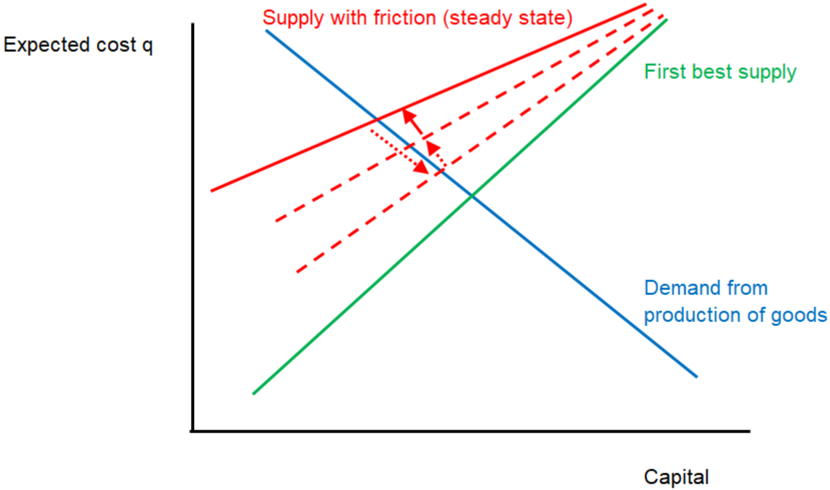
Second round effect of productivity

- Productivity back to normal, but higher capital raises wages. Supply partially moves back.
- Wages higher than in steady state (but lower than at period t), borrowers still quite creditworthy going into period $t+2$.



Gradual convergence

- Higher capital (than in steady state) raises wages, supports future lending. Gradually fades away.



BANK PANICS

Vulnerability of financial intermediaries

- Banks have a fundamental vulnerability because of **maturity transformation**: pool short-term deposits to fund long term projects.
- **Tension** between long term commitment to fund profitable projects and liquidity need of some depositors to use their savings in the short run.
- Maturity mismatch can lead to **self-fulfilling** panics.
- Diamond-Dybvig model, with three periods.
  - Period 0: unit mass of agents, each with one unit of endowment (good). Invest in cash or in a long term project.
  - Period 1: a share t of agents want to consume (**liquidity** need). Long term project can be liquidated, with one unit of investment giving one unit back.
  - Period 2: the other $1 - t$ agents consume. Long term project gives $R > 1$ units back.

Utility and allocations

- Ex-ante agents do not know whether they will be **impatient** (consume in period 1, probability t) or **patient** (consume in period 2, probability $1 - t$).
- Utility of consumption ($s = 1$ if impatient, $s = 2$ if patient):

$$\frac{1}{1-\sigma} (c_s)^{1-\sigma}$$

- **Autarky** allocation: $c_1^{\text{autarky}} = 1$ if impatient, $c_2^{\text{autarky}} = R$ if patient.
- Liquidity risk is **idiosyncratic** and should be pooled.
- **Insurance** maximizes expected utility, subject to resource constraint.
  - Smooths consumption across states: $1 < c_1^* < c_2^* < R$. ▸ Computations
  - No agent wants to claim being patient if they are not (and conversely).

Insurance through bank deposits

- What if the insurance cannot tell who is patient and who isn't?
- Bank **deposits** are the solution.
  - Everyone puts their endowment in the bank at time 0, it invests in the long project.
  - Agents can go to the bank in period 1 and get c_1^*, no questions asked.
  - They can go to the bank in period 2 and get c_2^*.
- This satisfies the resource constraints.
- **No incentive to lie**: patient agent is better of waiting than getting c_1^* in period 1 to keep until period 2.

Panics

- **Safe equilibrium**: impatient agents withdraw c_1^* in period 1 and patient agents withdraw c_2^* in period 2.
- What if some patient agents thinks that $t' > t$ agents will withdraw c_1^* in period 1? Not enough investment left to pay c_2^* to the patient agents.
- Optimal strategy for the patient agent: withdraw in period 1 and secure at least c_1^*.
- **Panic equilibrium**: if enough patient agents withdraw in period 1.
  - More that t agents withdraw c_1^*.
  - The bank pays off c_1^* until it runs out of money (failure).
- Key assumption: **sequential service** constraint, the bank does not observe how many consumers withdraw in the first period before handing out payments in the first period.

