Lecture 1: Banking, fragility, and crises

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Outline

- The role of banks
- Fragility and financial crises
- Is the current crisis similar or not to past crises?
- Theories of crises
- A framework of analysis
  - Applications
  - The bank run model

The role of banks

What do banks do?

- Provide transaction services/payment system
- Provide insurance and risk sharing (maturity transformation)
- Finance illiquid entrepreneurial projects

  (because of asymmetric information problems, like adverse selection and moral hazard, firms' projects need monitoring)

Uniqueness of banks

- Mix of features:
  - High (short term) leverage
  - Dispersed debtholders (less monitoring)
  - Opacity and long maturity of bank assets exacerbate moral hazard problem
- Consequences:
  - Fragility with high social cost of failure
  - Subject to *contagion* (via interbank commitments or indirect market-based balance sheet linkage) with *systemic* impact
- Banks have central position in economic system:
  - They are essential: when banks stop functioning a modern monetary economy stops

Versions of the story

- The demand deposit contract, redeemable at par, creates a coordination problem for investors that
  - has a good equilibrium which maturity transformation and liquidity insurance (Diamond and Dyvbig (1983)),
  - allows the banker not to extort rents on his abilities to collect illiquid loans (Diamond and Rajan (2001)), or
  - disciplines bank managers subject to a moral hazard problem (Calomiris and Kahn (1991), Gale and Vives (2002)).
- Because of asymmetric information firms may get no funding because they do not have enough pledgeable income (fraction of their return that can be committed to be paid to outsiders). Banks come to the rescue creating liquidity by holding collateral and commit to make payments (Holmstrom and Tirole (1997, 1998)).

Crises and fragility

- Liquidity provision leaves banks vulnerable to panics and crises (coordination failure of investors)
- Standard deposit contract and loan provision to opaque entrepreneurial projects are complementary:
  - Short-term debt provides incentives to bank managers subject to a moral hazard problem to monitor loans
- Competitive banking system may approximate second best efficiency but typically there is excessive liquidation/fragility

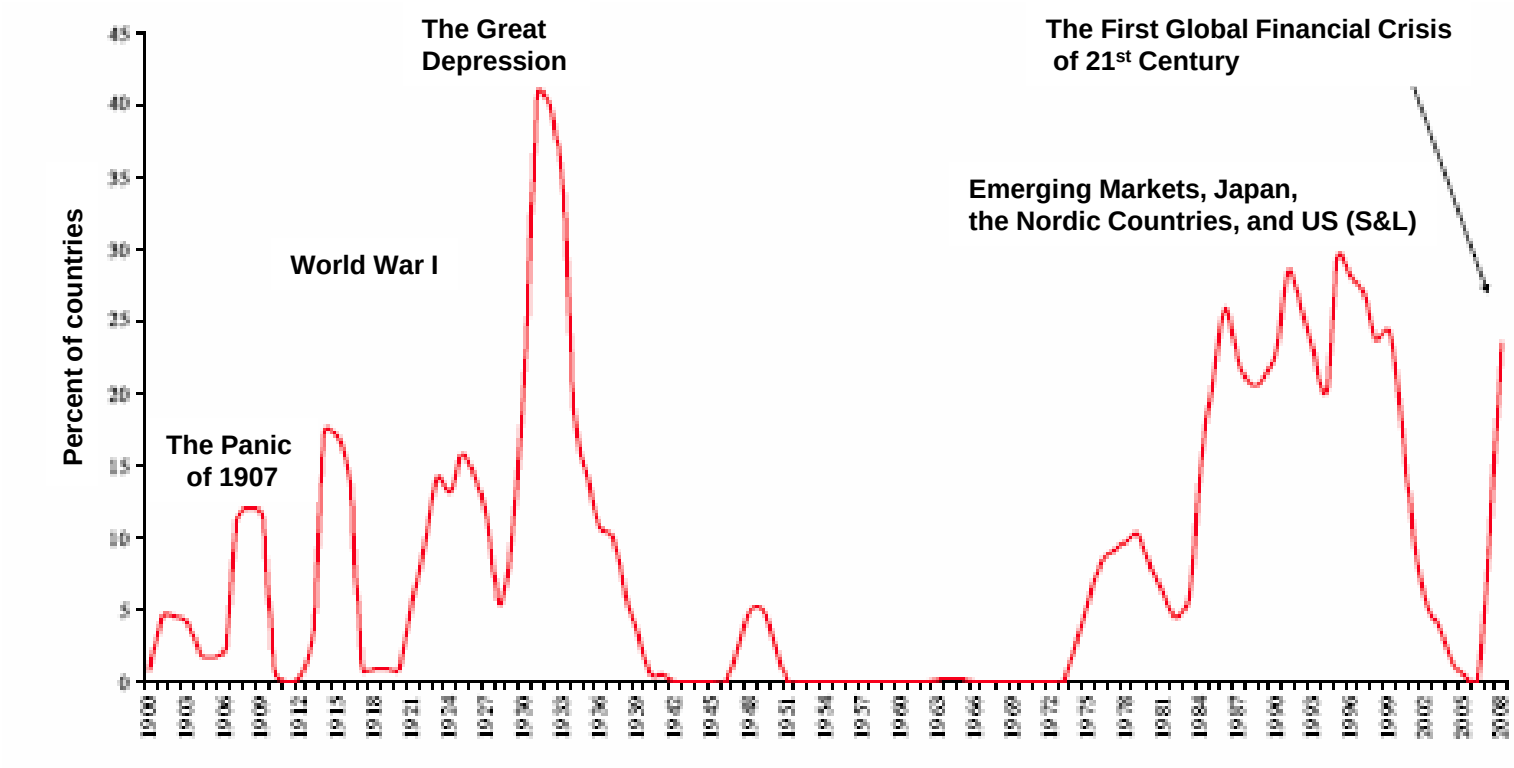
Fragility and financial crises

Financial crises

- 1907 Bankers' Panic
- 1929
- Spain (1977-1983)
- Savings and Loans crisis (1984-)
- 1990s Japan
- 1990s Nordic countries
  - Norway (1987-), Finland, Sweden (1991-),
- 1997-1998 Asian crisis
- 2007-2009

Proportion of countries with banking crises: 1900-2008

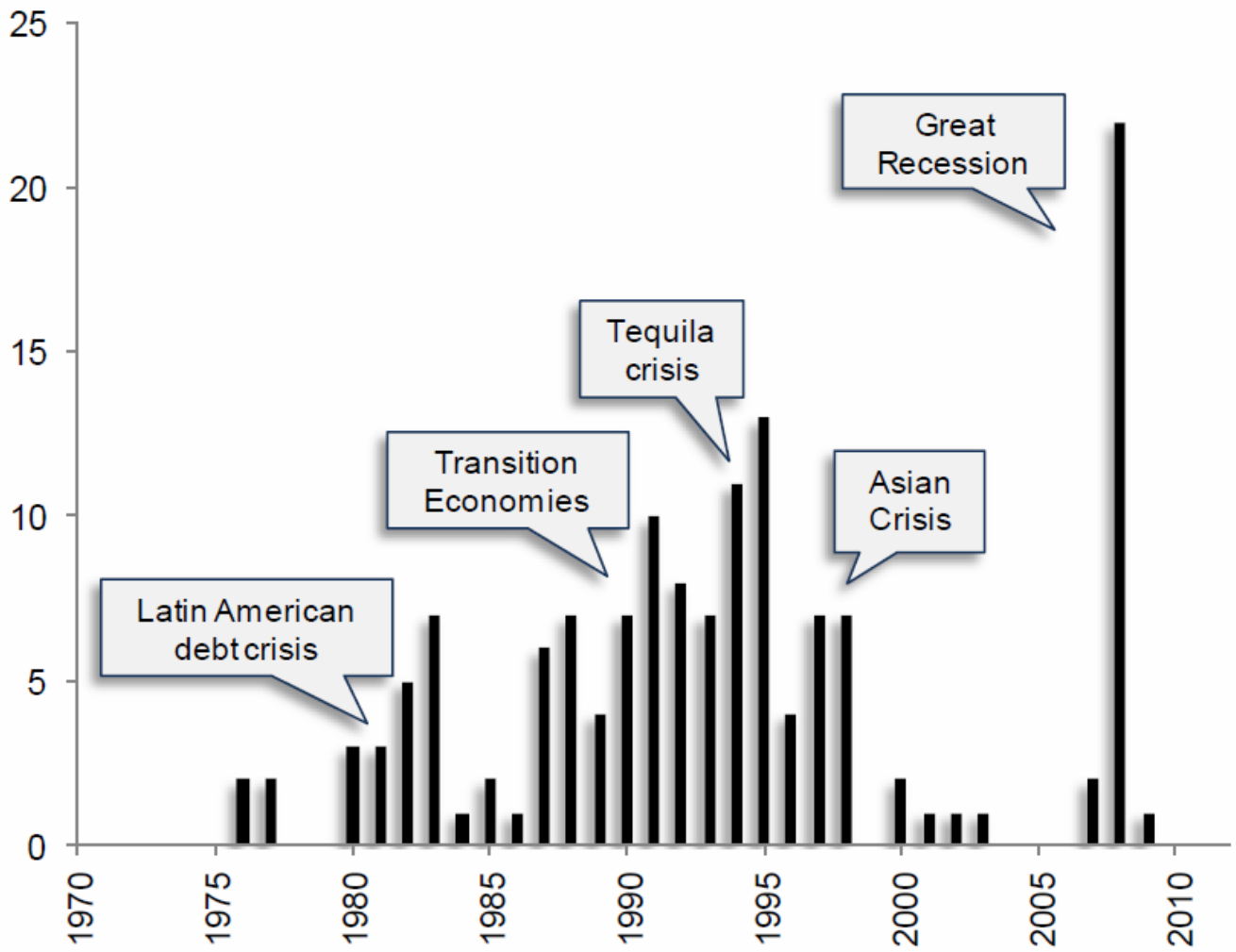
Weighted by their share of world income



Source: Figure 1 in Reinhart & Rogoff (2008), “Banking Crises, An Equal Opportunity Menace”, NBER WP 14587.

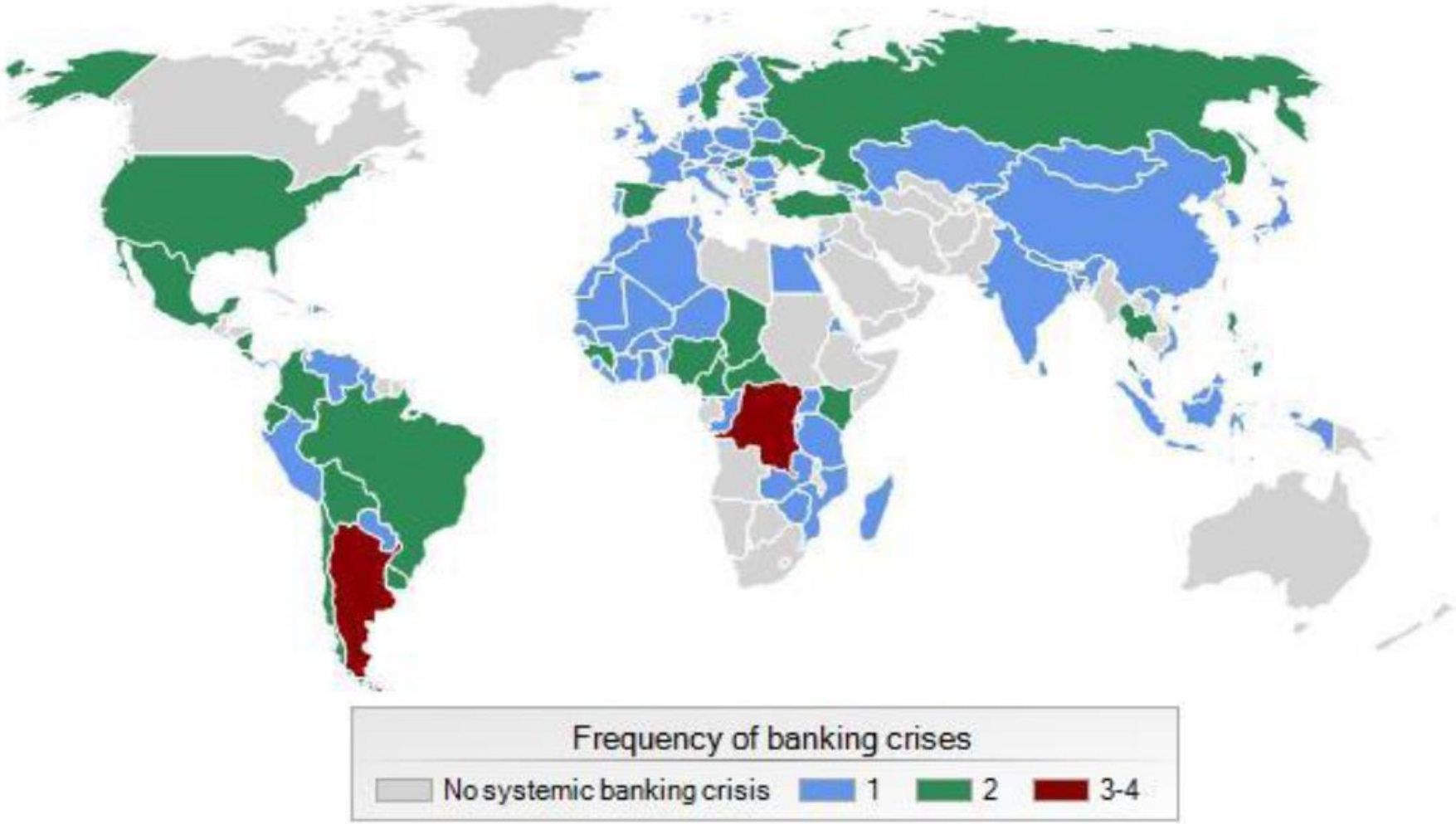
Banking crises cycles

Number of systemic banking crises starting in a given year



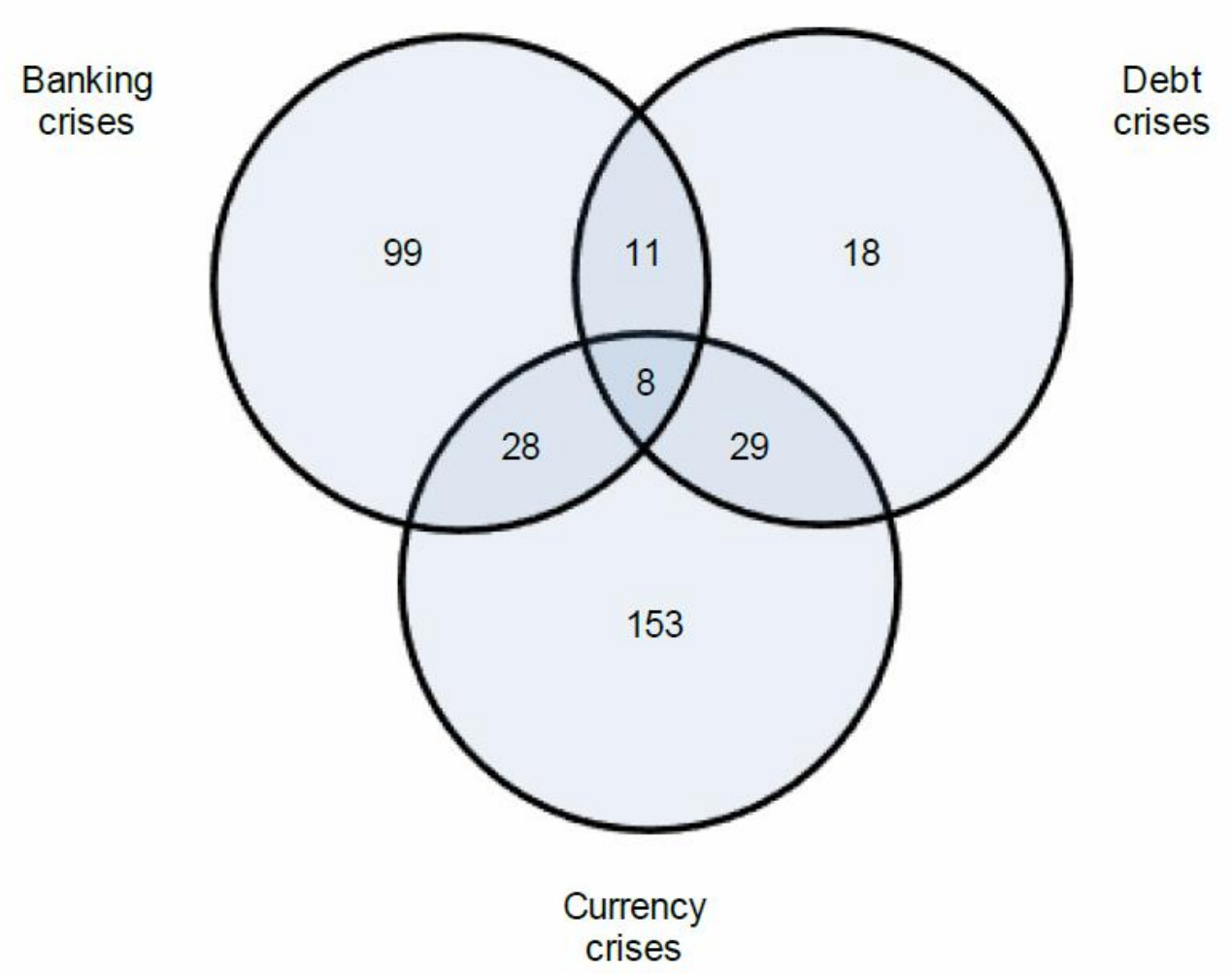
Source: Laeven and Valencia (2012)

Frequency of systemic banking crises around the world, 1970–2011



Source: Laeven and Valencia (2012)

Simultaneous crises, 1970-2011



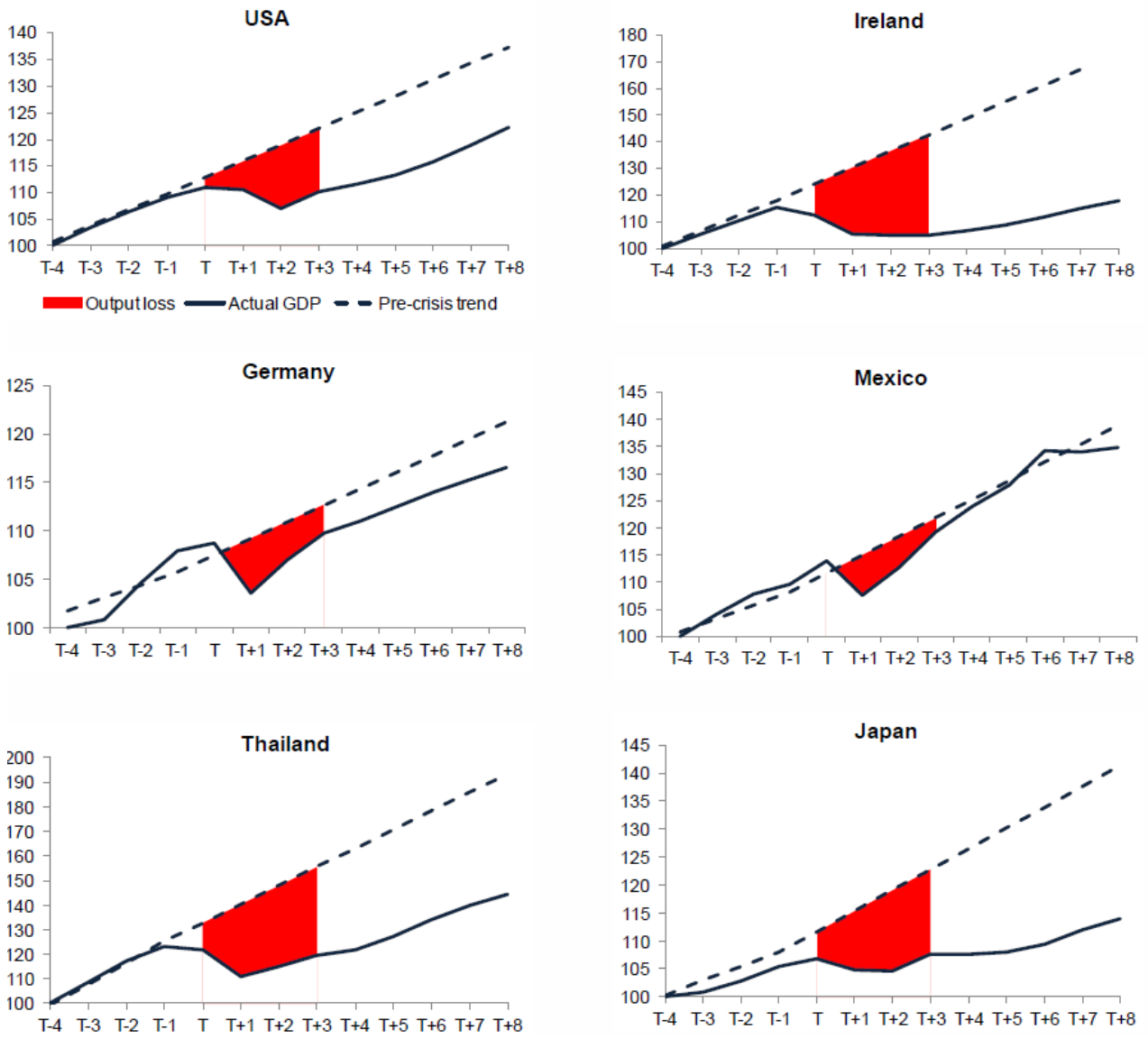
Source: Laeven and Valencia (2012)

