Liquidity and Crises in Financial Markets

Leverage and Funding Risk I

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What is Funding Risk?

Financial Intermediation relies on short-term debt to fund projects with long-term debt.

Traditionally, banks have carried out this process which is often called maturity transformation.

New Trends:

- disintermediation and funding through securitization
- funding of trading positions (rehypothecation)
- repo funding

Markets have taken on somewhat the role of intermediation.

Definition:

Funding risk is the risk of being able to keep on financing a certain financial position or investment.

Background

In the banking literature, funding risk is usually referred to as the risk of bank runs.

There are two possible reasons for runs:

- the bank is illiquid, as its short-term liabilities exceed its liquid assets
- the bank is insolvent, when its future liabilities exceed its assets

Difficult to determine why a bank is actually run.

We will work out a clear distinction between “insolvency risk” and “illiquidity risk” and how these two components of “credit risk” are related.

In order to do so, we need to avoid issues related to multiple equilibria a la Diamond and Dybvig.

The issue is that any financial institution that relies on funding is unstable:

- if everyone thinks the bank will fail, everyone will run to get their funding back
- hence: the bank will fail, even if there are no fundamental shocks
- illiquidity risk is infinite or zero

To avoid this issue, we will rely on a “global games” approach that will yield uniqueness.

Morris and Shin (2010)

Three dates:

- $t = 0$ initial balance sheet choice/regulation – exogenous
- $t = 1$ renewal of short-term funding
- $t = 2$ return realized

Uncertainty about future returns

- at $t = 0$: $\theta_1 = \theta_0 + \sigma_1 \epsilon_1$
- at $t = 1$: $\theta_2 = \theta_1 + \sigma_2 \epsilon_2$
- ϵ_t is uniform with support $[-\frac{1}{2}, \frac{1}{2}]$

Assume that $\rho = \frac{\sigma_2}{\sigma_1} < 1$.

Balance Sheet

Consider $t = 2$:

Assets	Liabilities
Cash M	Short Debt S_2
Investments $\theta_2 Y$	Long Debt L_2
	Equity E_2

Bank is solvent whenever

$$M + \theta_2 Y - S_2 - L_2 = E_2 \geq 0$$

or

$$\theta_2 \geq \theta^{**} = \frac{S_2 + L_2 - M}{Y}$$

Refinancing Problem

Need to rollover short-term debt at $t = 1$.

If short-term debt holders not willing to reinvest, need to raise cash:

- liquidity buffer – M
- possibility for secured borrowing – $\psi Y << Y$

Idea: ψ is a haircut on using Y as collateral to raise funds.

Alternatively, we could assume that haircuts depend on aggregate state.

$$(\psi + \delta(\theta_1 - \theta_0))Y$$

Bank Run and Failure

There is a measure 1 of short-term debt holders.

Assume that each each short-term debt holder is owed S at $t = 1$.

Bank fails, if more than $\lambda = \frac{M+\psi Y}{S}$ people do not renew funding.

Problem:

Assume that the pay-off from not running is 0 if bank fails at $t = 1$.

There is always a Nash equilibrium where everyone runs to get (a chance for) pay-off S.

Assumption:

Everyone believes that the fraction of people running is uniformly distributed on $[0, 1]$.

We will (somewhat) rationalize this as the correct equilibrium belief later on.

Insolvency Risk at $t = 1$

What is the risk that the bank will fail if there has not been a run?

If $\theta_1 \leq \theta^{**} - 1/2\sigma_2$,

$$\mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1) = 1$$

If $\theta_1 \in [\theta^{**} - 1/2\sigma_2, \theta^{**} + 1/2\sigma_2]$,

$$\mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1) = \frac{1}{2} + \frac{\theta^{**} - \theta_1}{\sigma_2}$$

If $\theta_1 \geq \theta^{**} + 1/2\sigma_2$,

$$\mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1) = 0$$

Expected Pay-off for Short-Debt

Investors are promised S_2 given their initial investment S.

Suppose there is no run at $t = 1$. Expected return on rolling over is

$$\frac{S_2}{S}(1 - \mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1)) = r_S(1 - \mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1))$$

Belief:

With probability $(1 - \lambda)$ there will be a successful run.

Hence, the expected return from rolling over is

$$r_S(1 - \mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1))\lambda + (1 - \lambda) \cdot 0 = r_S(1 - \mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1))\lambda$$

Illiquidity Risk at $t = 1$

Investors have an outside option of earning r^*.

Hence: Run if and only if

$$r_S(1 - \mathcal{P}(\theta_2 \leq \theta^{**}|\theta_1))\lambda \leq r^*$$

or

$$\theta_1 \leq \theta^* = \theta^{**} + \sigma_2\left(\frac{\mu}{\lambda} - \frac{1}{2}\right)$$

where $\mu = r^*/r_S < \lambda$ by assumption.

What is the additional probability $\mathcal{P}^+(\theta_1)$ that the bank will fail due to a run?

