Financial Stability Course
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Background

Concept of systemic risk (in finance) was put forward by **bank regulators around 1995.**

They recognized that their prudential tools (capital and liquidity regulations) were aimed at avoiding **individual bank failures** but would not prevent a **banking crisis.**

Background(2)

Simple (regulatory) definition of systemic risk:

any risk that can damage the **financial system** as a whole:

- Aggregate shocks (related to notion of **systematic** risk)
- Propagation of individual shocks (**contagion**)

Different from definitions used in Physics and other fields.

Background (3)

Distinction between **micro-prudential** regulation (protecting depositors) and **macro-prudential** regulation (protecting the financial system).

Our objective : **policy advice** : why and how public authorities should act to prevent systemic risk

- Rochet Tirole “Interbank lending and systemic risk” JMCB 1996
- Most academics were not interested at the time because systemic episodes had never occurred (yet).

Point of view of the lectures

- **Economic analysis** of the sources of systemic risk:

  down to earth models with balance sheets and markets

  math are just there when needed (I can reassure you they are needed!) : game theory, contract theory

- Objective: **understand how public authorities can act to avoid systemic risk:**

  Emergency liquidity assistance by central banks,

  capital and liquidity regulation.

Outline of the lectures

- **Bank Runs and the Lender of Last Resort:**
  Understanding modern form of bank runs and what Central Banks can do to avoid them.
- **Capital Regulation and Credit Fluctuations:** the role of countercyclical capital ratios.
- **Why do banks use so much short term debt?** Important source of fragility for the financial system.

Lecture 1
BANK RUNS AND
THE LENDER OF LAST RESORT

Introduction

- A **bank run** occurs when a large number of depositors withdraw their money simultaneously, typically because they fear the bank might default.
- The **fractional reserve system** makes banks structurally unable to face a run without emergency liquidity assistance by the central bank, who acts as a **lender of last resort.**

Introduction (2)

- Elaborated in the 19th century, the doctrine of the LLR seemed to work well but was criticized for provoking moral hazard.
- **Extensively used during the Global Financial Crisis of 2007-2009**: Central Banks have been forced to support many banks that could not find liquidity on the market.
- This lecture first **summarizes the LLR doctrine** (both in theory and in practice) then proposes a **model of modern bank runs** and provides a **conceptual foundation for the LLR in the 21st century.**

First part: survey of the theory and the practice

1 The classical doctrine

Thornton (1802) Bagehot (1873)

a) lend only against good collateral **(Solvent banks)**

b) lend at a penalty rate **(Illiquid banks)**

c) announce readiness to lend without limits **(Credibility)**

After the panic that followed the Overend and Gurney failure (1866), LLR operations became standard practice, first in the UK (Barings crisis, 1890) then in continental Europe (see “A Dangerous Fortune” the novel by Ken Follett)

Bordo (1990) provides historical evidence of the use of LLR functions as a way to mitigate banking crises.

Timberlake (1984) shows that US private clearing houses played a LLR role during the national banking era (1857-1907), before the creation of the FED and the discount window (1913)

Calomiris (1999), among many others, questions the role of the IMF as an international LLR.

2- The Practice: Several Examples

- Bank of New York, November 21st, 1985
  Computer bug in the bank's T- Bills clearing system
  emergency loan of $ 22.6 billion by the FED:
  too much for a single bank, too fast for a consortium.

- **Closure of a large bank, followed by Emergency Liquidity Assistance(ELA) offered to other banks**: Herstatt bank, 1974 (German Bundesbank), Barings, 1995 (Bank Of England).

- Intervention to prevent market crashes
  - commercial paper run after Penn Central Bankruptcy in June 1970 (Calomiris 1994)
  - Russian bonds default and LTCM crisis in September-November 1998 (Edwards, 1999; Furfine 2000)

- **Violations of a):**
- Rescue of Yamaichi Securities, 1965 (Bank Of Japan)
- Secondary Banking crisis in 1973-75 (Bank Of England)
- Liquidity support to insolvent institutions during the subprime crisis (e.g. Northern Rock,…).
- Wider notion of "market maker of last resort".