Solution: deposit insurance

- Deposit **insurance**: government promises to pay c_2^* in period 2 (maybe using tax revenue).
- No need for patient investors to withdraw at period 1. The government never has to deliver (**off-equilibrium** threat).
    - Creation of central banks in the early 20th century in response to frequent bank panics.
    - Need to monitor the bank so it does not take excessive risk.
- In reality, panics occur in bad times when the investment went wrong. The model can be extended to reflect this.
- Maturity transformation outside depository banks before the financial crisis. No deposit insurance, leading to bank runs in short term lending markets.

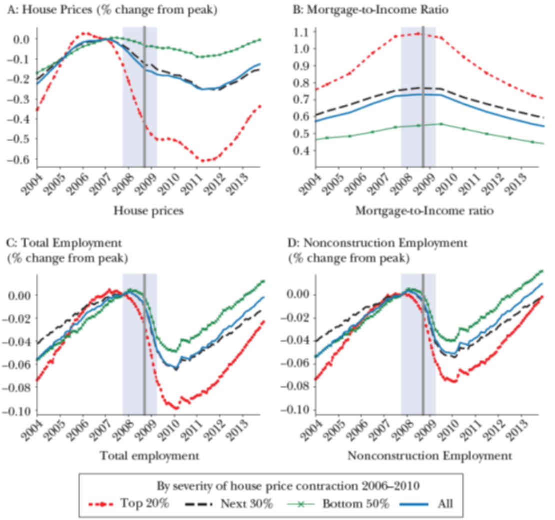
RECENT DEVELOPMENTS

Constraints on banks and households

- Crisis has shown that macroeconomics need to include financial frictions (Gertler-Gilchrist and Mian-Sufi, JEP 2018).
- Early financial accelerator models about borrowing constraints of firms. Focus has since broadened:
  - Financial **intermediaries** (banks) are themselves leveraged. Liabilities consist of deposits from households and equity.
  - Losses on assets can tighten the leverage constraint of banks.
  - **Households** are leveraged, especially in funding housing.
- Financial constraints to households matter. Tightening leads to a rapid contraction in consumption, which impacts GDP.
- Clear evidence of a deeper recession in regions where house prices fell more.

- Impact of borrowing constraints on households.

Figure 6
State-Level House Prices, Mortgage Debt, and Employment



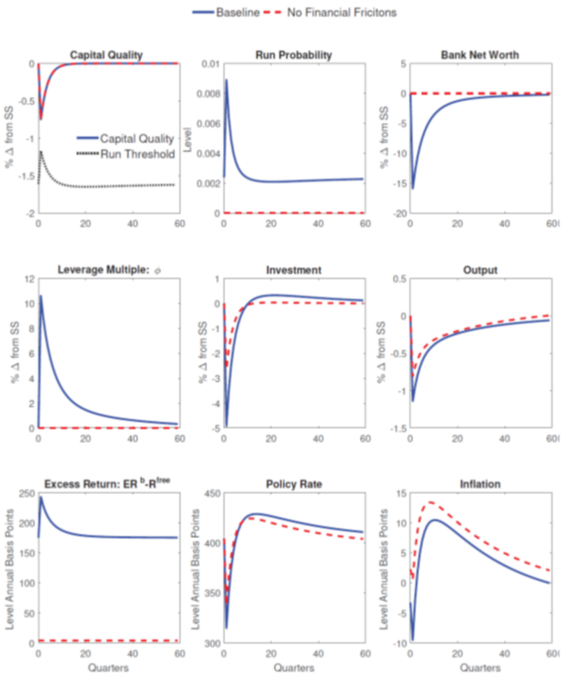
Gertler, Mark, and Simon Gilchrist (2018). “What Happened: Financial Factors in the Great Recession”, *Journal of Economic Perspectives* 32 (3), pp. 3-30.