Banking crises are costly

The social cost of failure of a bank

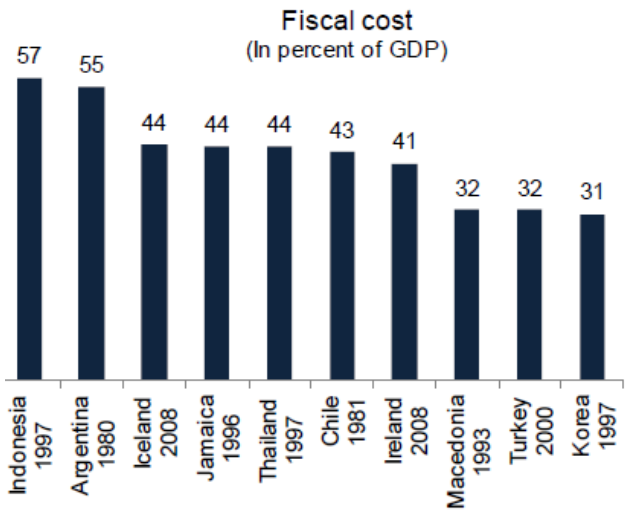
- Loss of informational capital and destruction of long-term relationships of borrowers of the bank -who have to find other lines of credit to continue their business
- Illiquidity costs of deposit holders (with a wealth effect which could induce a fall in aggregate demand)
- Disruption of the payment system -interrupting the clearing process, inducing perhaps a failure in interbank settlements
- Contagion effect -the failure of a bank carries bad news for another bank with a similar portfolio and can trigger its failure
- The budgetary costs of banking crisis (bail-outs) are high in terms of GDP points (ranging easily from 3% up to 20% and more). To this damage to the real sector should be added

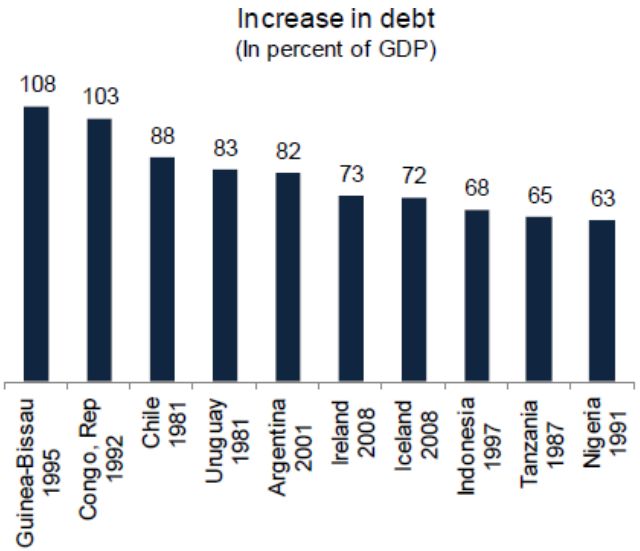
Output losses for selected crises episodes

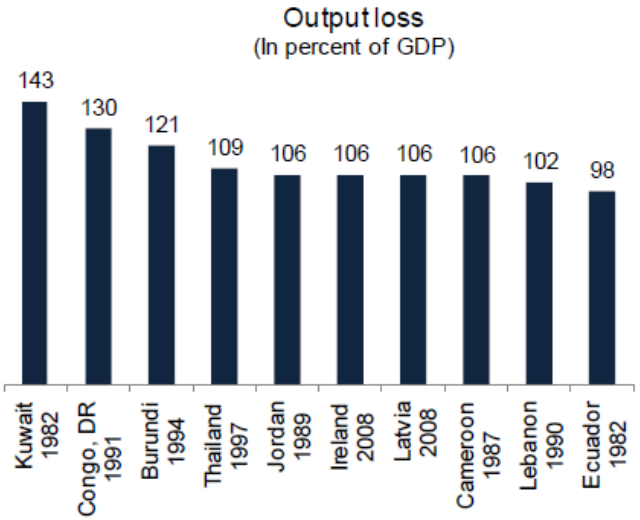


Source: Laeven and Valencia (2012)

Costliest banking crises since 1970

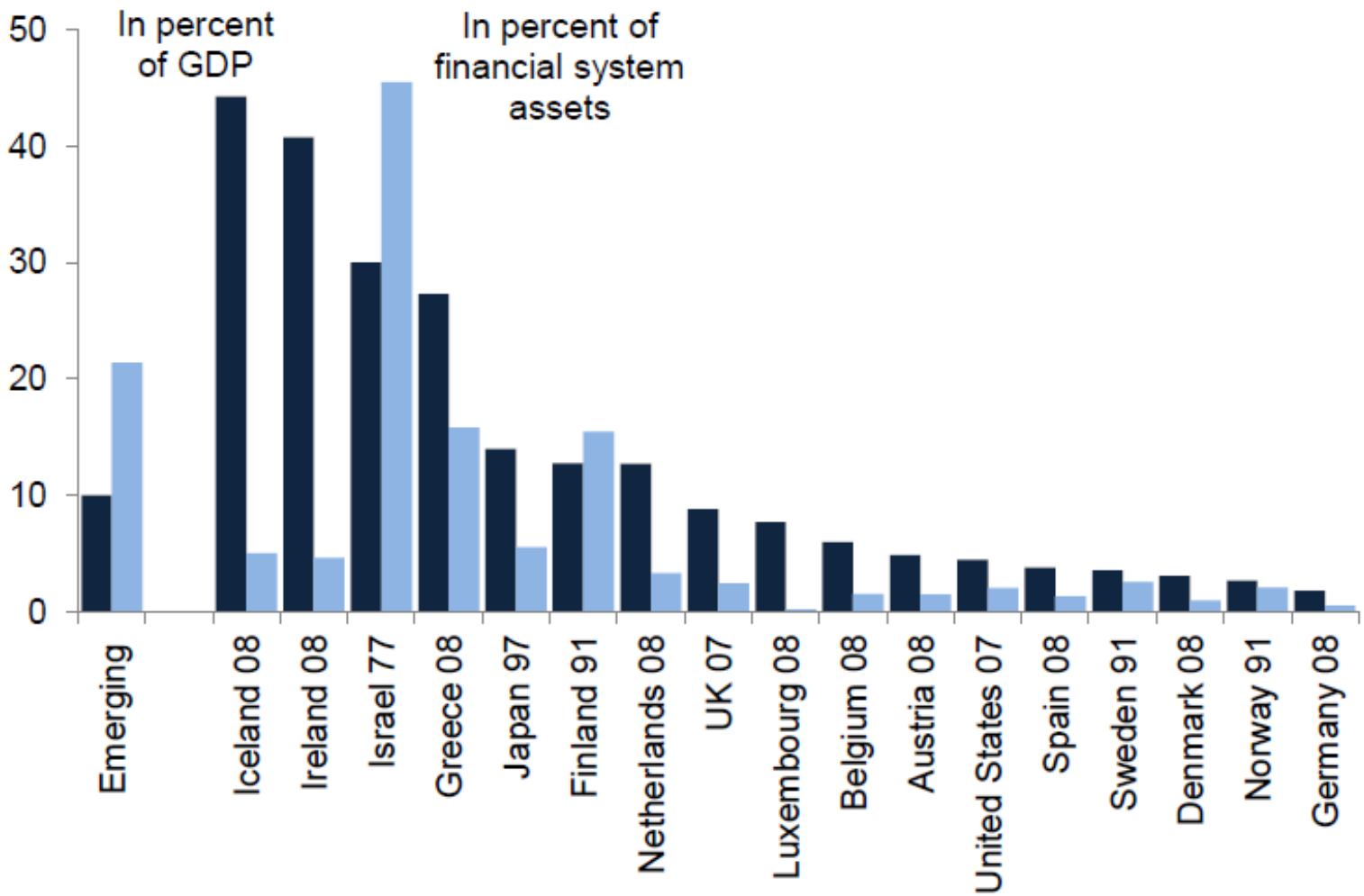






Source: Laeven and Valencia (2012)

Fiscal costs relative to GDP and financial system assets



Source: Laeven and Valencia (2012)

Banking crises outcomes, 1970–2011

Country	Output loss	Increase in debt	Monetary expansion	Fiscal costs	Fiscal costs	Duration	Peak liquidity	Liquidity support	Peak NPLs
	Medians								
	In percent of GDP				In percent of financial system assets	In years	In percent of deposits and foreign liabilities		In percent of total loans
All	23.0	12.1	1.7	6.8	12.7	2.0	20.1	9.6	25.0
Advanced	32.9	21.4	8.3	3.8	2.1	3.0	11.5	5.7	4.0
Emerging	26.0	9.1	1.3	10.0	21.4	2.0	22.3	11.1	30.0
Developing	1.6	10.9	1.2	10.0	18.3	1.0	22.6	12.3	37.5

Source: Laeven and Valencia (2012)

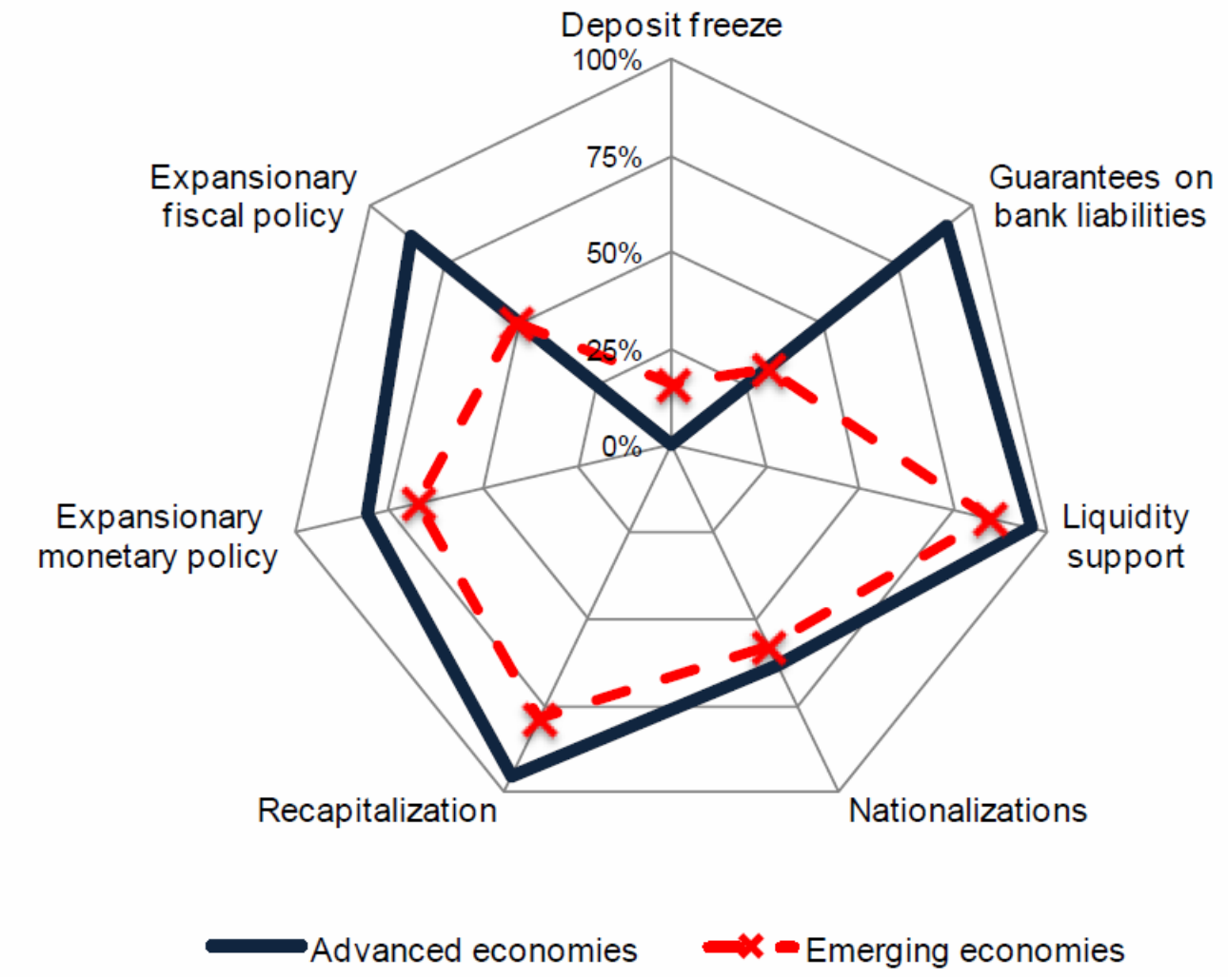
- Larger % output loss, increase in debt and monetary expansion in advanced countries
- Larger % fiscal costs and liquidity support in emerging/developing

Crises outcomes and resolution in the eurozone and the United States

Country	Output loss	Increase in debt	Monetary expansion	Fiscal costs	Fiscal costs	Peak liquidity	Liquidity support	Peak NPLs
	In percent of GDP				In percent of financial system assets	In percent of deposits and foreign liabilities		In percent of total loans
Euro area	23.0	19.9	8.3	3.9	1.7	19.3	13.3	3.8
United States	31.0	23.6	7.9	4.5	2.1	4.7	4.7	3.9

Source: Laeven and Valencia (2012)

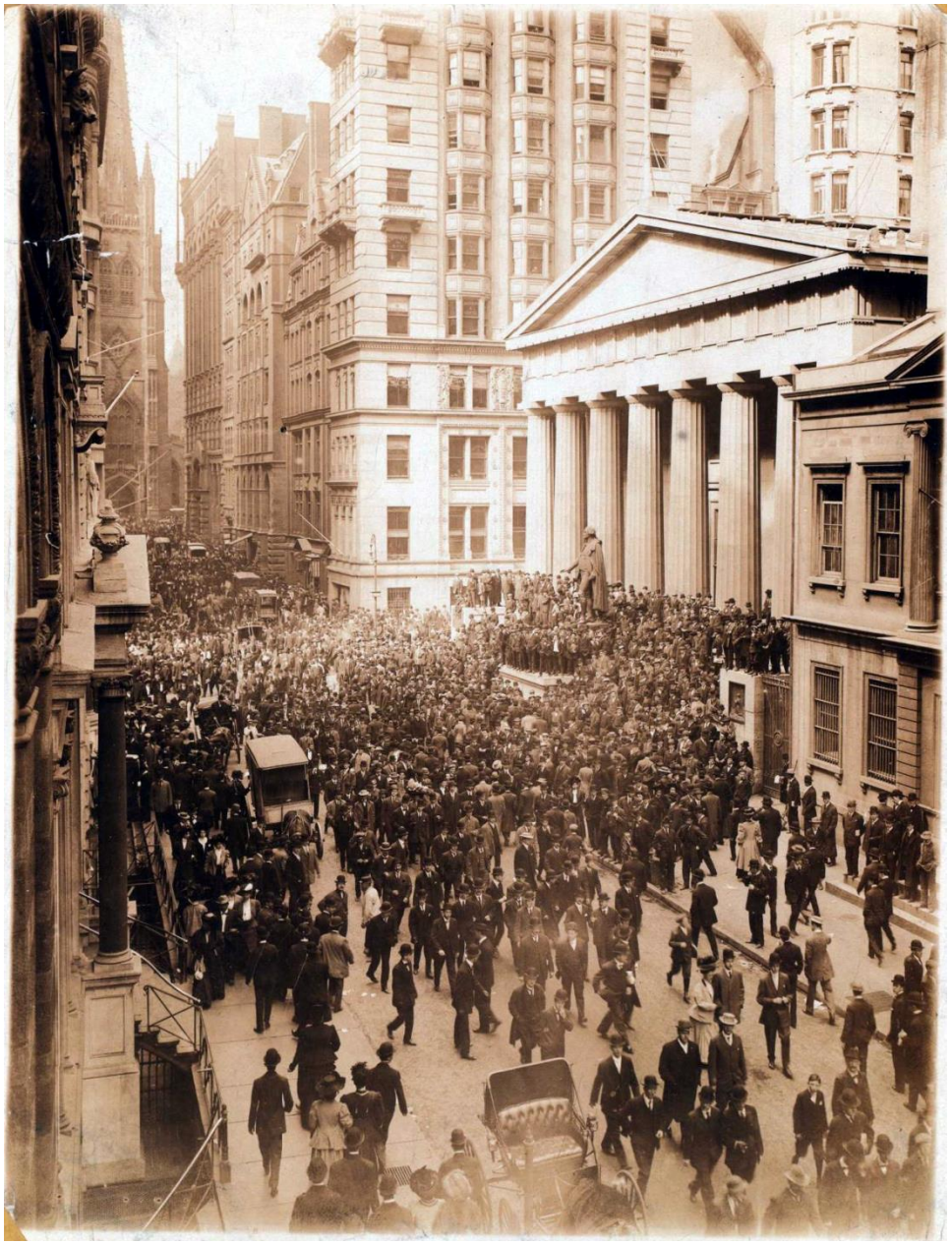
Differences in the mix of crisis policies



Source: Laeven and Valencia (2012)

Is the current crisis similar or not to past crises?