- Difficulty to separate the **LLR policy** from **banking supervision** and closure policy.

- Several well known examples of **insolvent banks** that were **bailed out** , either for purely **political reasons:** Crédit Lyonnais (1992-96, France), or on **contagion grounds**: Continental Illinois (1984, USA), (Johnson-Matthey, 1984, UK).

3- Criticisms to the Classical Doctrine

- Goodhart (1985): Impossibility of clearly drawing a line between **illiquid** and **insolvent** banks.

- Solow (1982): Central Bank also responsible for **stability of the financial system**

  ⇒ sometimes rescue insolvent banks
  ⇒ moral hazard

- Kaufman (1991): Public intervention subject to political pressure and regulatory capture. Discount window = disguised means to bail out insolvent banks.

Goodfriend and King (1988)

Monetary Policy
(aggregate liquidity)

Banking Policy
(interventions on
individual banks)

Argue that with modern inter-bank markets, banking policy has become redundant.

"A solvent bank cannot be illiquid"

LLR could be replaced by private Lines-Of-Credit services (Goodfriend-Lacker, 1999)

Second part: LLR in the 21st century

1 Modeling bank runs

- Since Bryant and Diamond-Dybvig, banking theory has modeled the fragility of banks by a game played by depositors in which there always coexist **good** and **bad** equilibria (coordination problem) .

But there is no explanation of what triggers run (sunspots?).
Hard to derive policy recommendations.

- Alternative view of Gorton (1988): runs are driven by fundamentals. During the Free Banking Era in the US (1837-1862), regional bank runs were systematically associated with "real" events : bad crops, recessions,… not by sunspots

- **We propose here a different model**, where bank runs are related to fundamentals but sometimes result from coordination failures.

- We use the global games methodology (Morris and Shin,1998). Related paper by Goldstein and Pauzner (2003) also uses global games methodology to model runs by retail depositors.

- Important difference: we introduce some important features of modern interbank markets: **uninsured wholesale deposits, managed by professional managers.**

- Thus we model the modern form of bank runs (large investors stop renewing CDs) instead of the old form (small depositors run to the bank).

- More importantly we also model **banks' solvency and liquidity ratios** and discuss the harmonization between **prudential regulation** or crisis prevention(ex-ante), **LLR intervention** or crisis management (interim), and **bank resolution** (ex-post)

- Finally, we **bridge the gap** between the **"sun spot"** (BDD) and the **"fundamental"** (Gorton, 1988) approaches to banking crises: in our model, a bank becomes illiquid when enough investors are suspicious about its solvency.

- In our model, bank runs are sometimes **inefficient** (thus there is scope for LLR intervention) but **always based on fundamentals.**

2- THE MODEL: One bank, 3 dates $\tau = 0, 1, 2$

- $\tau = 0$ **(ex-ante)**

M	D_0
I	E

Balance sheet

D_0 (normalized to 1) = **uninsured wholesale deposits (CDs)**
repay D upon withdrawal (unless failure)
E = **equity capital** (+ long term debt)
M = **"money"** (cash reserves)
I = **investment in risky assets**
(loans) $\to$ random return R at $\tau = 2$ $R \sim N\left(\overline{R}, \frac{1}{\alpha}\right)$

Bank supervisor: decides to let the bank operate or not, given:

- E/I = **solvency ratio**
- $m = M/D$ = **liquidity ratio.**

- $\tau = 1$ **(interim)**

  Each investor *i* privately observes a signal $s_i = R + \varepsilon_i$

  unbiased , with precision β $\left(\varepsilon_i \sim N\left(0, \frac{1}{\beta}\right)\right.$ i.i.d.)

  NB: crucial assumption = large number of investors, who cannot coordinate.

  If they could pool their info $\Rightarrow$ perfect knowledge of *R*.

  Instead, we assume that they decide independently to "withdraw" ($\rightarrow$ face value D) or not.

If withdrawals exceed liquid reserves of the bank, it is forced to sell some of its risky assets at a discount (fire-sales premium).

