Economics of Banking
Lecture 15

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Another extension of the DD model

Source of uncertainty: *Random timing* of investment

Projects finish at 1 with probability θ and at 2 with probability $1 - \theta$.

Type of investment revealed at $t = \frac{1}{2}$.

Entrepreneurs get R, banks only γR.

Contracts in the model

Banks demand repayment γR at $t = 1$.

At $t = \frac{1}{2}$ projects may be *restructured* to give l_1 at 1, l_2 at 2, $l_1 + l_2 < 1 < \gamma R$.

Banks are funded by depositors, who may run the bank (at date $\frac{1}{2}$ or later).

There is an *interbank loan market* at date 1 – banks and entrepreneurs may lend money to banks at rate r.

Bank choices

At $t = 1$, bank maximizes

$$\theta\gamma R + \mu(1-\theta)\left(l_1 + \frac{l_2}{r}\right) + (1-\mu)(1-\theta)\frac{\gamma R}{r}$$

wrt. $\mu \in [0, 1]$, fraction of late projects to be restructured.

By linearity optimal μ is either 0 (no restructuring) or 1 (all late projects restructured).

A **bank run** may occur:

Number of late projects in some bank very large

$\rightarrow$ interbank market reacts with high repayment rates

$\rightarrow$ banks otherwise solvent will be subject to runs.

Conditions for bank run

Entrepreneurs use outcome $(1-\gamma)R$ from the early projects

If $r \geq 1$ entrepreneurs are lenders, and if

$$I_1 + \frac{I_2}{r} < \frac{\gamma R}{r},$$

banks will be borrowers.

Bank insolvent due to many late projects is subject to a run

Therefore projects must to be restructured at $t = \frac{1}{2}$

Entrepreneurs of early projects financed lose profits
$\rightarrow$ Reduction in supply of funds
$\rightarrow$ This changes the solvency position of other banks. So bank runs are *contagious.*

Shadow banks in a dynamic framework

Impatient depositors in a shadow bank are repo traders not willing to renew the contract. What can the bank do?

Economy over an infinitely many time periods $\dots, t-1, t, t+1, \dots$

At each t, investors enter with 1 unit of money.

They live in three periods: at $t+1$ a fraction π and want the investment back.

The technology transforms input I_t at date t to output at date $t+2$ is RI_t for $I_t \leq \bar{I}$.

Repo trade

At t the bank sells securities b_t from the young investors at date t,

Promises to buy them back for $r_{1,t}$ at $t+1$ and $r_{2,t}$ at $t+2$.

Cash flow at date τ will be

$$\Pi_\tau = RI_{\tau-2} + b_\tau - \pi r_{1,\tau-1} b_{\tau-1} - (1-\alpha) r_{2,\tau-2} b_{\tau-2} - I_\tau .$$

We look at at *steady state* equilibrium (so that $(r_{1,t}, r_{2,t}) = (r_1, r_2)$):

Then repurchase rates satisfy

$$r_2 = r_1^2 .$$

Equilibrium

Find the variables r, I and b:

If $r > 0$ then $b = 1$, and if $\Pi > 0$ then $I = \bar{I}$.

Discounted profits are

$$\beta^2(R - (1-\pi)r^2) - \beta\pi r.$$

It can be shown that $r = \dfrac{1}{\beta}$.

Using this equilibrium rate, we find the profits of the bank as

$$\Pi = (R-1)\bar{I} + 1 - \pi r - (1-\pi)r^2 = (R-1)\bar{I} + 1 - \frac{\pi}{\beta} - \frac{1-\pi}{\beta^2},$$

If β is close to 1, then profits are positive.

Repo run

Suppose that t, the fraction $1 - \pi$ of patient investors from $t - 1$ want their money.

Then there are several possibilities:

(1) Current profits are large enough:

$$(R - 1)\bar{I} \geq r + (1 - \pi)r^2.$$

No run will occur.

Using new funding

(2) If new repo trades can be initiated, then the bank may meet the demand by reducing investment:

If $\bar{I}$ is reduced by $\frac{\Pi}{R}$, then profits in $t+2$ are

$$R\left(\bar{I}-\frac{\Pi}{R}\right)-\bar{I}+1-\pi r-(1-\pi)r^2=0,$$

and the bank is back at the steady state after two rounds.

By the same argument, investment at t can be reduced even more, namely to the extent that it needs $\frac{\Pi}{R}$ at $t+2$,

Further reduction

Repeating the argument, date t can be reduced by

$$\frac{1}{R}\Pi + \frac{1}{R^2}\Pi + \cdots = \frac{R}{R-1}\Pi$$

with return to the steady state path.

(3) Also profits at $t+1$ and $(1-\pi)r^2$ can be used at $t+2$, so date t investment can be reduced also with this amount.

Consequently, the run can be prevented if

$$(1-\pi)r \leq \frac{R+1}{R-1}\Pi + \frac{1}{R}(1-\pi)r^2.$$

Otherwise, the bank must close down.

Pricing deposit insurance

(1) The simplistic approach

Fair premium: If the risk of losing the deposits is p, then premium should be pD.

(2) The structural approach (Merton):

Deposit insurance is a *put option* on the assets:

The bank has obtained an *option* to sell its assets at date T at strike price $De^{r_D T}$.

Using option pricing

If the assets follow a geometric Brownian motion,

$$\frac{d\tilde{L}}{\tilde{L}} = \mu\, dt + \sigma\, dZ,$$

then by Black-Scholes the value of the deposit insurance is

$$P^* = De^{(r_D - r)T} N(d_2) - LN(d_1)$$

with

$$d_1 = \frac{\ln\left(\frac{De^{(r_D-r)T}}{L}\right) - \frac{1}{2}\sigma^2 T}{\sigma\sqrt{T}}, \;\; d_2 = d_1 + \sigma\sqrt{T},$$

Ratio of premium and deposit (potential loss) depends loans-deposits ratio and asset volatility.

Moral hazard

A simple example:

Bank has equity E_0, receives deposits D, and contract loans L_0, pays premium P.

Next period, loans are $\widetilde{L}$ and value of the bank is

$$\widetilde{E} = \widetilde{L} - D + \max\{0, D - \widetilde{L}\},$$

Inserting $D + E_0 = L_0 + P$ we get that profit is

$$\widetilde{\Pi} = \widetilde{E} - E_0 = (\widetilde{L} - L_0) + [\max\{0, D - \widetilde{L}\} - P].$$

How to maximize profits

Assume that

$$\widetilde{L} = \begin{cases} A & \text{with probability } p \\ 0 & \text{otherwise.} \end{cases}$$

Then

$$\mathrm{E}\,\widetilde{\Pi} = \mathrm{E}\left[\widetilde{E} - E_0\right] = (pA - L_0) + [(1-p)D - P]. \tag{1}$$

Suppose that bank chooses engagements from loans (p, A) all with the same expected payoff.

Then p is chosen as small as possible!

Is fair pricing possible?

Let $D(p)$ be optimal deposits given the investment choices of the bank.

A pricing rule $P(D)$ is fair if

$$P(D(p)) = (1-p)D(p)$$

for all p. Differentiating both sides we get

$$P'(D(p))D'(p) = (1-p)D'(p) - D(p). \tag{2}$$

Since $D(p)$ is the level of D which maximizes profits $(pA - L_0) + (1-p)D(p) - P(D(p))$, we have

$$(1-p) - P'(D(p)) = 0.$$

Multiply by $D'(p)$ and insert (2) to get

$$D(p) = 0$$

for all p, a contradiction.