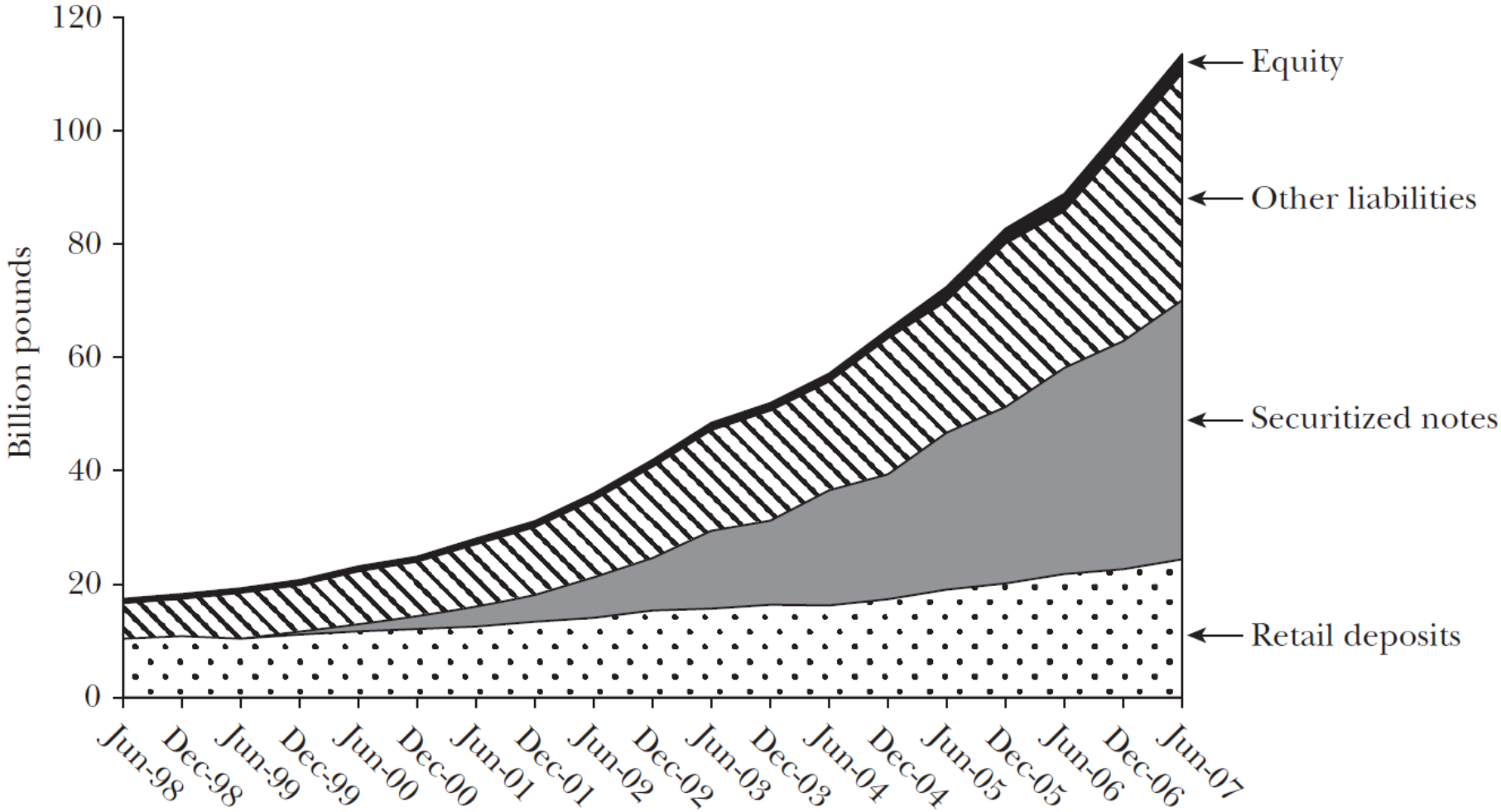
Overend Gurney, UK 1866



Bank panic in October 1907

Bank panic in October 2007

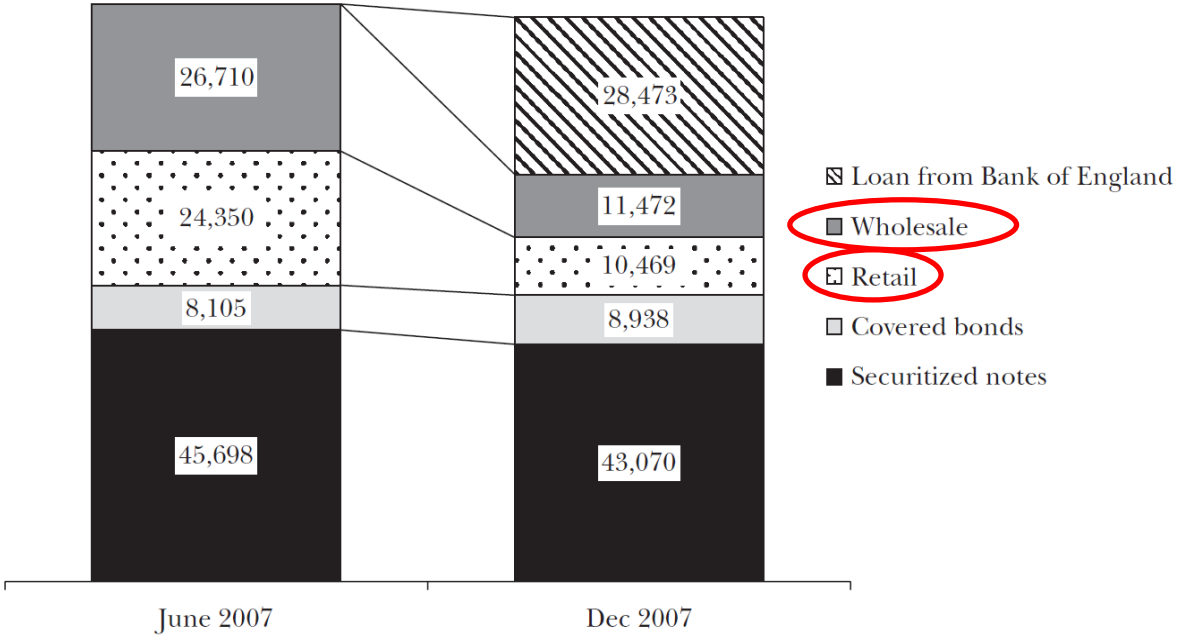
Composition of Northern Rock's Liabilities, June 1998–June 2007



Source: Shin, 2009, Journal of Economic Perspectives.

Composition of liabilities before and after the run

Composition of Northern Rock's Liabilities Before and After the Run
(millions of pounds)



Source: Shin, 2009, Journal of Economic Perspectives.

Loan from the BoE after its liquidity support to NR

Covered bonds increased from £8.1 bn in June 2007 to £8.9 bn in December 2007. Not responsible for the run

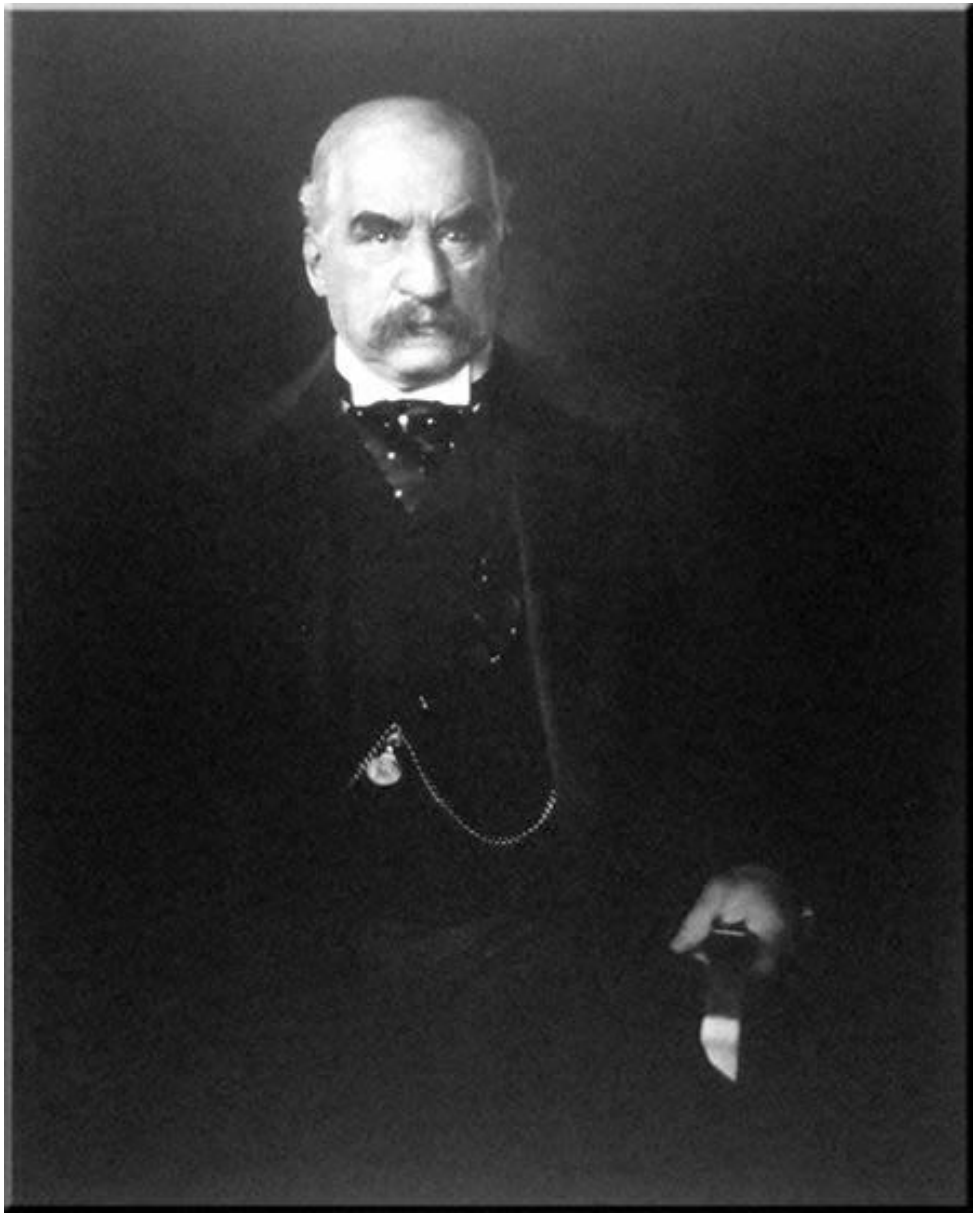
Securitized notes fell only slightly from £45.7 bn to £43 bn. Not responsible for the run.

Retail deposits and wholesale liabilities experienced the largest falls.

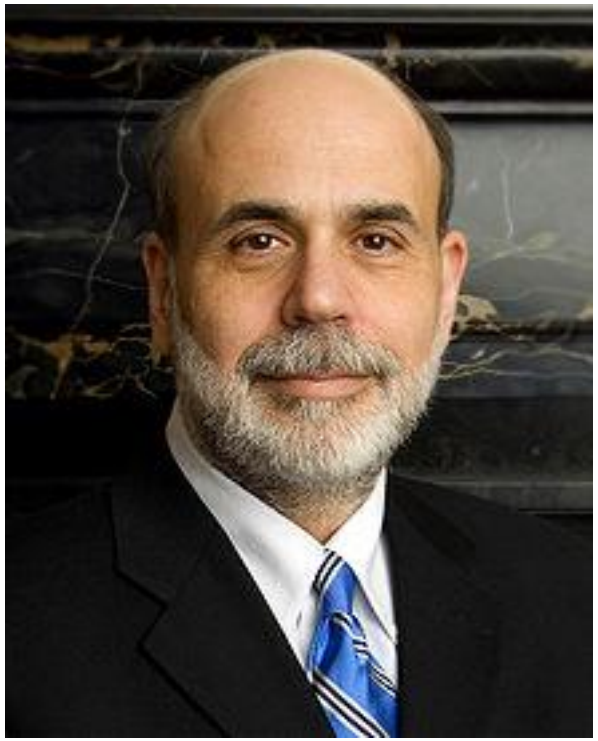
Is the current crisis similar or not to past crises?

- Both the past and the current crises have in common
  - maturity mismatch
  - contagion through interbank exposures
  - and coordination problems:
    - participants in the interbank market and in the commercial bond market do not renew their credit because of fear others will not either: **modern bank run**
- Contagion exacerbated by market channels: liquidity crisis?

The saviors



J.P. Morgan in 1907



B. Bernanke and M. Draghi

Theories of crises

Theories of crises

- Panic/self-fulfilling prophecy/sunspot
  - Kindleberger (1978), Friedman and Schwartz (1963)
  - Models: Bryant (1980)), Diamond and Dybvig (1983), Wallace (1988)
- Shock to fundamentals/business cycle
  - Gorton (1988), Calomiris and Gorton (1991), Calomiris and Mason (2003)
  - Models (information): Gorton (1985), Chari and Jagannathan (1988), Jacklin-Bhattacharya (1988), Allen and Gale (1998, 2004)

Diamond and Dybvig (1983)

- Early and late consumers (maturity transformation/ liquidity insurance)
- Bank returns are certain
- Two equilibria (coordination problem)
- Narrow banking: Reserve ratio of 100%
  - dominated by autarchy, does not provide efficient liquidity insurance

Fragility and coordination problems

- Incomplete information delivering a unique equilibrium with positive probability of run
  - Postlewaite-Vives (1987)
  - Global games: Morris-Shin (1998), Rochet-Vives (2004), Goldstein-Pauzner (2005)
- GSC with incomplete information as a bridge between panic (sunspot) and fundamental (information) view of crises

Evidence

- Banking crises are driven by both solvency and liquidity issues:
  - Calomiris and Mason (2003) find that some episodes of banking crises in the 1930s in the US can be explained by deteriorating fundamentals while others are open to being interpreted as the panic component dominating (as the crises in January and February of 1933).
  - Starr and Yilmaz (2007) study bank runs in Turkey and conclude that both fundamentals and panic elements coexist in the explanation of the dynamics of the crises.

A framework of analysis

A binary action Bayesian game of strategic complementarities (Vives (2014))

A stylized crisis model

- Continuum of players/investors
  - $y_i = 1$ to act; $y_i = 0$ not to act.
  - To act: attack a currency, run on a bank; run on debt; foreclose loan
- Fraction of people acting: y
- State of the world: θ
  - $h(\theta)$: *resistance* function: critical fraction so that it pays to act

- Differential payoff of acting: $\pi(y_i = 1, y; \theta) - \pi(y_i = 0, y; \theta)$:

	$y > h(\theta)$	$y \leq h(\theta)$
$\pi^1 - \pi^0$	$B > 0$	$-C < 0$

with $\pi^1 - \pi^0$ increasing in y and $-\theta$ or $\pi(y_i, y; \theta)$ with increasing differences in $(y_i, (y, -\theta))$

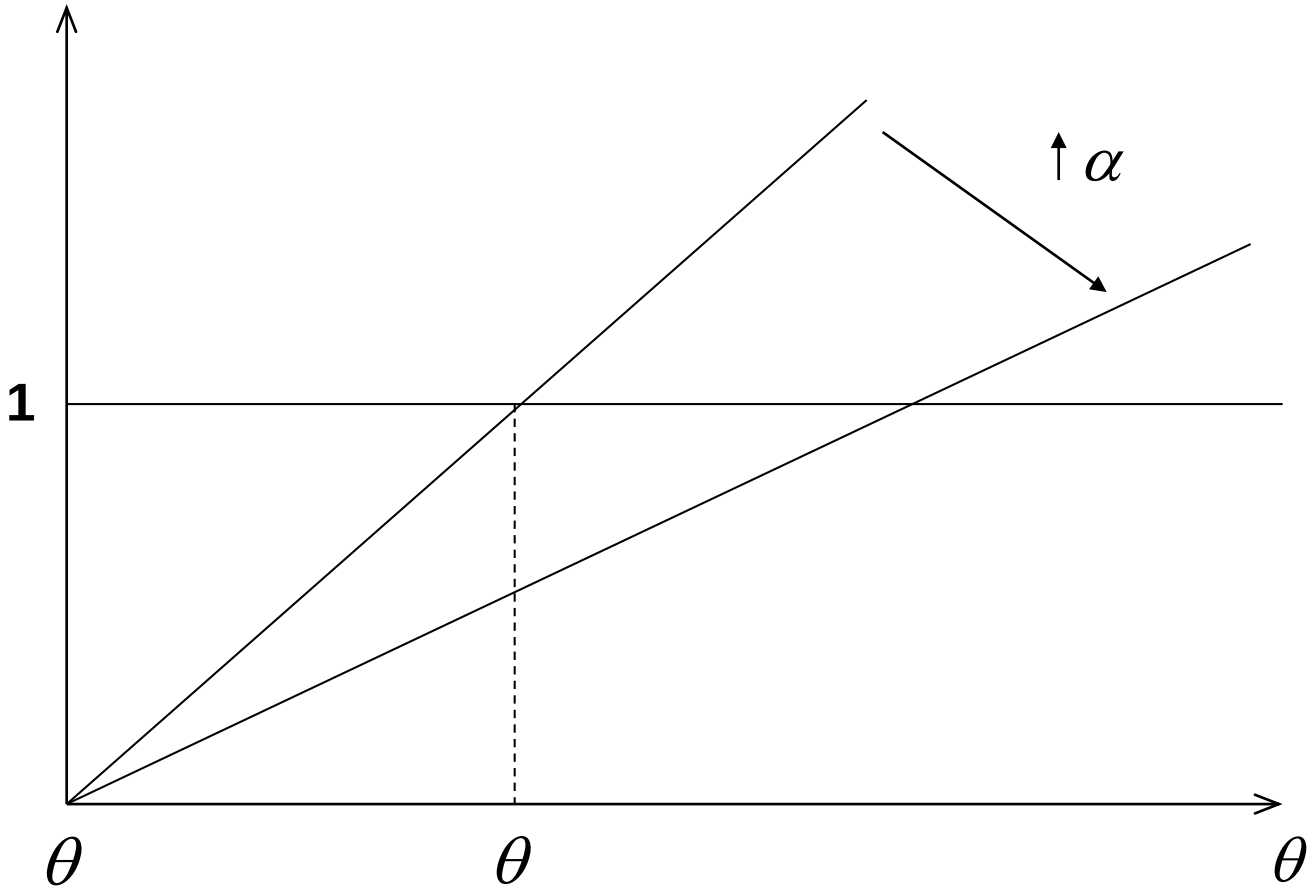
- Let $\gamma \equiv C / (B + C)$ be the critical success probability p of the collective action such that it makes an agent indifferent between acting and not acting: $pB + \left(1 - p\right)\left(-C\right) = 0$
- This is the ratio of the cost of acting to the differential incremental benefit of acting in case of success in relation to failure.

Resistance function: Critical fraction for successful attack

- $h(\cdot)$ is strictly increasing, crossing 0 at $\theta = \underset{\sim}{\theta}$ $\left(\lim_{\theta \uparrow \underset{\sim}{\theta}} h(\theta) = 0\right)$, and 1 at $\theta = \tilde{\theta} > \underset{\sim}{\theta}$, and smooth on $\left(\underset{\sim}{\theta}, \tilde{\theta}\right)$
- $h(\cdot;\alpha)$ is parameterized by α, with $\partial h / \partial \alpha < 0$
- A larger α means more vulnerability or a more stressful environment for the institution attacked since the threshold for the attack to be successful is lower

$$h(\theta;\alpha) = h_0(\alpha) + h_1(\alpha)(\theta - \underset{\sim}{\theta}(\alpha))$$

A larger α means more vulnerability or a more stressful environment for the institution attacked. Example:



Complete information game

$\theta < \underset{\sim}{\theta}$: Dominant strategy to act

$\theta \in \left(\underset{\sim}{\theta}, \tilde{\theta}\right)$: Multiple equilibria $\left\{ \begin{array}{c} \text{all act} \\ \text{no one acts} \end{array} \right.$

$\theta > \tilde{\theta}$: Dominant strategy not to act

Incomplete information game

- $\theta \sim N \quad \mu_\theta, \tau_\theta^{-1}$, τ_θ public precision
- Investor i observes private signal $s_i = \theta + \varepsilon_i$
  - $\varepsilon_i \sim N \quad 0, \tau_\varepsilon^{-1}$,i.i.d, τ_ε private precision

Identifying strategic complementarities

- Identifying strategic complementarities needs to disentangle the strategic aspect from responses of investors to common shocks:
  - Chen et al. (2010 use the fact that illiquid funds (those with a higher fire sales penalty) generate larger strategic complementarities for investors than liquid ones since redemptions impose larger costs in the former funds.
  - Hertzberg et al. (2010)) use a natural experiment with a credit registry expansion in Argentina.