More precisely, by selling y loans the bank gets $\frac{Ry}{1+\lambda}$,

.

where λ > 0 is the fire sales premium.

Note: market aggregates information efficiently (R revealed cf Atkeson critique) but resale capacity limited (λ > 0)

If too many withdrawals, bank may be closed at $t=1$.

$\tau = 2$ (if not closed at $\tau = 1$):

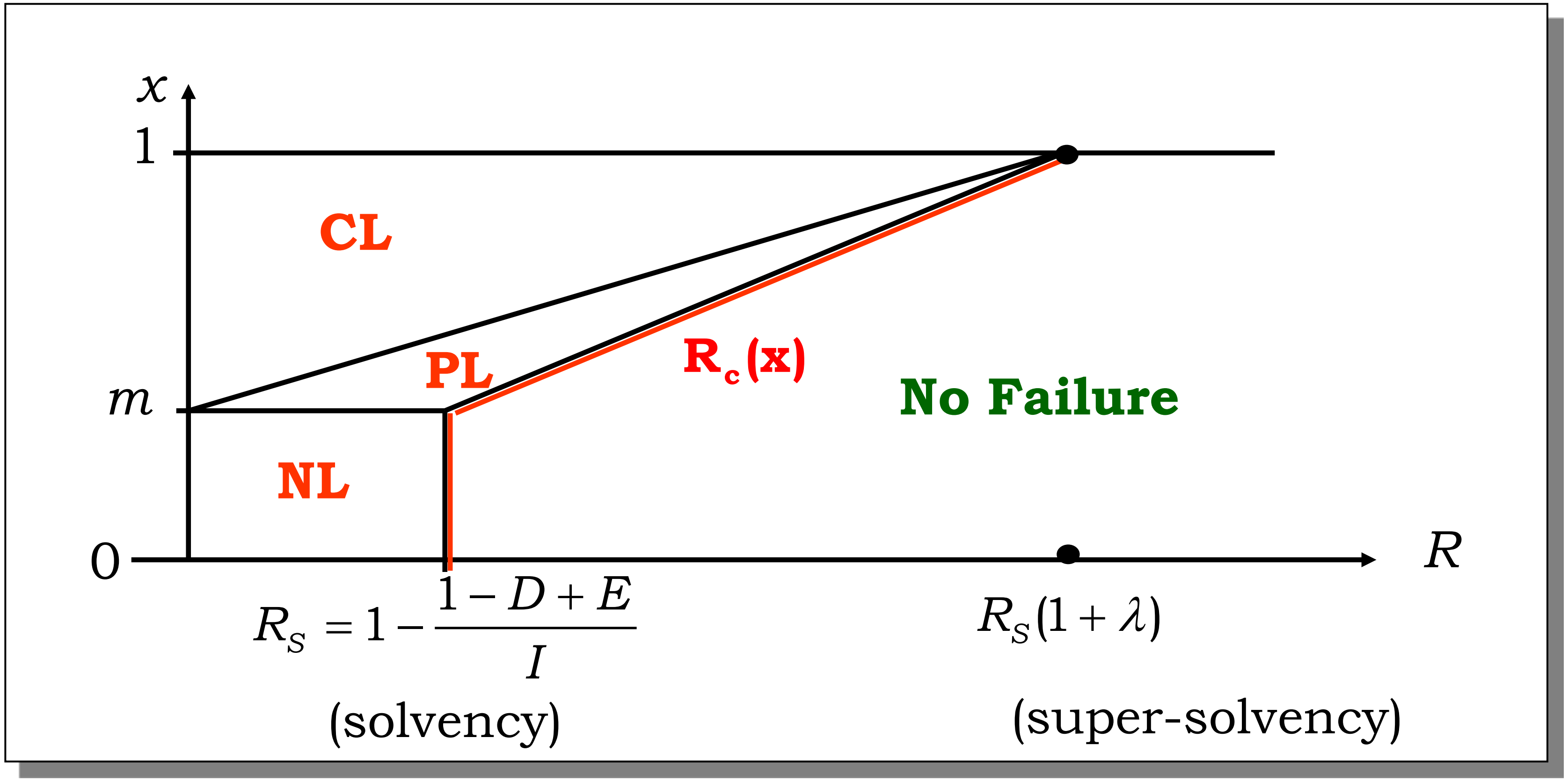
- Assets that have not been sold produce returns.
- Depositors who have not withdrawn are repaid.
- Shareholders get the rest (if any).