If $\theta_1 \in [\theta^{**} - 1/2\sigma_2, \theta^*]$, the bank fails for sure so that

$$\mathcal{P}^+(\theta_1) = \frac{1}{2} - \frac{\theta^{**} - \theta_1}{\sigma_2}$$

Otherwise, $\mathcal{P}^+ = 0$, i.e., the bank would not fail or would anyway fail with or without a run.

Ex-ante Measures

Assume risk is not trivial for initial θ_0

$$\theta_0 \in [\theta^{**} - \frac{1}{2}\sigma_1 + \frac{1}{2}\sigma_2, \theta^{**} + \frac{1}{2}\sigma_1 - \frac{1}{2}\sigma_2]$$

Ex-ante Insolvency risk

$$\mathcal{N}(\theta_0) = \int \mathcal{P}(\theta_2 \leq \theta^{**} | \theta_1) dF(\theta_1) = \frac{1}{2} + \frac{\theta^{**} - \theta_0}{\sigma_1}$$

Ex-ante Illiquidity risk

$$\mathcal{L}(\theta_0) = \int \mathcal{P}^{+}(\theta_1) dF(\theta_1) = \frac{\rho}{2} \left(\frac{\mu}{\lambda}\right)^2$$

Implications for Regulatory Policy

We can perfectly separate illiquidity from insolvency issues.

<u>Remark:</u>

This is not true for general distributions of θ_1 unless we have an uninformative prior distribution.

Insolvency does neither depend on μ nor λ, only on the solvency point θ^{**}.

The reverse holds for illiquidity risk.

We will look at the impact of two things regulators talk about:

- liquidity ratio λ
- "haircuts" ψ

Liquidity Ratios

What's the effect of changing M?

Think about a switch from Y to M – asset swap.

1) Total change in insolvency risk:

$$-\frac{d\mathcal{N}}{dY} + \frac{d\mathcal{N}}{dM} = \frac{1}{\sigma_1 Y}\left(\frac{S_2 + L_2 - M}{Y} - 1\right) < 0$$

since equity needs to be positive, $(Y + M) - (S_2 + L_2) = E \geq 0$, where these are book values.

Increasing liquid assets reduces insolvency risk.

Higher equity means the effect is stronger.

2) Total change in illiquidity risk:

$$-\frac{d\mathcal{L}}{dY} + \frac{d\mathcal{L}}{dM} = -2\mathcal{L}(\theta_0)\left(\frac{1-\psi}{M+\psi Y}\right)$$

Effects are smaller the higher "firesale" (ψ low) pressures are.

Do these channels describe the rationale why financial institutions shift to cash holdings in crises times?

How do we use this for policy? Prescription for setting liquidity buffers to keep risk constant?

What is missing is a theory (and welfare analysis) of balance sheet choice.

A "Simple" Global Game

Goal: Rationalize the assumption of uniform beliefs.

Basic Idea:

- Investors get signals x_i about θ_1 with small imprecision.
- They have to figure out $E(\theta_1|x_i)$.
- Marginal guy: given signal x^* indifferent between run or not.
- What is his belief about how many other people have worse signals than him and, hence, will run?

We will look at some details.

Investor obtains signal about returns on the bank's investment according to

$$x_i = \theta_1 + \tau\eta_i$$

where η_i is uniform on $[-1, 1]$ with zero mean and τ is small.

Suppose the whole support of θ_1 is possible with signal realization x:

$$\begin{aligned} x - \tau &\geq \theta_0 - \frac{1}{2}\sigma_1 \\ x + \tau &\leq \theta_0 + \frac{1}{2}\sigma_1 \end{aligned}$$

Then, the density for θ conditional on x is uniform on $[x - \tau, x + \tau]$ and we have

$$E(\theta|x) = x$$

Suppose now, investor i has observed x_i.

What is his belief about other players having observed $x \geq x_i$?

Fix the true state θ_1. We have

$$\mathcal{P}(x \geq x_i | \theta_1) = \mathcal{P}\left(\eta_i \geq \frac{x_i - \theta_1}{\tau}\right) = 1 - F\left(\frac{x_i - \theta_1}{\tau}\right)$$

The fraction of people that observe at least x_i is less than $1 - \lambda$ when

$$\begin{aligned} 1 - F\left(\frac{\theta_1 - x_i}{\tau}\right) &\leq (1 - \lambda) \\ \theta_1 &\leq x_i - \tau F^{-1}(\lambda)(= \hat{\theta}) \end{aligned}$$

Given signal x_i, probability that the fraction of people observing x_i or better is less than $(1-\lambda)$:

$$\mathcal{P}(\theta_1 \leq \hat{\theta}|x_i) = \mathcal{P}\left(\eta_i \geq \frac{x_i - \hat{\theta}}{\tau}\right) = 1 - F\left(\frac{x_i - \hat{\theta}}{\tau}\right) = (1-\lambda)$$

The fraction of people observing a better signal than investor observing x_i is uniformly distributed.

Hence: the cut-off point for rolling over is given by $x^* \geq \theta^*$.

People with $x > x^*$ strictly prefer to roll over, people with $x < x^*$ strictly prefer not to roll over.

For $\tau \rightarrow 0$, we obtain our earlier analysis.

One can show that this equilibrium is indeed unique for all τ small for a framework close to one we have looked at.