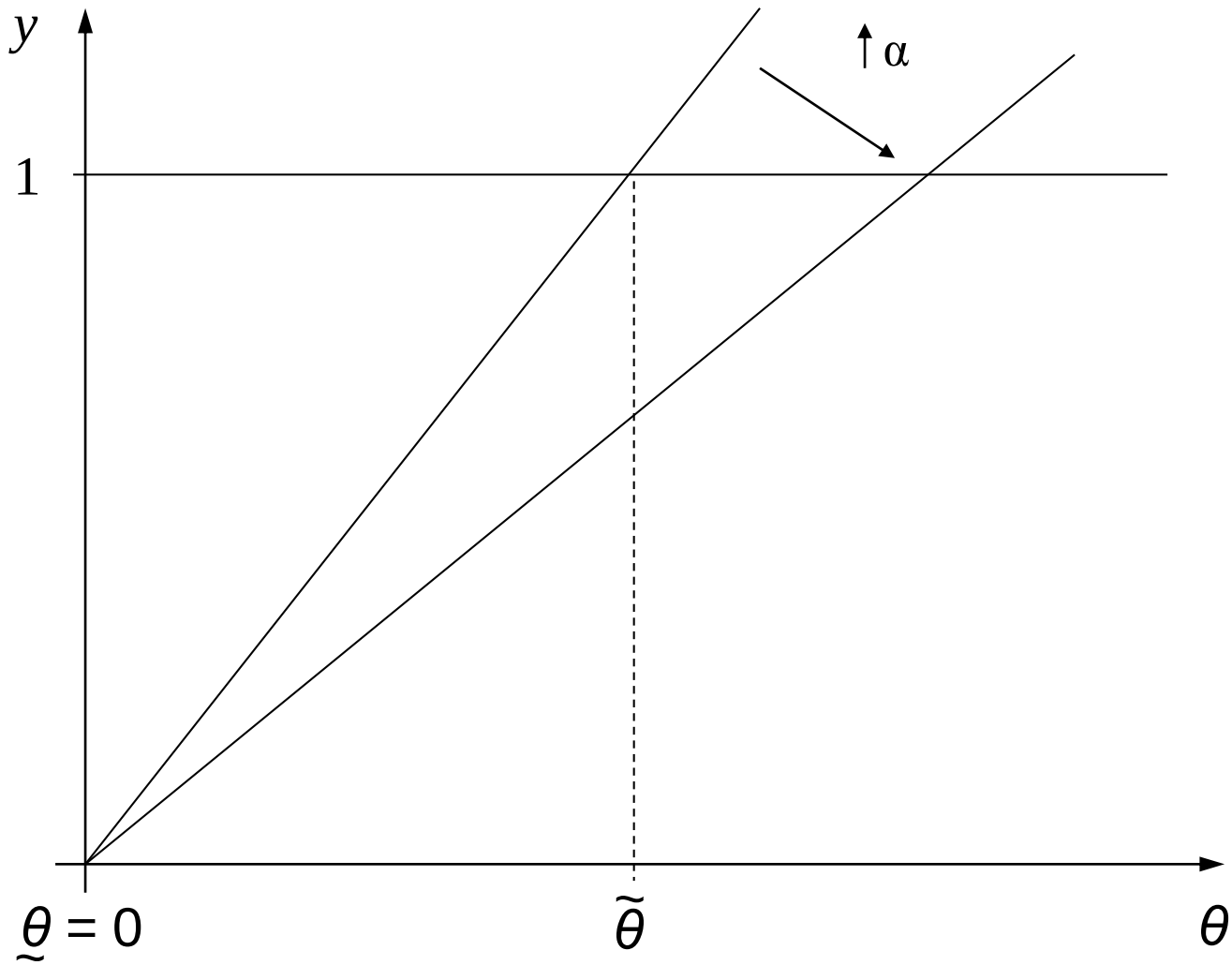
Model nests

- Currency attacks (Morris and Shin (1998))
- Foreclosing a loan (Morris and Shin (2004))
- Credit freezes (Bebchuk and Goldstein (2011)
- Run on financial institution (Rochet and Vives (2004))

Currency attacks
(Morris and Shin (1998), modified)

- θ *:* reserves of central bank ($\theta \leq 0$ means no reserves)
- Speculator i has one unit to attack ($y_i = 1$)
- $h(\theta) = \alpha^{-1}\theta$ where $\alpha > 0$ is mass of attackers or α^{-1} is proportion of uncommitted reserves
- Cost of attack: C
- Capital gain if devaluation: $\hat{B}$ (fixed)
- Let $B = \hat{B} - C$

$$h(\theta;\alpha) = \alpha^{-1}\theta$$



Foreclosing a loan
(Morris and Shin (2004))

- θ : ability of firm to meet short-term claims ($\theta \leq 0$ means no ability)
- Creditor i forecloses if $y_i = 1$
- $h(\theta) = \alpha^{-1}\theta$ where $\alpha > 0$ is mass of creditors (or α^{-1} proportion of uncommitted liquid resources of firm) and project fails if $y \geq \alpha^{-1}\theta$
- Face value of loan: L
- Value of collateral (interim liquidation): $K < L$
- Let $B = K$ and $-C = K - L$

Credit market freezes

(Bebchuk and Goldstein (2011))

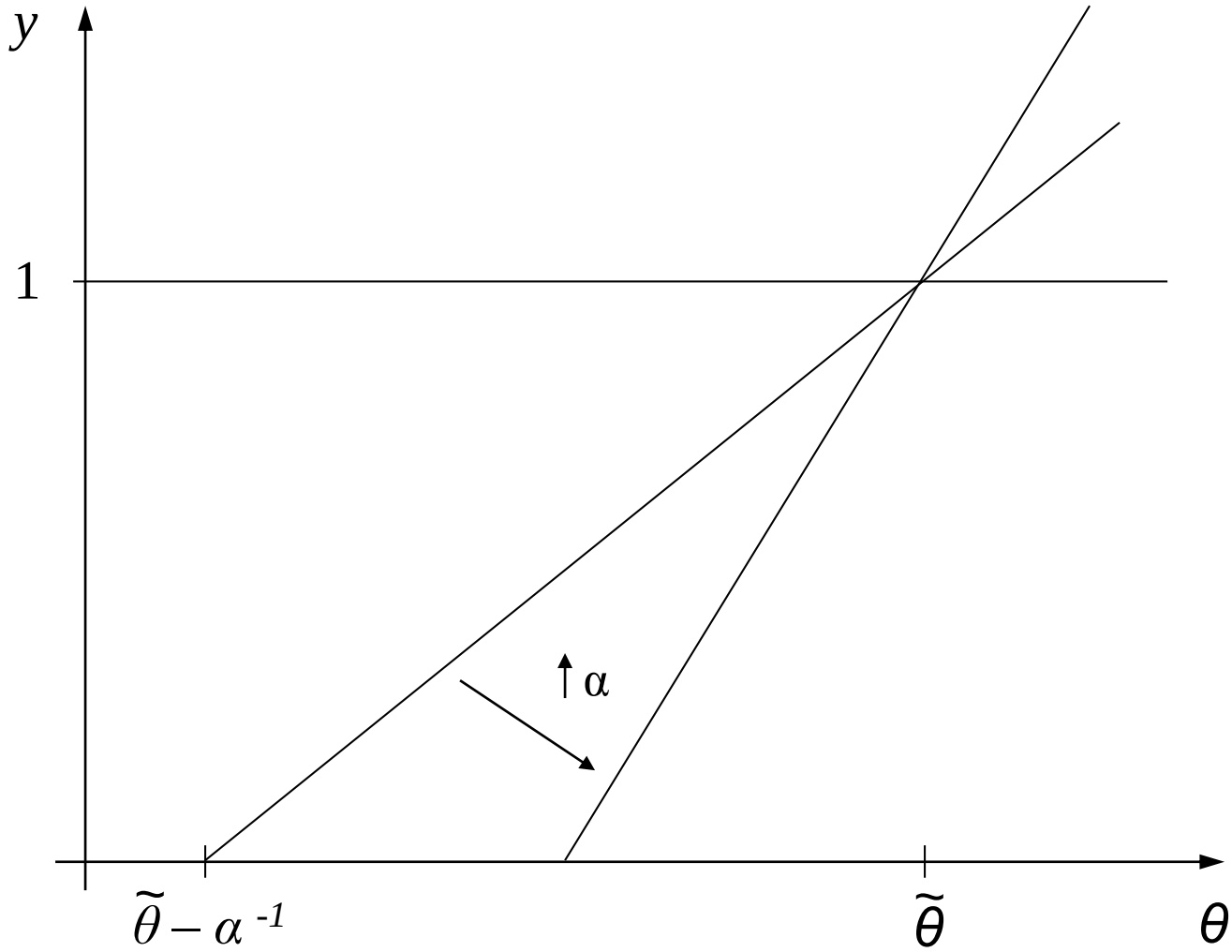
- θ are the fundamentals of the firms and y the proportion of banks not renewing credit to firms.
- Firms with good projects, at which banks can invest, have a return above the risk-free rate only if $\theta \geq \underset{\sim}{\theta}(\alpha) + \alpha^{-1} y$ where $\underset{\sim}{\theta}(\alpha) = \tilde{\theta} - \alpha^{-1}$ with $\tilde{\theta} > 0$. (Firms with bad projects return nothing and banks can detect good projects from bad ones.)
- α is the inverse of the product of the mass of banks and a complementarity parameter that explains the performance of firms.

Credit market freezes

(Bebchuk and Goldstein (2011))

- $h(\theta;\alpha) = \alpha(\theta - \underset{\sim}{\theta}(\alpha))$ and $\partial h/\partial\alpha = -\tilde{\theta} < 0$ (but $\partial h_1/\partial\alpha > 0$):
- $1-\gamma$ equals the ratio of the gross risk-free return to the gross return of good projects.

$$h(\theta;\alpha) = \alpha(\theta - \underset{\sim}{\theta}(\alpha))$$



The Rochet-Vives(2004) model

Dates: $t = 0,1,2$

Bank's balance sheet at $t = 0$:

I	$D_0 = 1$
M	E

- D_0 : volume of uninsured wholesale deposits
- Nominal value of deposits if withdrawn $(t = 1,2)$: $D \geq 1$
- E: value of equity
- I: investment in risky assets, with random return
- $\theta \sim N(\mu_\theta, (1/\tau_\theta))$ at $t = 2$.
- M: cash reserves held by bank

The model

- Withdrawal decision delegated to fund managers who prefer to renew the deposits but are penalized by the investors if the bank fails.
  - Payoff to fund manager depends on whether he takes the "right decision". Differential payoff of withdrawing with respect to rolling over the CD is
    - $-C < 0$ if no failure; and
    - $B > 0$ if failure.
  - Behavioral rule: withdraw iff $PB - (1 - P)C > 0$ or $P > \gamma$, where $P = \text{Prob. bank fails}$ and $\gamma = \frac{C}{B+C}$.

The model

- At $t = 1$, fund manager i observes private signal $s_i = \theta + \varepsilon_i$ (ε_i are i.i.d. $N(0, (1/\tau_\varepsilon))$)
- Proportion y decides to withdraw (not renew CDs)
- If $yD > M$, bank forced to sell assets.
- If bank does not fail at $t = 1$ it continues until date 2.

The model

- Modeling captures main institutional features of modern interbank markets:
  - Banks finance themselves by equity (or long term debt) and uninsured short term deposits (or CDs)
  - In case of liquidity shortage at $t = 1$, banks can access informationally efficient secondary (repo) market

(price aggregates decentralized information of investors about quality of bank's assets and depends on θ)

- Sale of assets with proportional loss of (final) value ($\theta/(1+\lambda)$), $\lambda > 0$
  - Volume of asset sales needed to face yD is:

$$\frac{1+\lambda}{\theta}[yD - M]_+$$

The fire sales penalty

Parameter λ: "fire sales" penalty in secondary market for bank assets (or repo market) due to:

- *Asymmetric information*: limited commitment of future cash flows (Hart and Moore (1994) or Diamond and Rajan (1997)), moral hazard (Holmstrom and Tirole (1997)) or adverse selection (Flannery (1996))
  - Adverse selection:
    - Bank may want to sell its assets because it needs liquidity or because it wants to get rid of its bad loans (with zero value).
    - Investors only accept to pay $(\theta/(1+\lambda))$ because they assess probability $(1/(1+\lambda))$ to the liquidity needs.
- *Liquidity premium* (Allen and Gale (1998)) : temporary liquidity shortage in interbank market

Early closure

- Early closure is possible:
  - Operation in interbank market does not involve physical liquidation of assets but when θ small or λ large interbank markets do not suffice to prevent early closure of bank.
- Early closure (t = 1):
  - Involves physical liquidation of assets and is costly: (per unit) liquidation value of assets is $\nu\theta$, with $\nu \ll \left(\frac{1}{1+\lambda}\right)$.
  - It is never ex post efficient but may be ex ante efficient to discipline bank managers.

Features of the model

- Bank as corporation of stockholders and not mutual.
- Shift emphasis from maturity transformation and liquidity insurance of small depositors to "modern" form of bank runs: short horizon with investors refusing to renew their CDs on interbank market.
- Motivation for demandable debt: discipline bank managers (Calomiris and Kahn (1991)).
- Modeling captures main institutional features of modern interbank markets

When does the bank fail?

- If all fund managers renew credit to the bank (i.e., $y=0$), then there are no fire sales at $t=1$ and the bank fails at $t=2$ iff

$$M+I\theta<D \text{ or } \theta<\underset{\sim}{\theta}\equiv\left(D-M\right)\big/I$$

(solvency threshold).

- If at $t=1$, the bank must liquidate some (but not all) assets, $M+I\theta\left(1+\lambda\right)^{-1}\geq yD>M$. Then the bank will fail at $t=2$ iff $I\theta-\left(1+\lambda\right)\left(yD-M\right)<\left(1-y\right)D$

(failure threshold).

Regions (liquidation)

$yD \leq M$: no liquidation at t = 1 and failure at t = 2 iff

$$\theta I + M < D \Leftrightarrow \theta < \underset{\sim}{\theta} = \left(\frac{D-M}{I}\right).$$

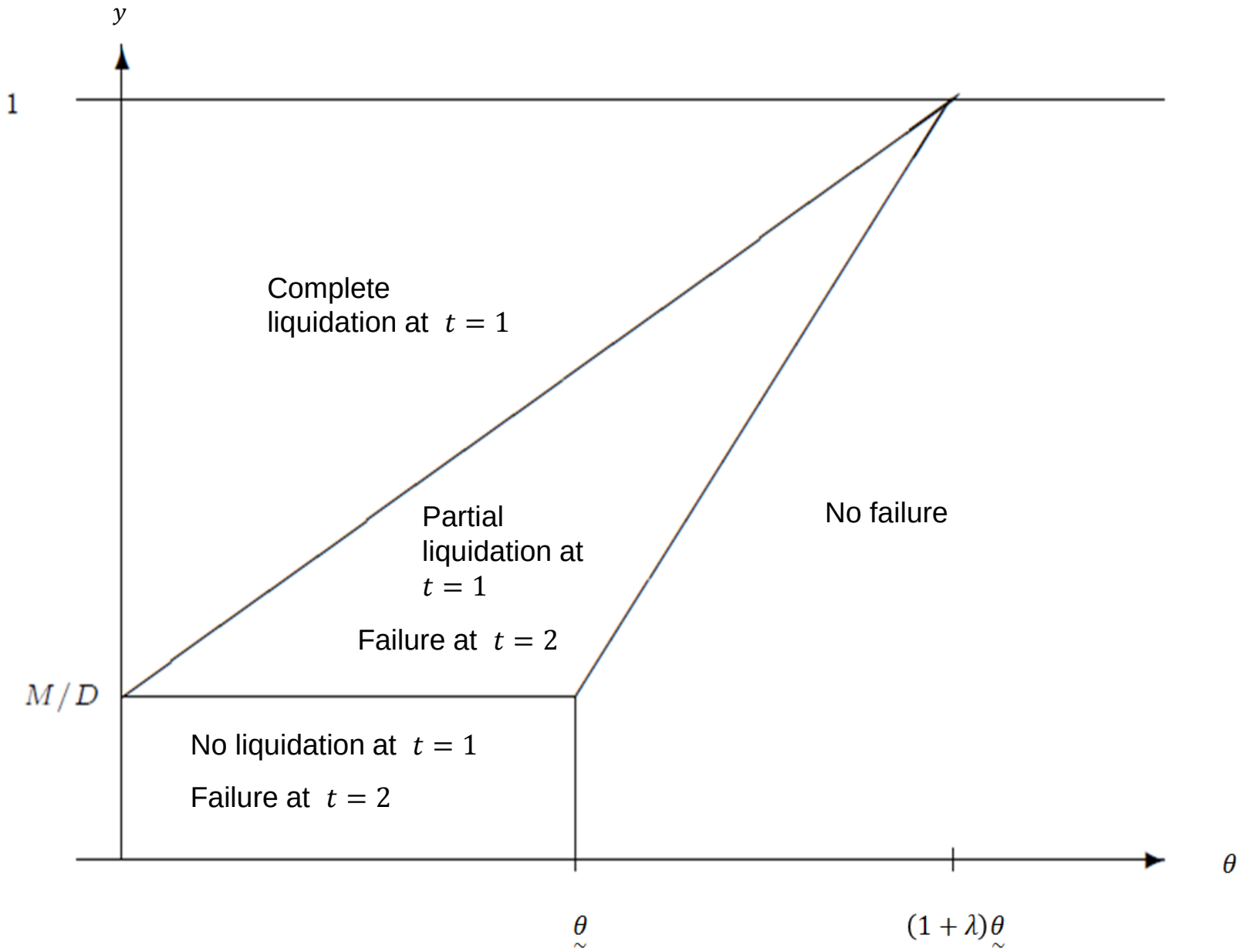
($\underset{\sim}{\theta}$: solvency threshold of bank)

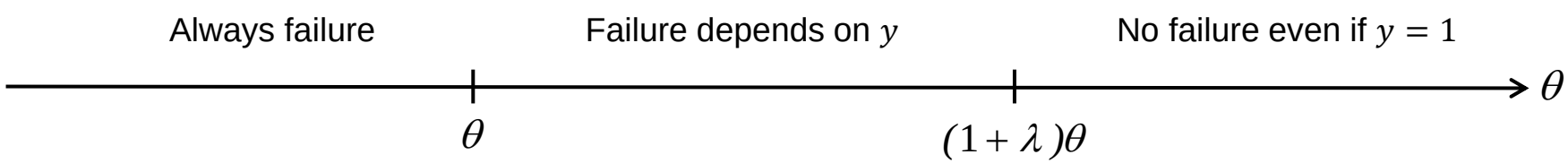
- $M < yD \leq M + (\theta I/(1+\lambda))$: partial liquidation at t = 1, and failure at t = 2 iff

$$\theta I - (1+\lambda)(yD - M) < (1-y)D \Leftrightarrow \theta < \underset{\sim}{\theta}[1 + \frac{yD-M}{D-M}))]$$

(solvent banks can fail when y is too large but not when bank is supersolvent: $\theta > (1+\lambda)\underset{\sim}{\theta}$))

- When $yD > M + (\theta I/(1+\lambda))$, bank is liquidated at t = 1 (early closure)


y
1
Complete liquidation at $t = 1$
Partial liquidation at $t = 1$
Failure at $t = 2$
No failure
M/D
No liquidation at $t = 1$
Failure at $t = 2$
θ
$\underset{\sim}{\theta}$
$(1+\lambda)\underset{\sim}{\theta}$


Always failure
Failure depends on y
No failure even if $y = 1$
θ
θ
$(1+\lambda)\theta$

- The balance constraint at $t = 0$ is

  $E + D_0 = I + M$

  and the solvency threshold

  $\underset{\sim}{\theta} \equiv (D - M)/I = (1 - m)/(\ell^{-1} + d^{-1} - m)$

where

$m = M/D$ is the liquidity ratio

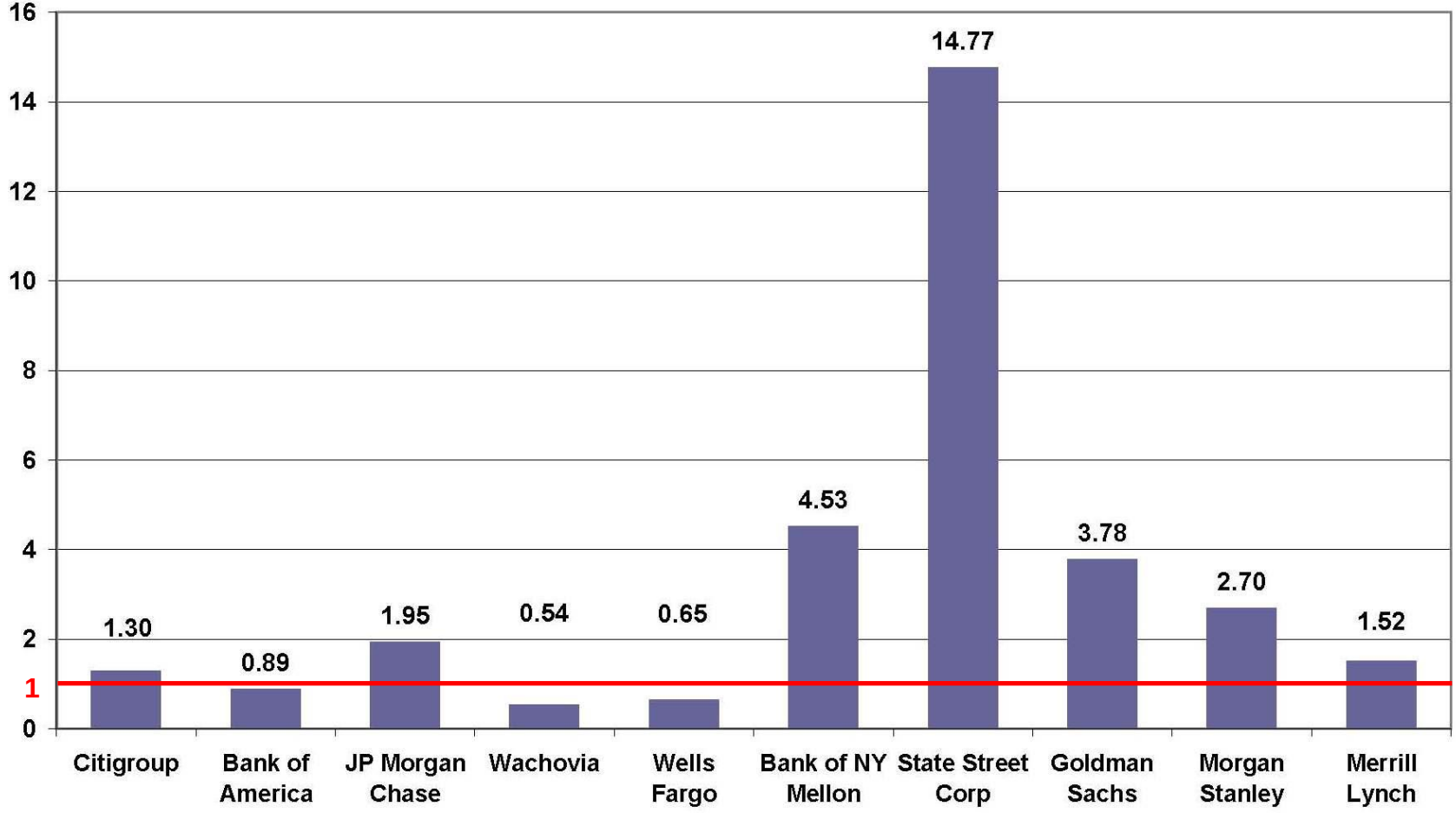
$\ell = D/E$ is the short-term leverage ratio

$d = D/D_0$ the return (face value) of short-term debt.