Note that liquidity problems at $\tau = 1$ can generate default at $\tau = 2$ (even if returns are above the solvency threshold) because of the fire sales premium.

The critical threshold below which the bank fails is

$$R_c(x) = R_S[1 + \frac{\lambda(x-m)_+}{1-m}]$$

⇒ Different regimes occur, as a function of R and x



Failure region

- **CL = Complete Liquidation (early closure)**
- **PL = Partial Liquidation**
- **NL = No liquidation**

***at* τ = 1**

3- DIFFERENCES WITH BRYANT-DIAMOND-DYBVIG:

- **Short horizon**: Time unit = day
  Motivation for demandable debt = disciplining bankers (?)
  (Calomiris -Kahn, 1991; Diamond 1994;...)
  No maturity transformation.

- **No physical liquidation (unless early closure)**
  ∃ **secondary market for bank loans** (or a repo market) .
  By selling y loans they get $\frac{yR}{1+\lambda}$, where $\lambda > 0$.
  Efficient aggregation of information, but limited resale capacity

λ : fire-sales premium

No direct inefficiency of inter-bank markets:
fire-sales premium only has redistributive effects,
unless there is early closure: proportional liquidation cost $(1-\mu)$
(Only source of inefficiency in our model)

Possible justifications for the fire-sales premium:

- **partial transferability of future returns** (Hart and Moore 1994)
- **adverse selection** (Flannery 1996)
- **temporary liquidity shortage on the interbank market** (Goodhart and Huang 1999a)

Superiority of LLR over market investors:

- **better means of recovering debts**
- **large investor: can eliminate adverse selection by pooling**
- **cool head, no cash constraint and long horizon**

4- BEHAVIOR OF INVESTORS:

• management of deposits delegated to fund managers who decide to withdraw if they anticipate a probability of failure larger than γ (GIVE MICROFOUNDATION)

• computation based on their signal s and on the anticipated behavior of other depositors:

withdraw iff their signal $s \leq$ threshold t

Notation:

proportion of (other) fund managers observing signal $\leq t$

$$x(\underset{-}{R}, \underset{+}{t}) = \text{Proba}(R + \varepsilon < t) = \Phi(\sqrt{\beta}(t - R))$$

$P(s,t)$ = **Probability of failure computed by fund manager** depends on private signal s and anticipated threshold t.

$$P(s,t) = \text{Proba}\left[R < R_c(x) \mid s\right] \quad \text{where } x = x(R,t)$$

Properties of $(s, t) \to P(s, t)$:

$$P(s,t) = \text{Proba}\left[R < R_C \left\{ \underset{+}{x}(\underset{-}{R}, \underset{+}{t}) \right\} \mid s \right]$$

- P is decreasing in s:

  The higher the private signal, the less likely the bank failure.

- P is increasing in t:

  The less confident the other investors, the higher the proportion of withdrawals, the more likely the bank failure (strategic complementarity).