Bank runs in macroeconomic model

- Inclusion of bank runs in a standard DSGE macro model (Gertler, Kiyotaki and Prestipino 2017).
- Capital can be held by banks or households (less efficient). In case of a run capital holdings are shifted to households.
- Small shocks do not lead to concerns about banks' solvency.
  - No incentive to run on deposits, moderate recessions (although larger than in the absence of frictions).
- **Large enough shocks** call the solvency into question.
  - Possibility of self-fulfilling runs leading to a sharp recession (the banks would be fine without a run).
- **Nonlinear dimension** as a given shock can have a much larger impact when banks are already fragile.

- Impact of shocks **without** a bank run.

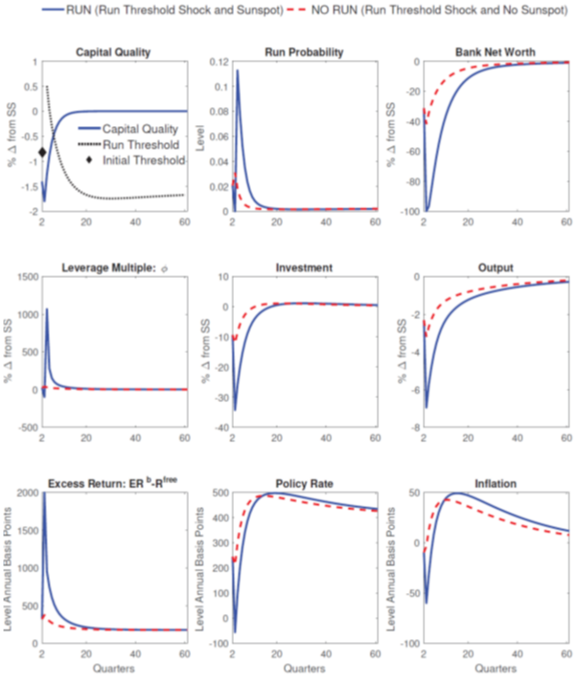
Fig. 1. Response to a Capital Quality Shock (1 std): No Run Case



Gertler, Mark, Nobuhiro Kiyotaki, and Andrea Prestipino (2017), "A Macroeconomic Model with Financial Panics", NBER working paper 24126.

- Impact of shocks **with** a bank run.

Fig. 2. Response to a Sequence of Shocks: Run VS No Run



Gertler, Mark, Nobuhiro Kiyotaki, and Andrea Prestipino (2017), "A Macroeconomic Model with Financial Panics", NBER working paper 24126.

EXTRA SLIDES : ADVERSE SELECTION

Simple model of adverse selection

- Loan of amount L and interest rate r_l (appendix also considers collateral).
- Borrower invests in a project with risky payoff R.
  - Low return, $R' - x$, or high return, $R' + x$, each with probability 50%.
  - x measures **risk**.
- Ex-post the borrow can:
  - Repay and keep $R - (1 + r_l) L$ (the lender gets $(1 + r_l) L$).
  - Default and get nothing (the lender gets R).
- Repaying is feasible if $R > (1 + r_l) L$.
- Assume that the borrower defaults when payoff is low (focus on **strategic default** under high payoff):

$$R' - x < (1 + r_l) L$$

Payoffs

- Borrower repays when the project succeeds (we'll make sure this is rational). Her **expected return** is:

$$E\pi^B(x) = \frac{1}{2}\left(R' + x - (1 + r_l)L\right)$$

- This is **increasing in risk** x (keep the gain of success, limit the loss of failure).
  - High interest rate $\rightarrow$ only borrowers with a high risk x are willing to borrow.
- Lender gets $(1 + r_l)L$ when the project works, $R' - x$ if it does not.
- Net **expected lender's payoff** (over the safe return r from bonds):

$$E\pi^L(x) = \frac{1}{2}(1 + r_l)L + \frac{1}{2}\left(R' - x\right) - (1 + r)L$$

- Inversely related to risk x.