- We have that $sign\{\partial \underset{\sim}{\theta}/\partial m\} = sign\{1 - \ell^{-1} - d^{-1}\}$.
- Assume $1 - \ell^{-1} - d^{-1} < 0$

Short-term leverage ratio of US banks

D / E = (Deposits (Uninsured) + Short Term Debt + Other Liabilities) /
(Equity + Long Term Debt + Deposits (Insured))
(Sep. 30, 2008)



Source: Veronesi y Zingales (2009), Paulson's Gift.
*Data for Goldman Sachs and Morgan Stanley as of 08/31/2008.

Critical values

Early closure: $\theta_{ec}(y) = (1+\lambda)\frac{(yD-M)_+}{I}$.

Failure: $\theta_f(y) = \underset{\sim}{\theta} + \lambda\frac{(yD-M)_+}{I}$.

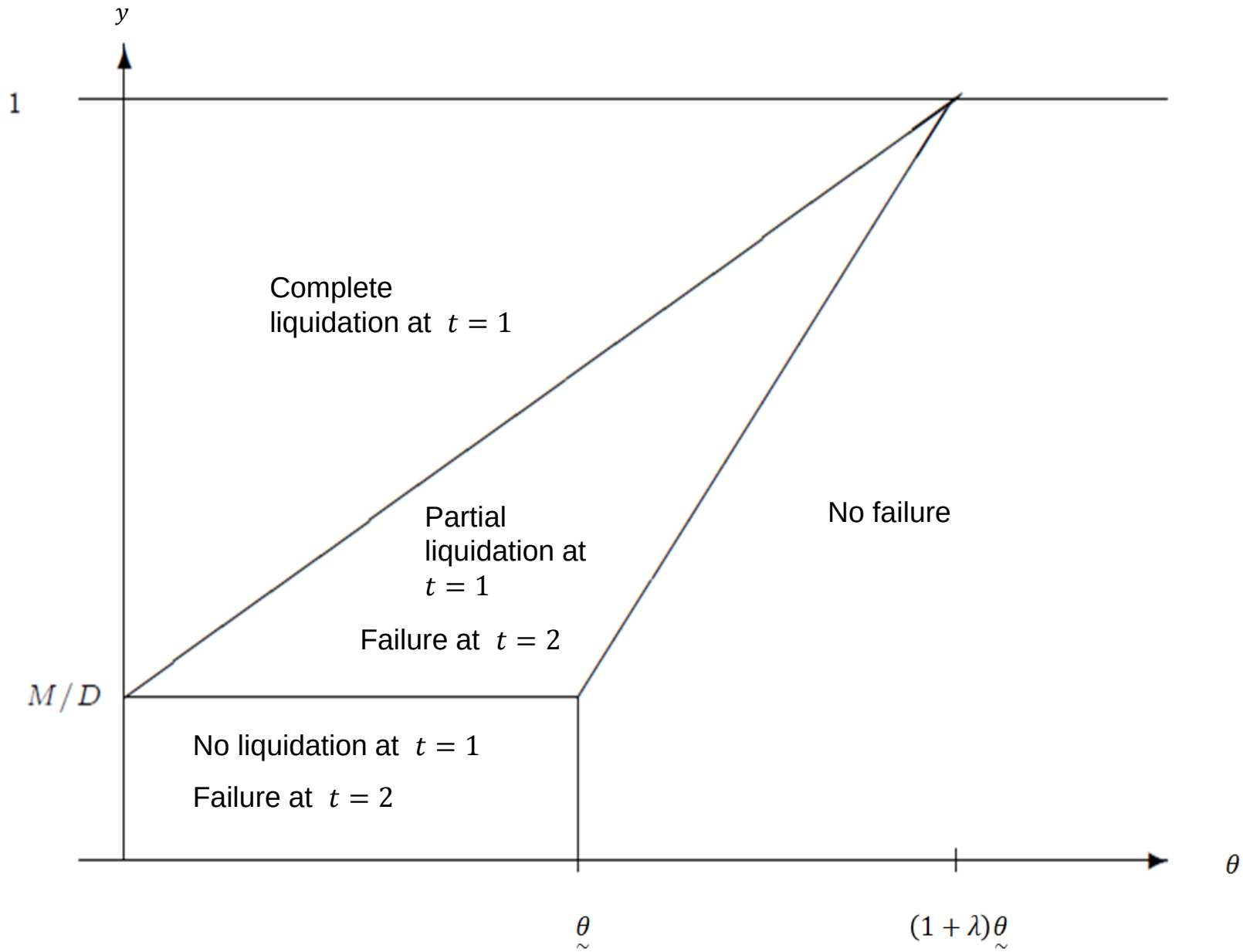
- Equivalently:

$$\theta_{ec}(y) = \underset{\sim}{\theta}(1+\lambda)\frac{(y-m)_+}{1-m}$$

$$\theta_f(y) = \underset{\sim}{\theta}\left(1+\lambda\frac{(yD-M)_+}{1-m}\right) \text{ (inverse of } h(\theta))$$

- Note that

$$\theta_{ec}(y) < \theta_f(y)$$


y
1
Complete
liquidation at $t = 1$
Partial
liquidation at
$t = 1$
Failure at $t = 2$
No failure
M/D
No liquidation at $t = 1$
Failure at $t = 2$
θ
$\underset{\sim}{\theta}$
$(1+\lambda)\underset{\sim}{\theta}$

Resistance function
(Failure threshold)

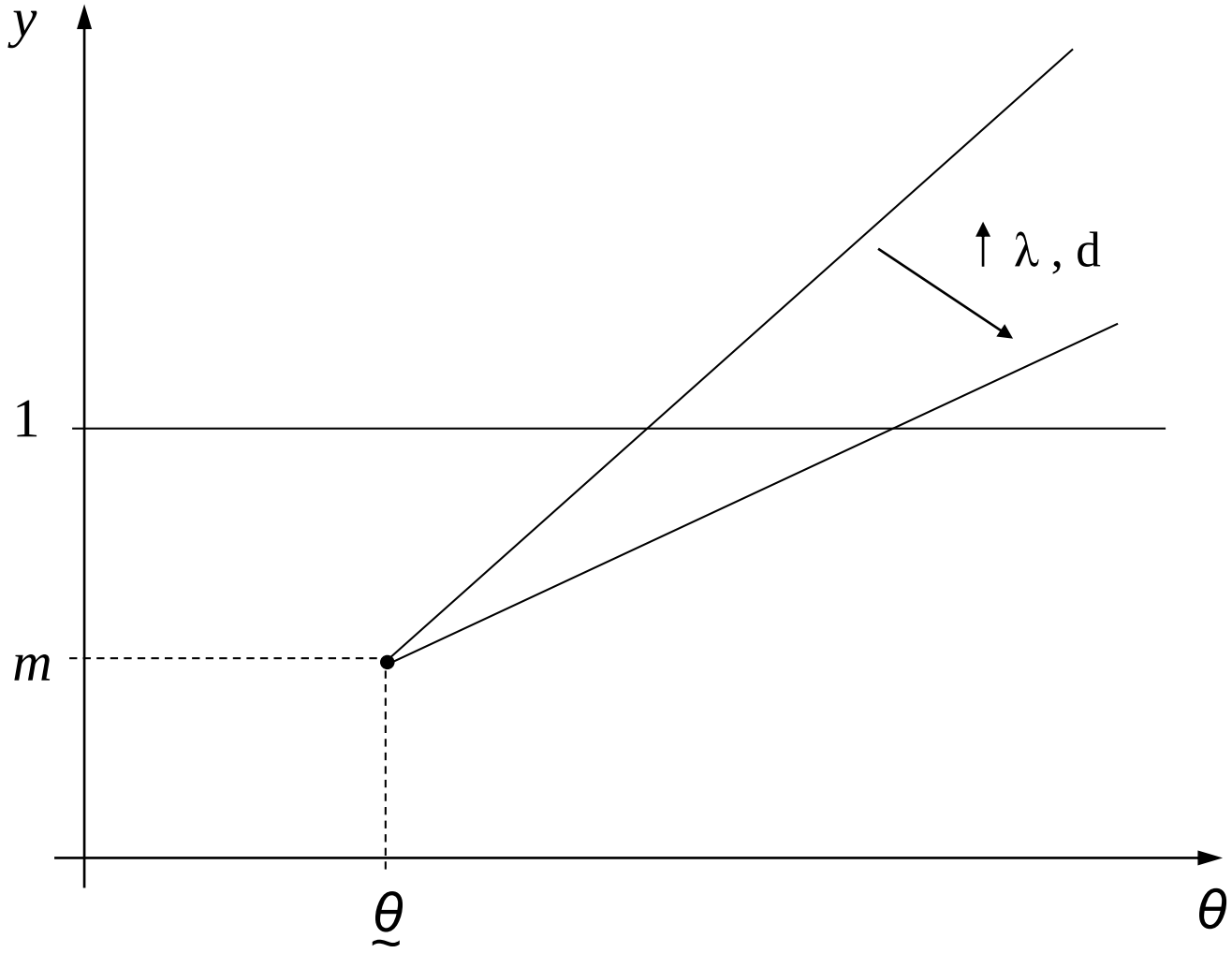
- Bank fails if $y > h(\theta)$ where

$$h(\theta) = m + \frac{\ell^{-1} + d^{-1} - m}{\lambda}(\theta - \underset{\sim}{\theta})$$

for $\theta \geq \underset{\sim}{\theta}$ and $h(\theta) < 0$ otherwise

- Increasing in fundamental value θ
- Decreasing in $\alpha \equiv \lambda, d, \ell$ and m^{-1} if $1 - \ell^{-1} - d^{-1} < 0$

$$h(\theta) = m + \frac{\ell^{-1} + d^{-1} - m}{\lambda}(\theta - \underset{\sim}{\theta})$$



Back to the general model

Equilibrium in the general model

- We seek equilibrium in which investors play threshold strategies: run iff $s_i < \hat{s}$
- $r(\hat{s})$: best response of an investor when other investors play threshold $\hat{s}$
- Equilibrium is characterized by two thresholds (s^*, θ^*) with s^* a fixed point of $r(\cdot)$ and $\theta^* \in [\underset{\sim}{\theta}, \tilde{\theta})$ the state-of-the-world below which acting mass is successful (e.g. bank fails).

Computation of best response (I)

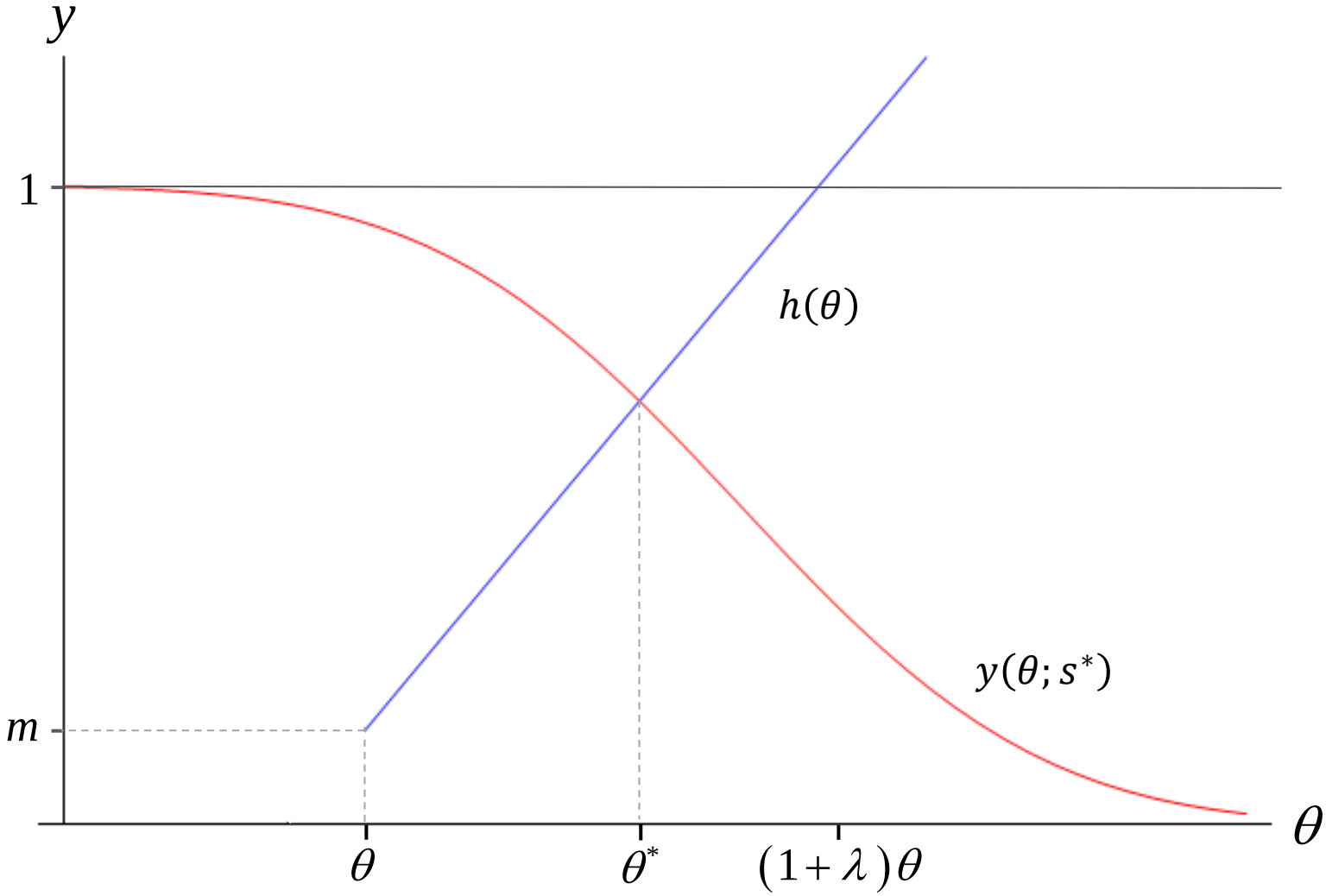
- Given a signal threshold $\hat{s}$ at which other investors run the investor computes *failure threshold* $\hat{\theta}$ such that the entity fails/the attack is sucessful iff $\theta < \hat{\theta}$

$$y\left(\hat{\theta}; \hat{s}\right) \equiv Pr\left[s < \hat{s} \middle| \hat{\theta}\right] = h\left(\hat{\theta}\right), \text{ or}$$

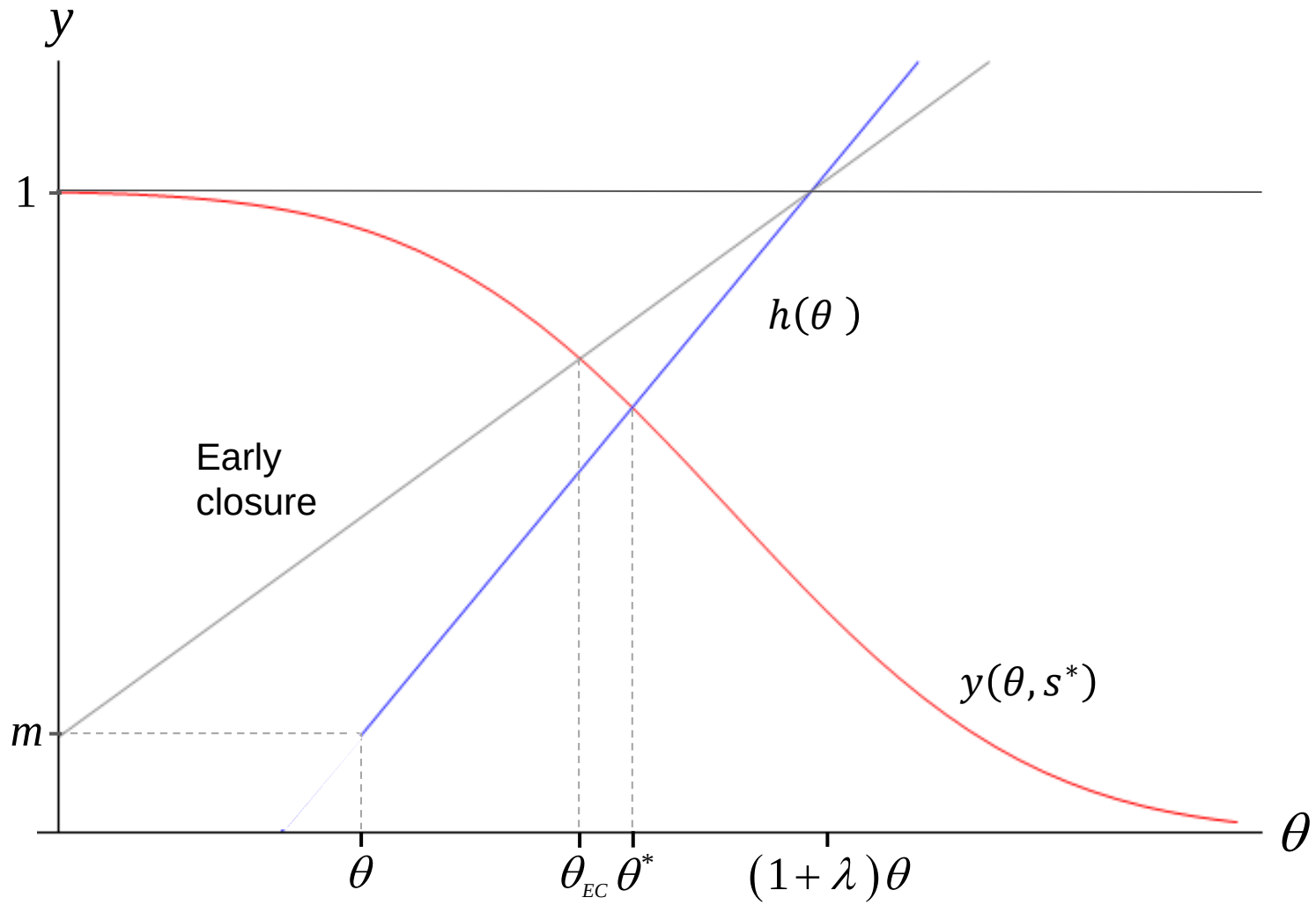
$$\hat{\theta} = \theta_F\left(\hat{s}\right)$$

(It depends on $s|\theta$ and on the resistance function $h(\theta)$)

Failure threshold given critical signal
(Bank run model)



Early closure threshold given critical signal (Bank run model)



Computation of best response (II)