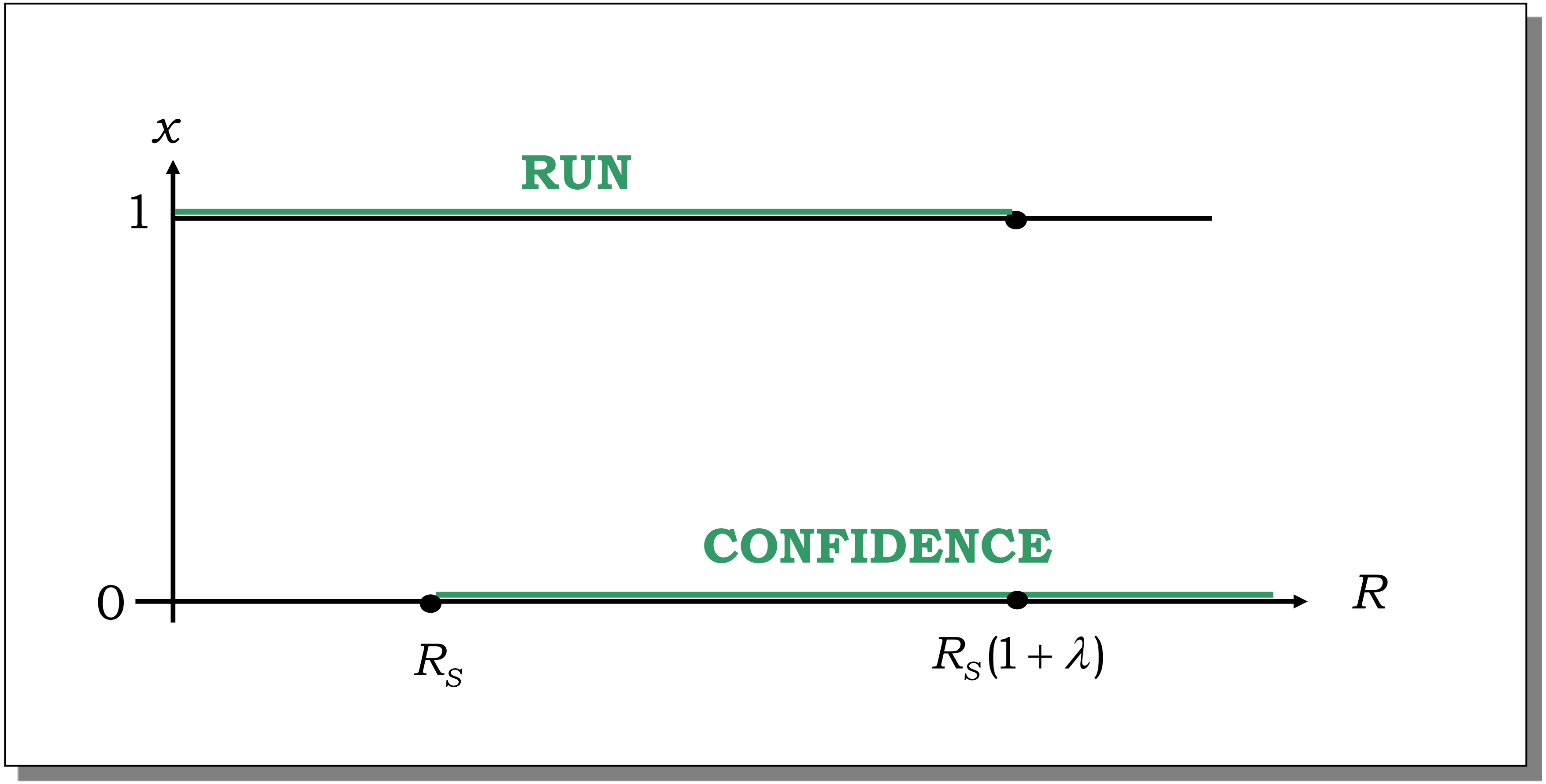
Perfect information benchmark

$\beta = \infty$ (infinite precision of private signals)

$s_i = R$ for all i

$$
P(s,t) = \begin{cases} 0 & \text{if } s > R_S(1+\lambda) \\ 1 & \text{if } s < R_S \\ \mathbb{1}_{s \le t} & \text{otherwise} \end{cases}
$$