Heterogeneous pool of borrowers

- **Two types** of borrowers (each is 1/2 of the population): safe with x_g and risky with $x_b > x_g$.
  - If the lender knows the type, charge a different interest rate.
- **Friction**: lender cannot see the type of each borrower, charges the same rate r_l to all.
- $r_l < r_l^*$: all borrowers apply. Expected lender's payoff:

$$E\pi_{b,g}^{L}(r_l) = \frac{1}{2}(1 + r_l)L + \frac{1}{2}\left(R' - \frac{x_g + x_b}{2}\right) - (1 + r)L$$

- $r_l > r_l^*$: safe borrowers drop out ($R' + x_g = (1 + r_l^*)L$), risky ones remain ($R' + x_b > (1 + r_l^*)L$). Expected lender's payoff:

$$E\pi_{b}^{L}(r_l) = \frac{1}{2}(1 + r_l)L + \frac{1}{2}(R' - x_b) - (1 + r)L$$

Discontinuity in lender's payoff

- How does the interest rate affect the lender's payoff?
- If r_l is **just below** r_l^*, the lender gets $E\pi_{b,g}^L(r_l^*)$. If r_l is **just above** r_l^*, she gets $E\pi_b^L(r_l^*)$.
- Discontinuity at r_l^*:

$$E\pi_b^L(r_l^*) - E\pi_{b,g}^L(r_l^*) = -\frac{x_b - x_g}{4} < 0$$

- Lender does not set the interest rate above r_l^*.
- **Rationing** if demand exceeds supply at r_l^*: borrowers get less than L, or only some get L and the others nothing. Return

EXTRA SLIDES : MORAL HAZARD

Simple model of moral hazard

- A borrower can invest in a **safe project** A and a **risky project** B, akin to gambling. Project j $(= A, B)$ succeeds and gives R^j with probability p^j, otherwise it gives nothing.
  - Project B pays off more in case of success ($R^b > R^a$).
  - Success is less likely with project B ($p^a > p^b$).
  - The expected payoff of project A is higher, $p^a R^a > p^b R^b$, so project A is better ex-ante.
- The borrower takes a loan L with interest r_l.
  - If the project is successful, he repays the loan with interest.
  - If not he defaults and the lender gets nothing (appendix also considers collateral).

Expected payoffs

- Expected payoffs of the lender and the borrower for project j are:

$$E\pi^j_{Lend} = p^j (1 + r_l) L \quad ; \quad E\pi^j_{Bor} = p^j \left(R^j - (1 + r_l) L\right)$$

- The **lender** clearly prefers that project A be done, but **cannot monitor** that the borrower does it.
- The **borrowers** undertakes project A if:

$$\frac{p^a R^a - p^b R^b}{p^a - p^b} > (1 + r_l) L$$

- A high interest rate makes risk-taking more likely.
- The lender is thus not willing to push the interest rate too high.

Return

EXTRA SLIDES : BANK PANIC

Utility under autarky

- **Ex-post** utility of consumption under autarky:

$$\frac{1}{1-\sigma}(c_1)^{1-\sigma}\text{if impatient, probability } t$$
$$\frac{1}{1-\sigma}(c_2)^{1-\sigma}\text{if patient, probability } 1-t$$

- **Expected** utility of agent in autarky (consume 1 today if impatient, R tomorrow if patient):

$$U^{\text{autarky}} = t\frac{1}{1-\sigma}(1)^{1-\sigma} + (1-t)\frac{1}{1-\sigma}(R)^{1-\sigma}$$

Optimal insurance

- Insurance sets the consumptions to maximize:

$$U^{\text{insurance}} = t\frac{1}{1-\sigma}\left(c_1^*\right)^{1-\sigma} + (1-t)\frac{1}{1-\sigma}\left(c_2^*\right)^{1-\sigma}$$

- Budget constraints:

$$tc_1^* + s = 1 \qquad ; \qquad sR = (1-t)\,c_2^*$$

- Optimal allocation is (assume $\sigma > 1$):

$$\begin{aligned} c_1^* &= \frac{1}{1-(1-t)\left[1-(R)^{\frac{1-\sigma}{\sigma}}\right]} > 1 \\ c_2^* &= R\frac{1}{1+t\left[(R)^{\frac{\sigma-1}{\sigma}}-1\right]} < R \end{aligned}$$

- Insurance reduces the differential between patient and impatient agents. Patient agents get more: $c_2^* > c_1^*$ (this can be proved).

Return