- Given a failure threshold $\hat{\theta}$, the investor computes the *signal threshold* $\hat{s}$ below which it is optimal to run

$$Pr\left[\theta < \hat{\theta} \middle| \hat{s}_{-}\right] = \gamma \text{, or}$$

$$\hat{s} = s_T\left(\hat{\theta}_{+}\right)$$

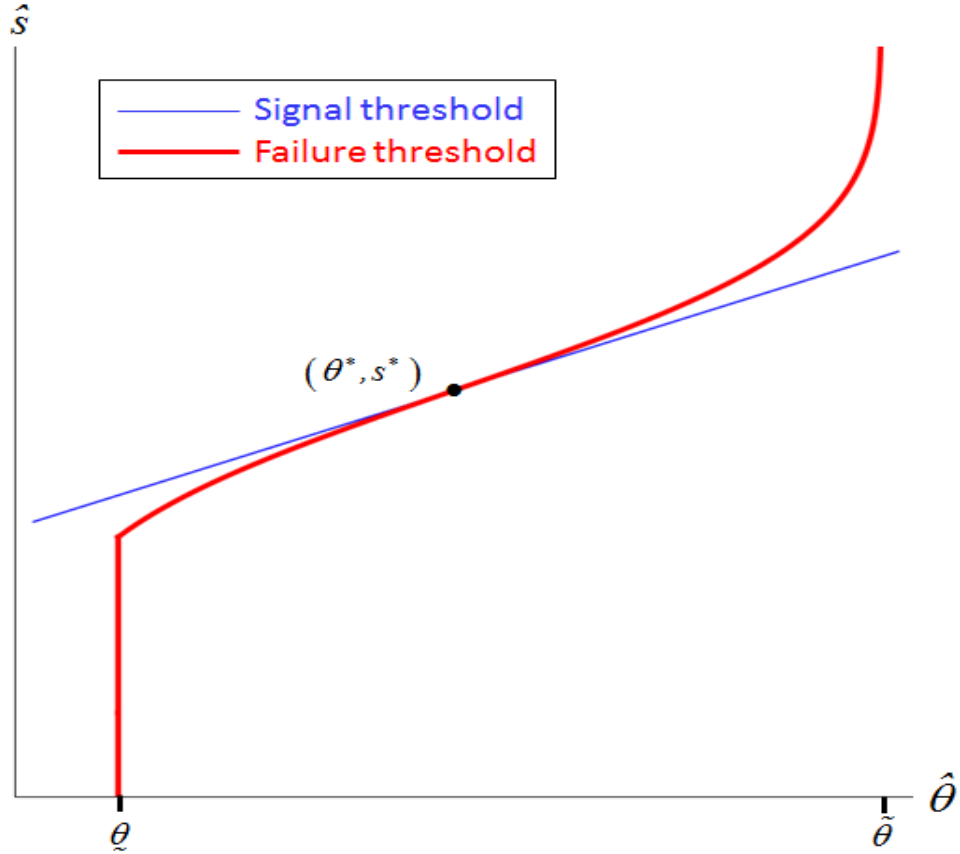
(It is linear and depends on $\theta | s$ and on conservativeness γ of investors)

Equilibrium characterization

- Equilibria are the intersection points of the two increasing curves yielding failure and signal thresholds $\left(\hat{\theta},\hat{s}\right)$:

$$\hat{\theta} = \theta_F(\hat{s})$$
$$\hat{s} = s_T\left(\hat{\theta}\right)$$

Determination of equilibrium pair
Bank run model



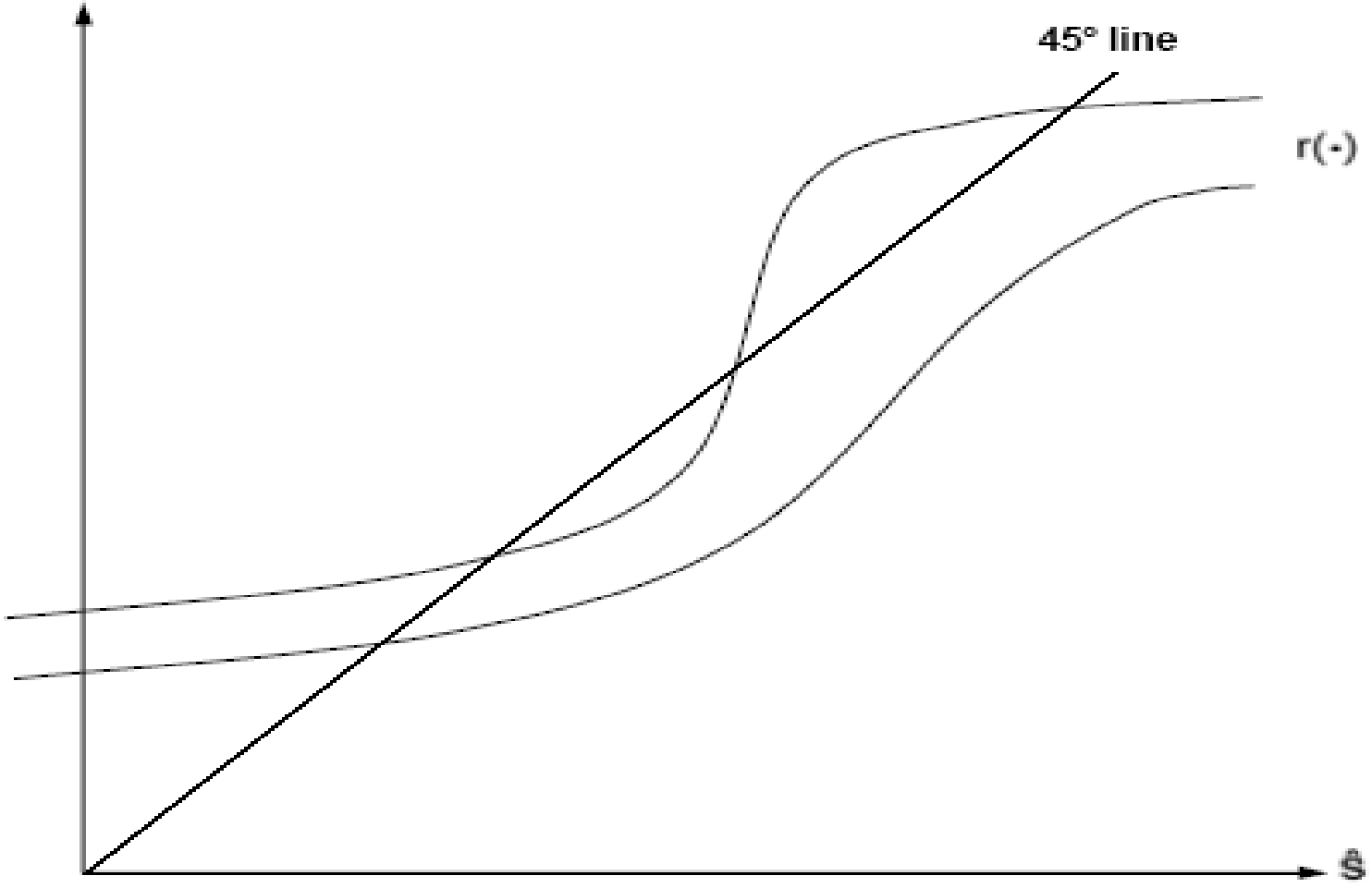
- Strategic complementarity: both curves are increasing and may give rise to multiple equilibria

Best response function

$$r(\hat{s}) = \hat{s}_T\left(\theta_F(\hat{s})\right)$$

$$r(\hat{s}) = \frac{\tau_\theta + \tau_\varepsilon}{\tau_\varepsilon}\theta_F(\hat{s}) - \frac{\tau_\theta}{\tau_\varepsilon}\mu_\theta - \frac{\sqrt{\tau_\theta + \tau_\varepsilon}}{\tau_\varepsilon}\Phi^{-1}(\gamma)$$

Best response, SC and multiplicity



Equilibrium

- The probability of a crisis conditional on $s = s^*$ is γ.
- There are at most three equilibria in the linear case.
- There is a critical $\bar{h}_0 \in (0,1)$ such that:
  - At the smallest equilibrium, $\theta^* = \underset{\sim}{\theta}$ if $h(\underset{\sim}{\theta}) \geq \bar{h}_0$;
  - $\theta^* > \underset{\sim}{\theta}$ for any equilibrium if $h(\underset{\sim}{\theta}) < \bar{h}_0$.
- The equilibrium is unique if $\tau_\theta / \sqrt{\tau_\varepsilon} \leq h_1 \sqrt{2\pi}$ where h_1 is the minimal slope of $h(\cdot)$.

Argument

- Game is (symmetric) monotone supermodular (Vives (1990), Van Zandt-Vives (2007)):
  - $\pi(y_i, y; \theta)$ has increasing differences in $(y_i, (y, -\theta))$,
  - signals are affiliated.
- Therefore,
  - extremal equilibria exist, are symmetric, and
  - in monotone (decreasing) strategies of the form: $y_i = 1$ if $s_i < \hat{s}$;
- Any equilibrium (s^*, θ^*) fulfills:
  - $y(\theta^*, s^*) = Pr(s \leq s^* \mid \theta^*) = h(\theta^*)$, and
  - $E(\pi(1, y(\theta); \theta) - \pi(0, y(\theta); \theta) \mid s = s^*) = 0$ or $Pr(\theta \leq \theta^* \mid s^*) = \gamma$,

  where $\gamma \equiv C / (B + C) < 1$.
- Show that there is $\bar{h}_0$ such that $\theta^* = \underset{\sim}{\theta}$ for $h(\underset{\sim}{\theta}) \geq \bar{h}_0$, and for $h(\underset{\sim}{\theta}) < \bar{h}_0$ we have that $\theta^* > \underset{\sim}{\theta}$.
- If $\tau_\theta / \sqrt{\tau_\varepsilon} \leq h_1 \sqrt{2\pi}$ then $r' \leq 1$ and the equilibrium is unique.

Strength of SC

- Depends on the slope of the best reply r'
- r' is increasing in τ_θ (better public information)
- The maximal value of r' is

$$\overline{r}' \equiv \frac{\tau_\theta + \tau_\varepsilon}{\tau_\varepsilon + h_1\sqrt{2\pi\tau_\varepsilon}}$$

  - decreasing in h_1 (slope of h, sensitiveness of critical fraction to θ) and
  - decreasing and then increasing in τ_ε with $\overline{r}' \to \infty$ as $\tau_\varepsilon \to 0$ and $\overline{r}' \uparrow 1$ as $\tau_\varepsilon \to \infty$.

- The slope r' will tend to be larger
  - with a smaller slope of h (e.g. balance sheet and market stress)
  - with more noise in the signals in relation to the prior ($\tau_\theta / \sqrt{\tau_\varepsilon}$)

Balance sheet structure of intermediary

- Short-term leverage
- Liquidity ratio

Market stress indicators

- Competitive pressure
- Fire sales penalties

Information parameters /transparency

Degree of strategic complementarity of actions of investors

Fragility

Balance sheet structure of intermediary

- Short-term leverage
- Liquidity ratio

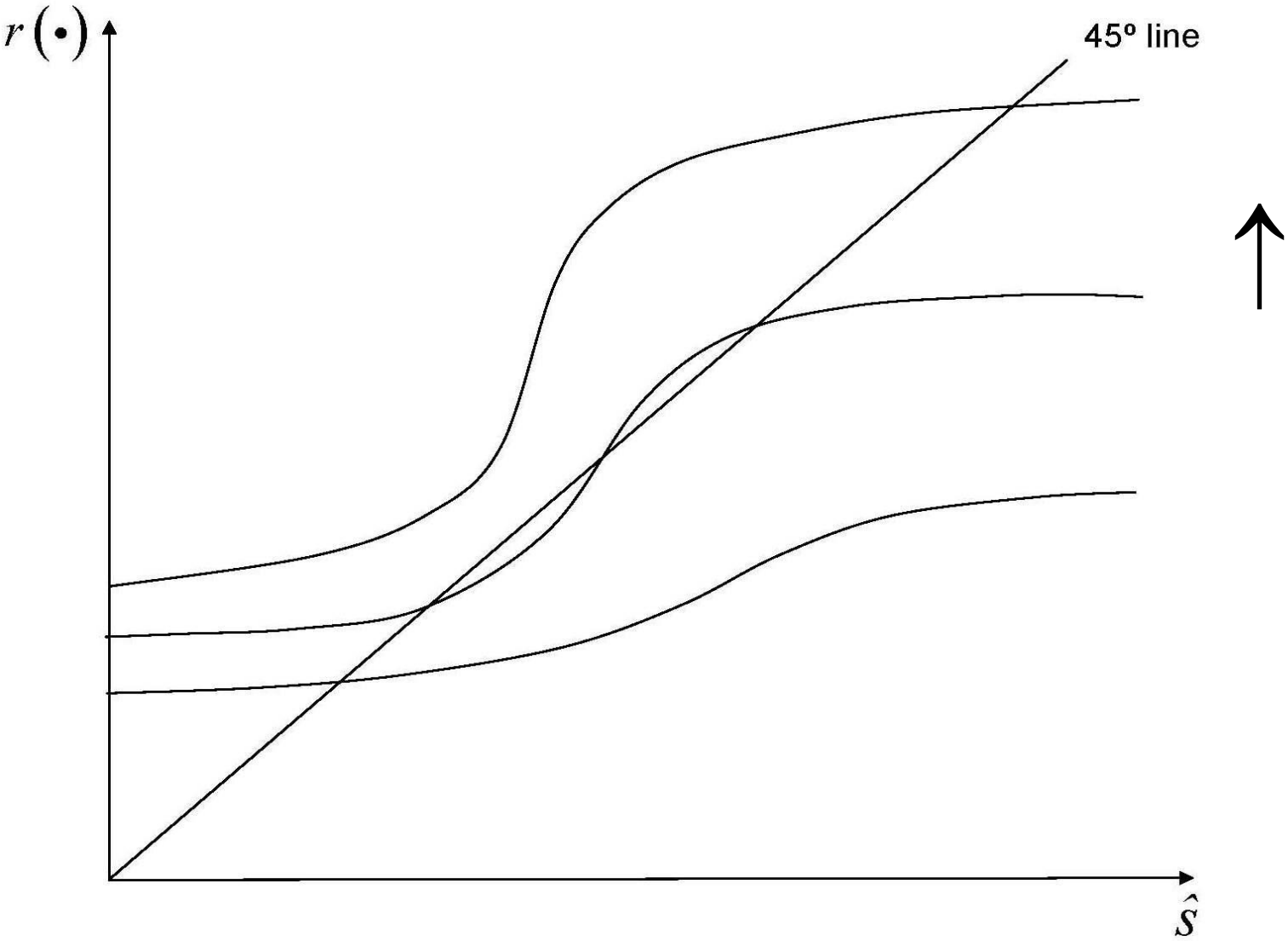
Market stress indicators

- Competitive pressure
- Fire sales penalties
- Conservatism (“risk aversion”) of investors

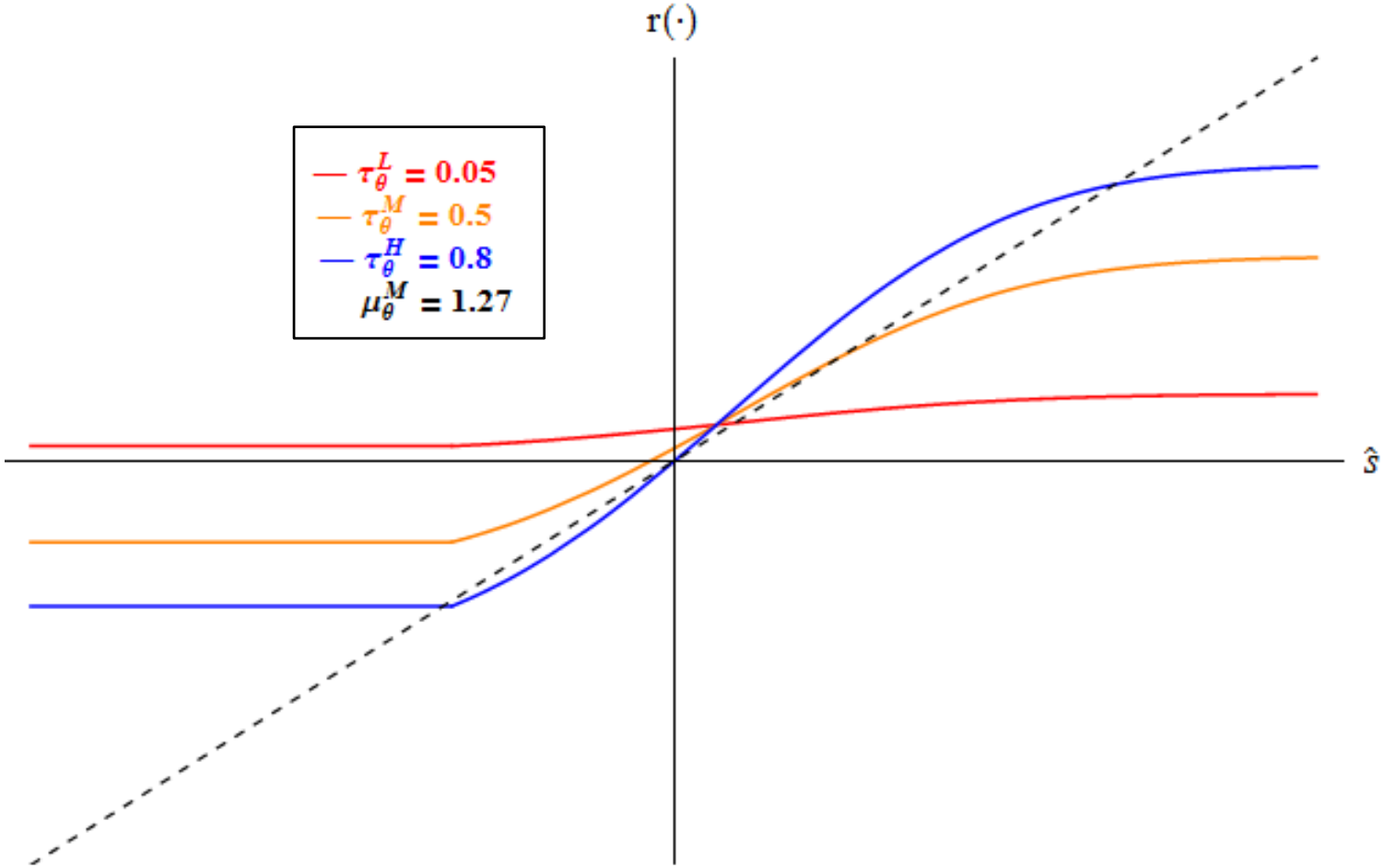
Information parameters /transparency

Probability of failure/crisis

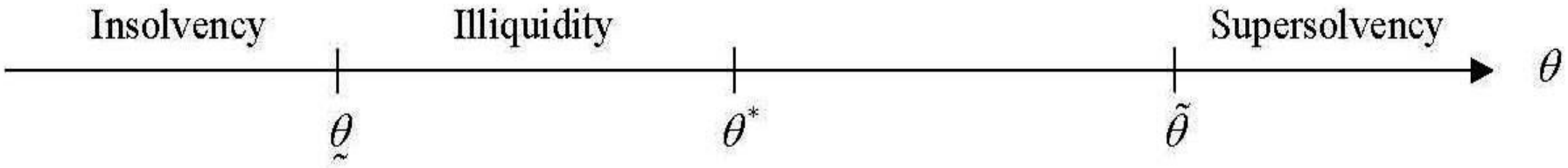
Bank run: the effect of increasing d, ℓ, λ



Bank run: increase in public precision



Coordination failure, illiquidity risk and solvency risk



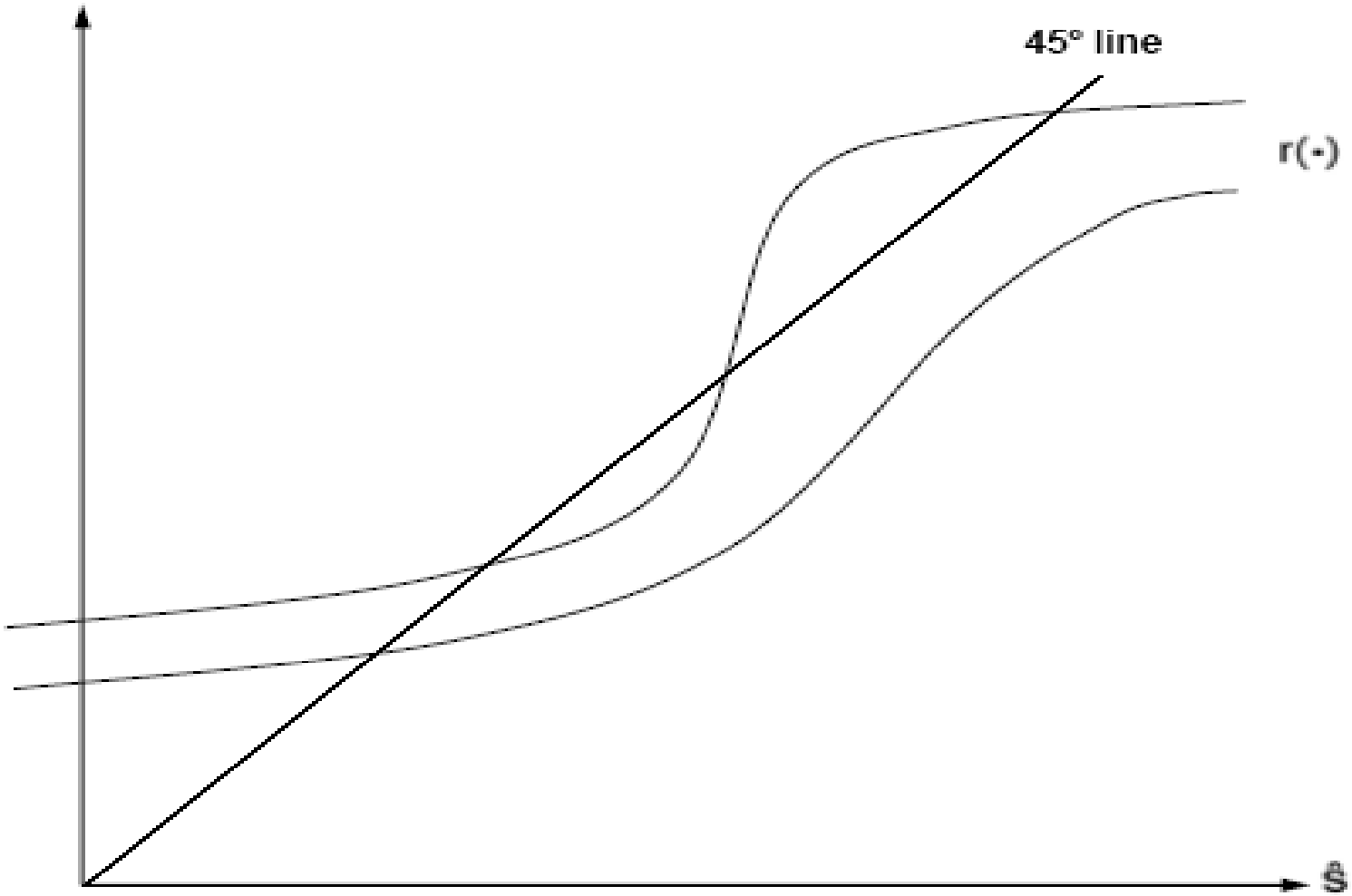
Coordination failure, illiquidity risk and solvency risk

- In the range $\left[\underset{\sim}{\theta},\theta^{*}\right)$ there is coordination failure from the point of view of the institution attacked.
  - In the bank case the bank is solvent but illiquid.
- The risk of illiquidity is given by $Pr\left(\underset{\sim}{\theta} \leq \theta < \theta^{*}\right)$
- The risk of insolvency by $Pr\left(\theta < \underset{\sim}{\theta}\right) = \Phi\left(\sqrt{\tau_{\theta}}\left(\underset{\sim}{\theta} - \mu_{\theta}\right)\right)$.