$\Rightarrow$ 1 or 2 equilibria in pure strategies



NB: In Diamond- Dybvig there are always 2 equilibria

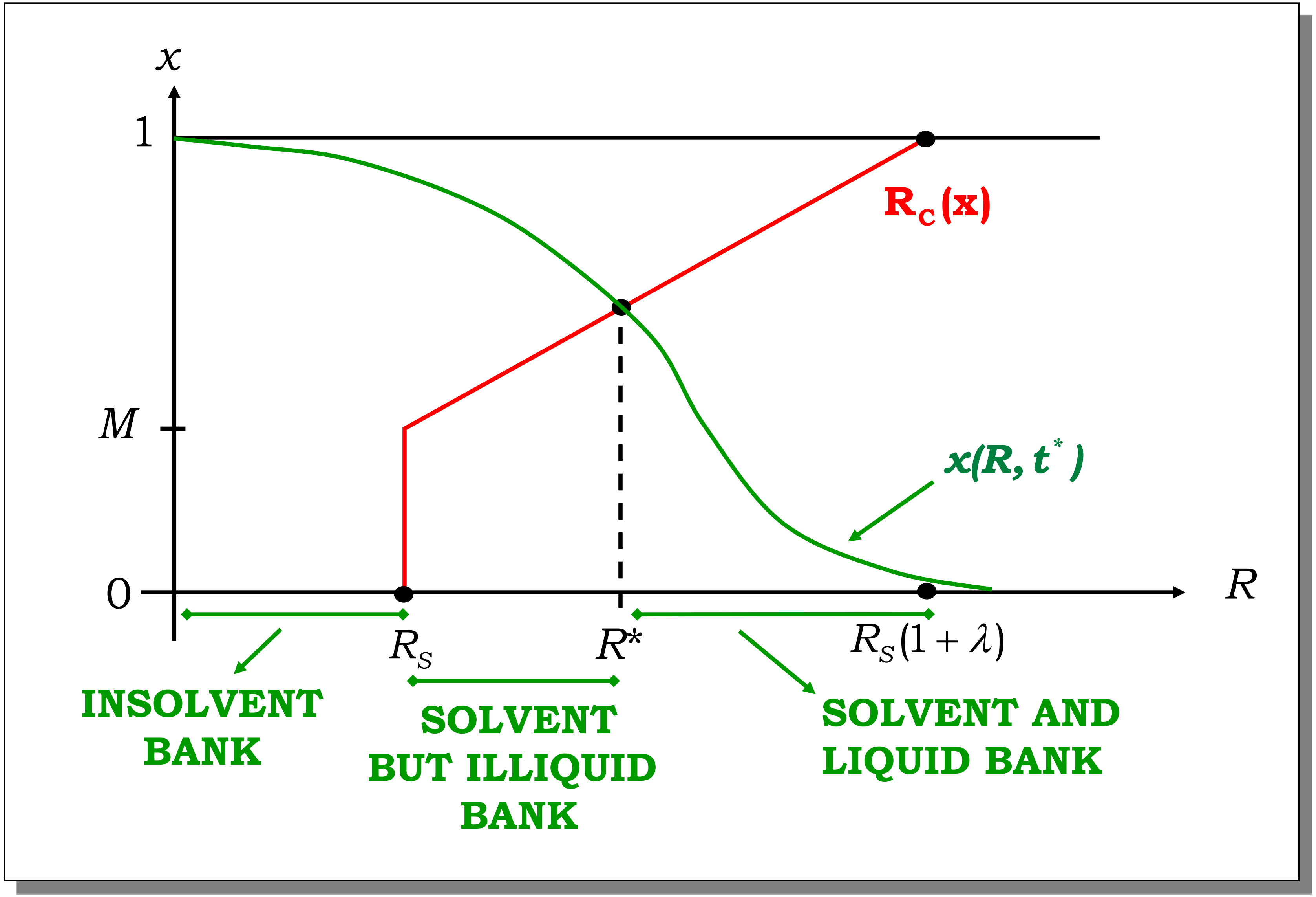
5- Equilibrium of the investors' game

PROPOSITION 1: When β (the precision of private signals) is large enough (but finite) there is a unique equilibrium:

- **investors withdraw iff their signal < threshold** t^*
- **the proportion of withdrawals decreases with *R***
- **the bank fails if and only if** $R < R^* = R_c(x(R^*, t^*))$