  (The probability that the bank is insolvent when there is no coordination failure from the point of view of the bank.)
- The overall probability of a “crisis” is $Pr\left(\theta < \theta^{*}\right) = \Phi\left(\sqrt{\tau_{\theta}}\left(\theta^{*} - \mu_{\theta}\right)\right)$.

Comparative statics

Out-of-equilibrium dynamics



Comparative statics

- For extremal (interior) equilibria or under adaptive dynamics: both θ^* and s^* (and the probability of crisis) are:
  - Decreasing
    - in $\gamma \equiv C / (B + C)$ (less conservative investors) and
    - in μ_θ (with multiplier effect increasing in τ_θ)
  - Increasing in stress indicator α.
- As h_1 decreases the region of potential multiplicity $\tau_\theta / \sqrt{\tau_\varepsilon} > h_1 \sqrt{2\pi}$ grows.

Examples

- Currency attacks:
  - The probability of a currency crisis is decreasing in the relative cost of the attack $\gamma = C/\hat{B}$ and in the expected value of the reserves of the central bank μ_θ.
  - The probability of illiquidity increases with the mass of attackers α.
- Credit freezes:
  - An increase in the mass of banks increases strategic complementarity and thus also increases the impact of public signals.

Comparative statics

		$\Pr(\theta < \underset{\sim}{\theta})$ (Insolvency)	$\Pr(\theta < \theta^*)$ (Failure)	$\theta^* - \underset{\sim}{\theta}$ (Range of illiquidity)
μ_θ (Strength of fundamentals)		(–)	(–)	(–)
τ_θ (Precision of public information)	μ_θ low	(+) (*if* $\underset{\sim}{\theta} > \mu_\theta$)	(+)	(+)
	μ_θ high	(–)	(–)	(–)
τ_ε (Precision of private information)	μ_θ low	0	(–)	(–)
	μ_θ high	0	(+)	(+)

Effect of precision of public information

- Increase in public precision increases strategic complementarity and helps investors coordinate on a run (bank, currency attack) or a panic credit freeze when fundamentals are weak.
- Multiplier effect of public information grows with its precision

Multiplier of public information

- The prior mean μ_θ of θ can be understood as a public signal of precision τ_θ.
- An increase in μ_θ will have an effect on the equilibrium threshold s^* over and above the direct impact on the best response of a player $\partial r / \partial \mu_\theta$:

$$\left| \frac{ds^*}{d\mu_\theta} \right| = \frac{|\partial r / \partial \mu_\theta|}{1 - r'} > \left| \frac{\partial r}{\partial \mu_\theta} \right|$$

- The multiplier increases with τ_θ since the slope r' increases with τ_θ and the impact of bad news about the fundamentals (lower μ_θ) is magnified.

Evidence of the multiplier effect of public information

- During the crisis banks borrowed from the Term Auction Facility, where the borrowing bank is one of many, at higher rates than those available at the discount window with stigma, and this spread was increasing with more stressed conditions in the interbank market (Armantier et al. (2010)).
- Bank of England announces that less information will be disclosed about use of discount lending facility.
- In the credit registry expansion in Argentina (Hertzberg et al. (2010)).

Bank run model

Bank run model

- There is a critical $\bar{m} \in (0,1)$ such that for $m < \bar{m}$, $\theta^* > \underset{\sim}{\theta}$; for $m \geq \bar{m}$, $\theta^* = \underset{\sim}{\theta}$ at smallest equilibrium.

Assume $1 - \ell^{-1} - d^{-1} < 0$ and $m < \bar{m}$. Then:

- $Pr\left(\theta < \underset{\sim}{\theta}\right)$ is decreasing in m and in μ_θ, increasing in d, and independent of λ, ℓ, and γ.

- $Pr\left(\theta < \theta^*\right)$ (and the critical θ^*) are decreasing in m, γ, and in μ_θ, and increasing in λ, ℓ, and d.

- $\left[\underset{\sim}{\theta}, \theta^*\right)$ is decreasing in m and increasing in d. Both the range and $Pr\left(\underset{\sim}{\theta} \leq \theta < \theta^*\right)$ are decreasing in γ and increasing in λ and ℓ.

Example

<u>Case</u> $\tau_\varepsilon \to \infty$ (unique equilibrium with closed-form solution):

$$s^* = \theta^* = \underset{\sim}{\theta}\left(1 + \frac{\lambda}{1-m}\left(max\{1-\gamma-m, 0\}\right)\right)$$

and

$$\bar{m} = 1 - \gamma$$

Comparative statics of solvency & liquidity risk for $m < \bar{m}$

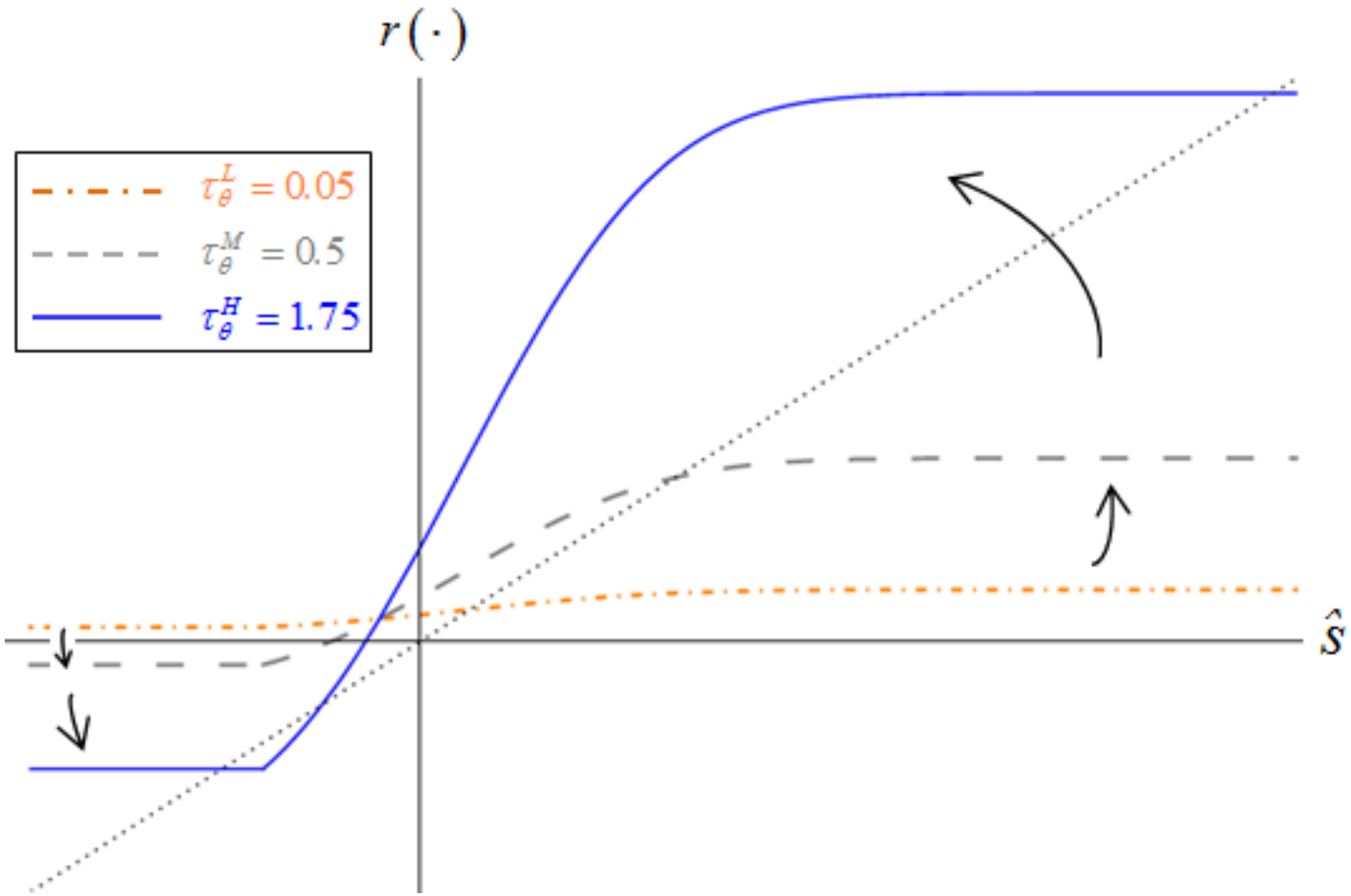
	$\Pr(\theta < \underset{\sim}{\theta})$ (Insolvency)	$\Pr(\theta < \theta^*)$ (Failure)	$\theta^* - \underset{\sim}{\theta}$ (Range of illiquidity)
m (Liquidity ratio)	$(-)$	$(-)$	$(-)$
ℓ (Leverage ratio)	$(+)$	$(+)$	$(+)$
d (Cost of funds)	$(+)$	$(+)$	$(+)$
λ (Fire sales penalty)	0	$(+)$	$(+)$
γ (Less conservative investors)	0	$(-)$	$(-)$

The effect of bad news and increased public precision

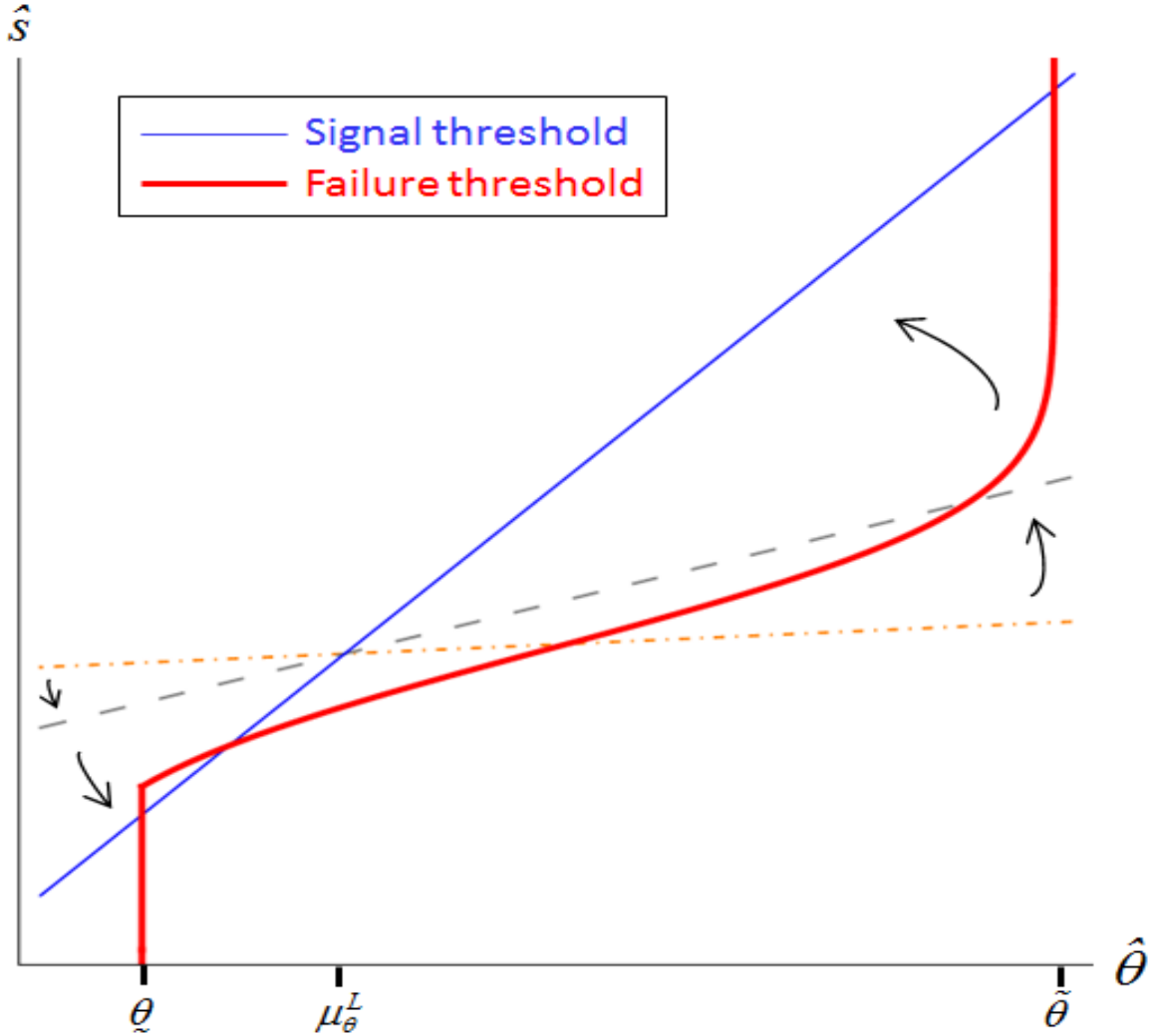
Simulations

Increase in public precision with weak fundamentals

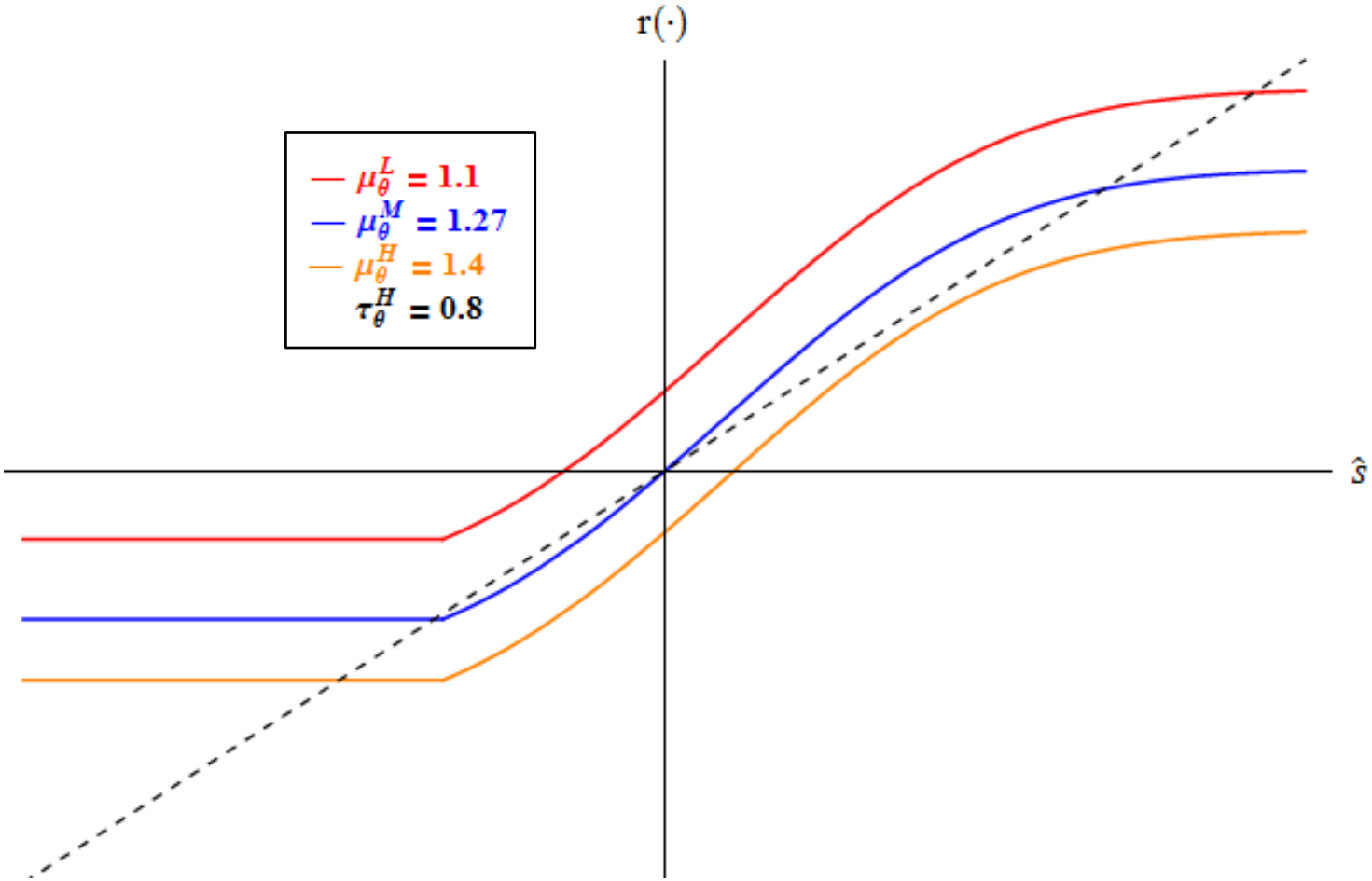
(low public signal)



Increase in public precision with weak fundamentals (low public signal): towards run equilibrium (even if safe equilibrium appears)