N.B. R^* is defined implicitly by

$$\sqrt{\alpha+\beta}\,\Phi^{-1}(\gamma) = \alpha(R^* - \overline{R}) - \sqrt{\beta}\,\Phi^{-1}\left(\frac{I}{\lambda D}(R^* - R_S) + m\right)$$



x
1
M
0
R
Rc(x)
x(R, t*)
R_S
R*
R_S(1 + λ)
INSOLVENT BANK
SOLVENT BUT ILLIQUID BANK
SOLVENT AND LIQUID BANK

Intuition of the proof of Proposition 1:

For a given threshold *t*, the best strategy of an investor is to withdraw iff

$$P(\underset{-}{s},\underset{+}{t}) \geq \gamma \qquad \Leftrightarrow \qquad s \leq s^*(t) \quad \text{(increasing)}$$

A Nash equilibrium is thus characterized by a threshold such that $t^* = s^*(t^*)$ or $P(t^*, t^*) = \gamma$

Now if β is large, investors give a lot of weight to their signal *s*

$$\Rightarrow \left|\frac{\partial P}{\partial s}\right| \text{ is large}$$

$\Rightarrow$ $t \to P(t,t)$ is decreasing

$\Rightarrow$ unique solution t^*

NB: One can prove that t^* is stable by iterative elimination of dominated strategies.

6- PROPERTIES OF THE EQUILIBRIUM:

PROPOSITION 2:

When the liquidity ratio of the bank m is larger than some value

$\overline{m}$ **we have that** $R^* = R_s$

This means that the **coordination failure disappears when the bank is sufficiently "liquid". (see SLIDE 24)**

We now focus on the case where m is less than $\overline{m}$

and thus $R^* > R_s$

This means that for R in the interval $[R_S, R^*)$

the bank is **solvent but illiquid** (there is a coordination failure)

The critical return R* is defined implicitly by

$$\sqrt{\alpha+\beta}\,\Phi^{-1}(\gamma)=\alpha(R^{*}-\overline{R})-\sqrt{\beta}\,\Phi^{-1}\left(\frac{I}{\lambda D}(R^{*}-R_{S})+m\right)$$

PROPOSITION 3: (COMPARATIVE STATICS)

R^{*} (and thus the probability of failure) decreases when:

- m **(liquidity ratio)** ↑
- R_S **(solvency ratio)** ↑
- $\overline{R}$ **(expected return on bank's assets)** ↑
- γ **(cost of withdrawals)** ↑
- λ **(cost of liquidity)** ↓

7- COORDINATION FAILURE AND LLR POLICY

Imposing sufficient liquidity can eliminate the coordination failure. However, this is limits seriously the bank's lending capacity (credit crunch).

If the Central Bank observes ***R*** perfectly (at $\tau = 1$) , **the coordination failure can also be eliminated by the following LLR policy**: whenever a solvent bank cannot find enough liquidity in the market, the CB offers to lend without limit at a rate r slightly above zero.

However this obliges the CB to lend as much as $\frac{\lambda}{\lambda - r} D(\overline{m} - m)$

Another possibility is to limit CB lending to the liquidity that the bank cannot find on the market

$$L(R) = \frac{\lambda D\{x(t^*, R) - m\}}{\lambda - r}$$

CONCLUSION:

•We have built **a simple model of banking crises** that takes into account the **main features of modern inter-bank markets**

•In this framework, we have been able to provide a **rationale for BAGEHOT ' s doctrine** of providing liquidity assistance to illiquid but solvent banks

•A LLR can indeed solve the **co-ordination problems** faced by inter-bank markets when an **individual bank is close to insolvency** (R small) or when there is a **temporary liquidity shortage** (λ large) on the inter-bank markets

However, **when the liability structure of banks is endogenized** by introducing moral hazard problems for bank managers, the intervention threshold of the LLR differs from the solvency threshold, leading to **two types of crisis resolution regimes :**

- a **prompt corrective action** regime where the LLR is to be prevented from intervening too often (commitment problem).

- a **regime of orderly resolution of failures** where on the contrary an outside source of funds has to be found to cover the expected costs of banks assistance.