The effect of bad news when public precision is high



The 2007 run on SIV in the subprime crisis

The 2007 run on SIV

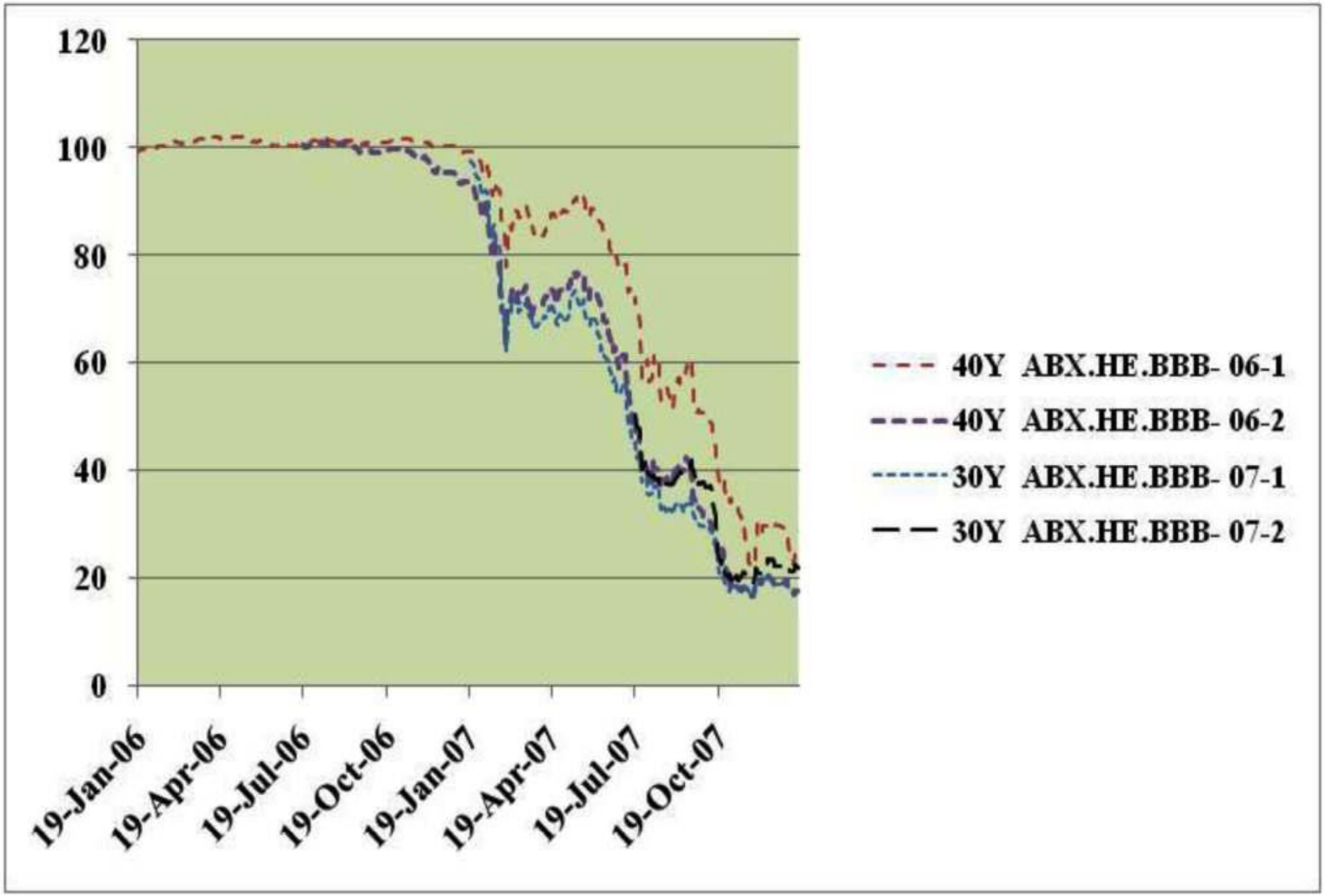
- The run began on ABCP conduits and SIVs which had some percentage of securities backed by subprime mortgages.
- These vehicles were funded with short term maturity paper and the run amounted to investors not rolling over the paper.
- The run seems to have been triggered by an unexpected decline in the ABX indexes in 2007.
- The accumulated bad news in the ABX indexes culminated in the panic of August 2007 when BNP Paribas froze a fund because of a complete evaporation of liquidity in some segments of the US securitized market.

ABX index

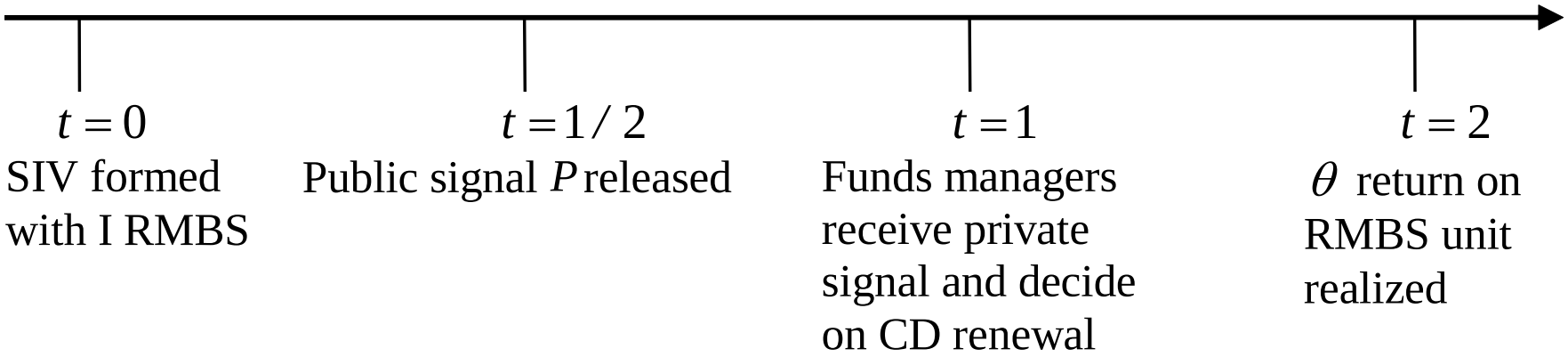
- Launched in January 2006 to track the evolution of residential mortgage-based securities (RMBS).
- The index is a credit derivative based on an equally weighted index of 20 RMBS tranches

  (and there are also subindexes of tranches with different rating, for different vintages of mortgages).
- The ABX index has provided two important functions:
  - information about the aggregate market valuation of subprime risk, and
  - an instrument to cover positions in asset-based securities, for example by shortening the index itself (Gorton (2008, 2009)).

ABX BBB- Prices



SIV 2007 run



The public signal *P* is the price of a derivatives' market with RMBS as underlying asset (ABX index).

SIV run

- Introduction of the ABX index implies a discrete increase in the public precision which raises strategic complementarity.
- A high level of noise in the signals will also increase strategic complementarity.
  - Imprecise signals of SIV investors are likely given the opaqueness of the structured subprime products and distance from loan origination.
- When bad news strike then a run equilibrium is induced.
- The impact of the bad news is magnified since short-term leverage and the cost of funds (because of competition) were high and fire sales penalties for early asset sales became high during the crisis

  (all those factors make strategic complementarity high).

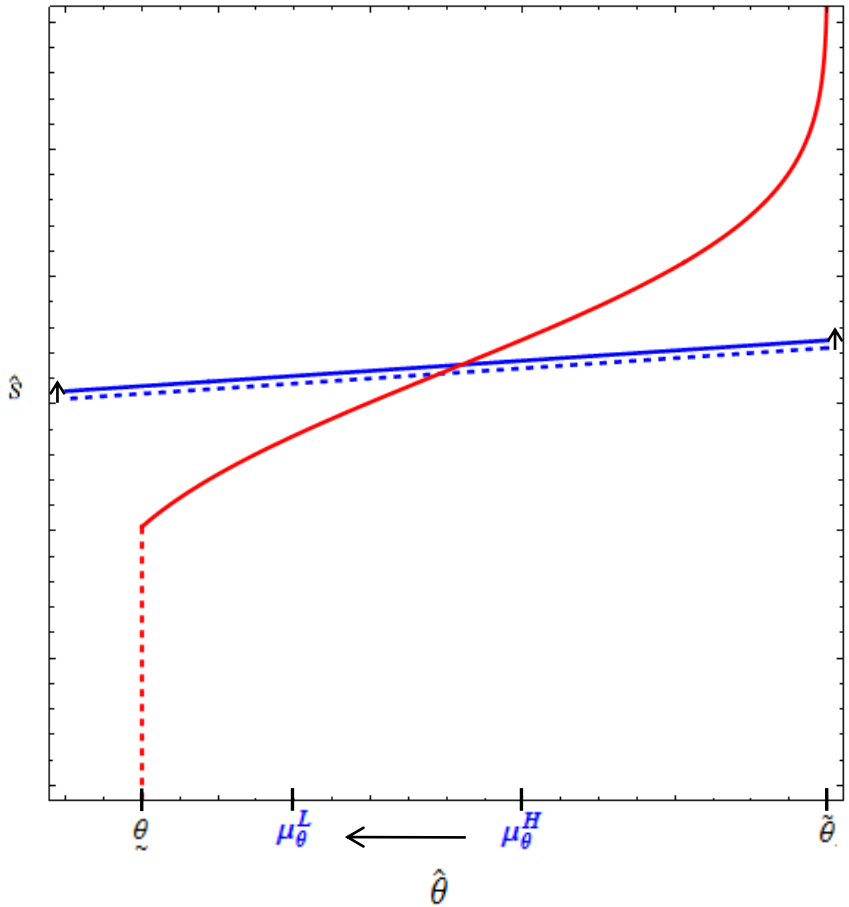
Simple scenario

- The public signal is the price of a derivatives' market with RMBS as underlying asset (ABX index).
  - It aggregates the information of market participants
- Neither the SIV nor the fund managers in the short-term debt market participate in the derivative market.
- Introduction of the ABX index implies a discrete increase in the public precision, which together with bad news will lead to a higher probability of a crisis

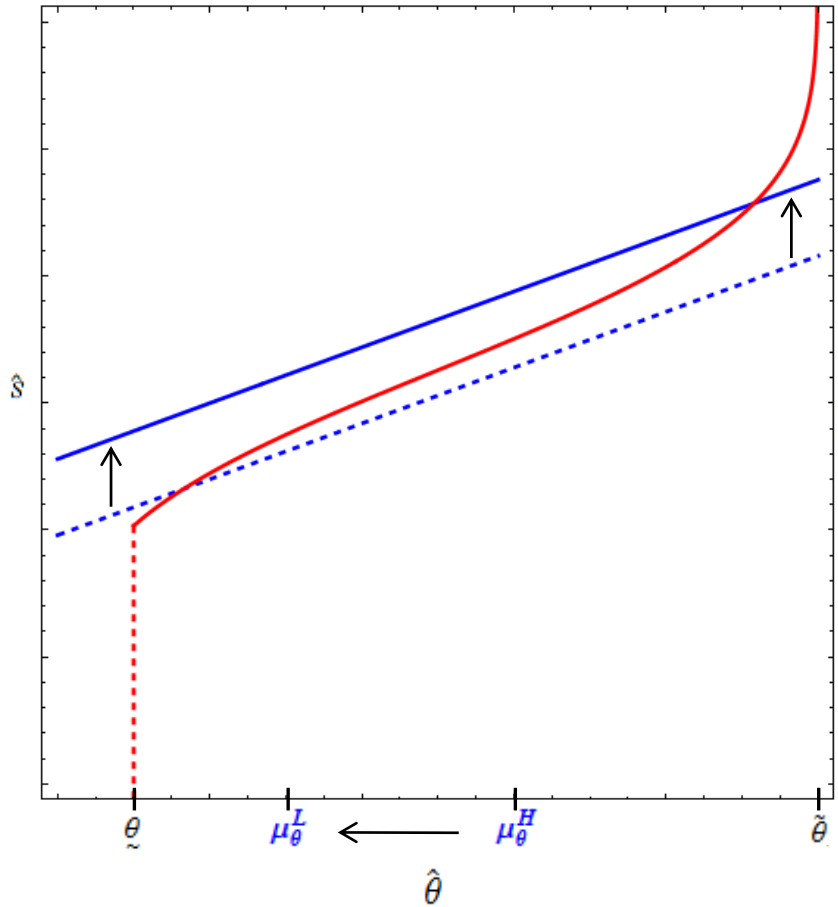
  (both because of the direct impact of bad news and increased public precision (together with bad news))
- A high level of noise in the signals will push in the same direction.
  - Imprecise signals of SIV investors are likely given the opaqueness of the structured subprime products and distance from loan origination

The effect of bad news

Low precision of public information



High precision of public information



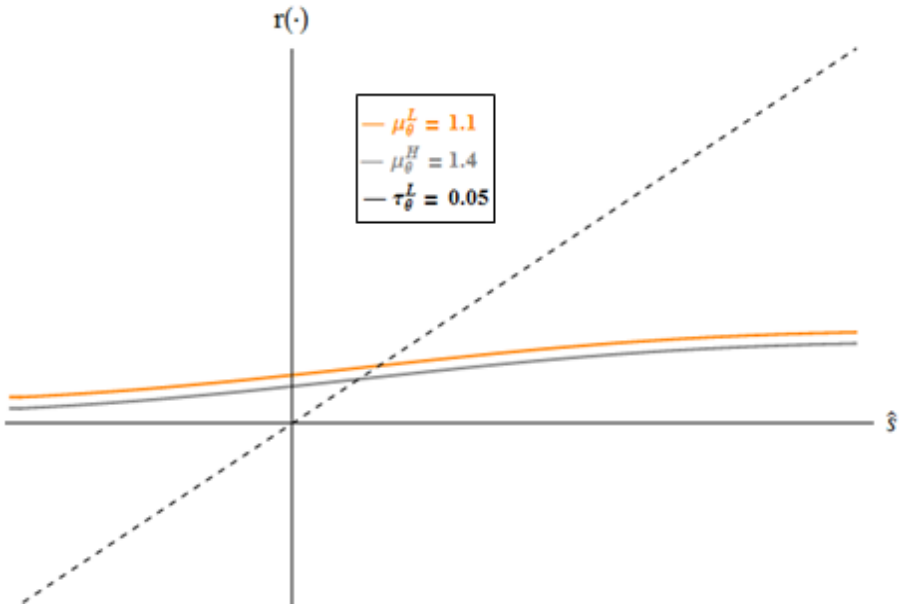
Failure curve

— Optimal threshold $\mu_\theta^L = \{1.1\}$
··· Optimal threshold $\mu_\theta^H = \{1.4\}$
$\tau_\theta^M = \{0.5\}$

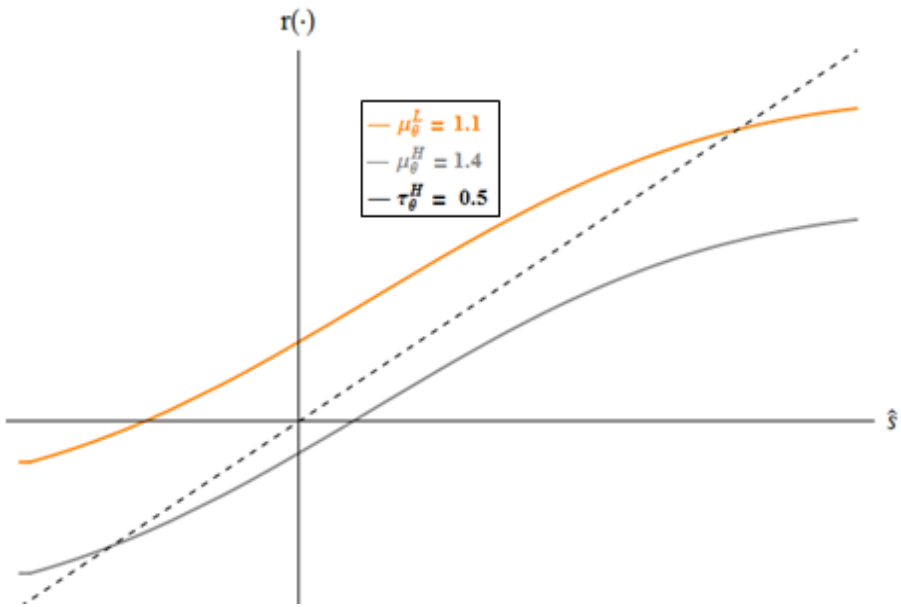
— Optimal threshold $\mu_\theta^L = \{1.1\}$
··· Optimal threshold $\mu_\theta^H = \{1.4\}$
$\tau_\theta^L = \{0.05\}$

The effect of bad news

Low precision of public information



High precision of public information



Effect of bad news in the ABX

From safe equilibrium to run equilibrium

High SC with high:

- **precision of public information,**
- **short-term leverage,**
- **competitive pressure,**
- **fire sales penalty.**

Failure curve

— **Optimal threshold** $\mu_\theta^L = \{1.1\}$

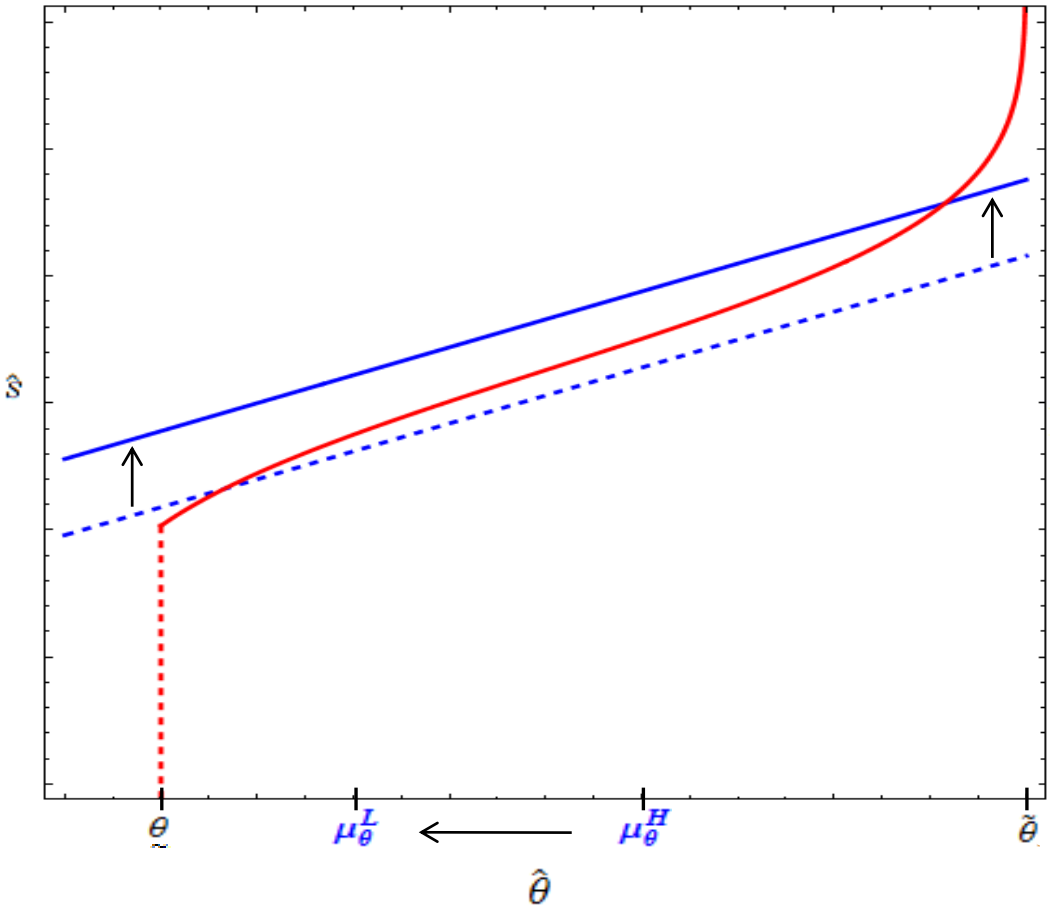
··· **Optimal threshold** $\mu_\theta^H = \{1.4\}$

$\tau_\theta^M = \{0.5\}$

— **Optimal threshold** $\mu_\theta^L = \{1.1\}$

··· **Optimal threshold** $\mu_\theta^H = \{1.4\}$

$\tau_\theta^L = \{0.05\}$



Summary of results

- Probability of failure increases with
  - balance sheet stress (short-term leverage, low liquidity, high return on short-term debt);
  - market stress (fire sales penalty, more conservative investors), and with
  - the precision of public information when fundamentals are weak.
- Fragility (equilibrium sensitivity to small changes and possibility of discrete jumps) increases with degree of SC:
  + short-term leverage, competition, fire sales penalty, precision of public information
- Higher disclosure or introducing a derivatives market may backfire, aggravating fragility (in particular when the asset side of a financial intermediary is opaque).

Balance sheet structure of intermediary

- Short-term leverage
- Liquidity ratio

Market stress indicators

- Competitive pressure
- Fire sales penalties
- Conservatism (“risk aversion”) of investors

Information parameters /transparency

Probability of failure/crisis

Balance sheet structure of intermediary

- Short-term leverage
- Liquidity ratio

Market stress indicators

- Competitive pressure
- Fire sales penalties

Information parameters /transparency

Degree of strategic complementarity of actions of investors

Fragility

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THE ROLE OF REGULATION AND COMPETITION POLICY

XAVIER VIVES

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