

Finance and AI

When does an asset loss become a credit contraction?

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Day 1

Day 1 outline

- 1) Questions and Introduction
- 2) Losses and the equity buffer
- 3) Why intermediary net worth matters
- 4) The incentive constraint and debt limit
- 5) Equilibrium amplification
- 6) Capital repair and policy

Part I

Questions and Introduction

What happened?

Why did we miss it?



What happened?

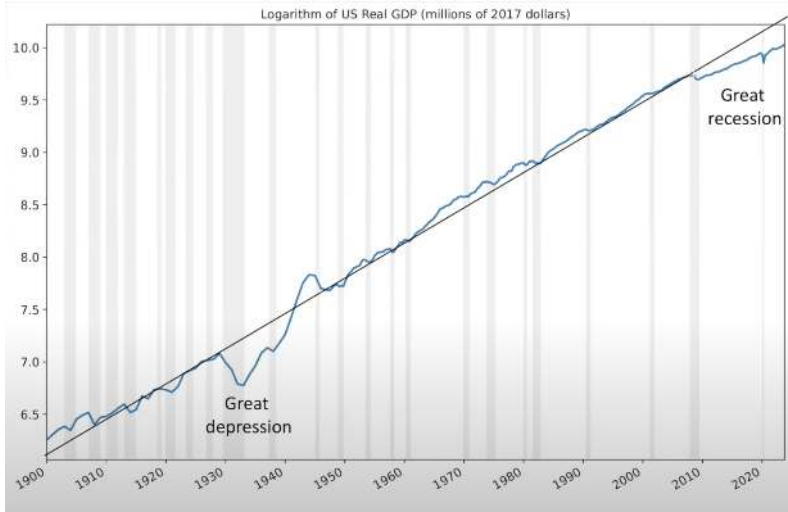


Figure: *

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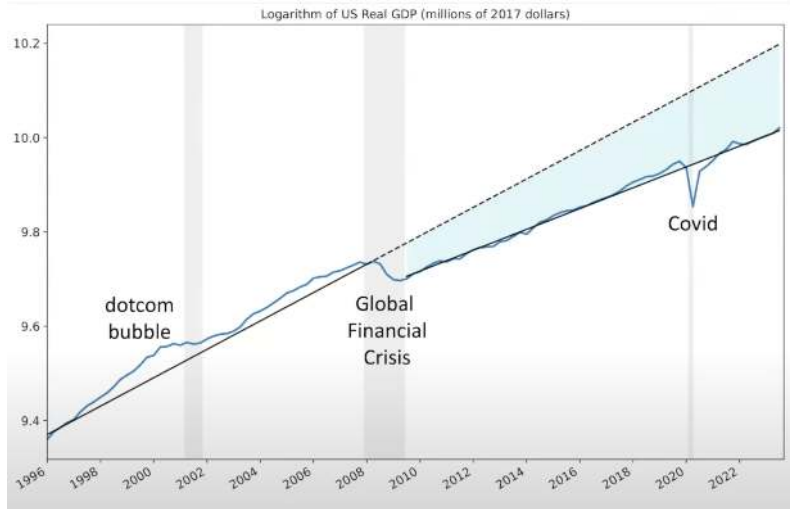


Figure: *

Queen's Question

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[Financial Times - 2008]



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[Guardian - 2012]



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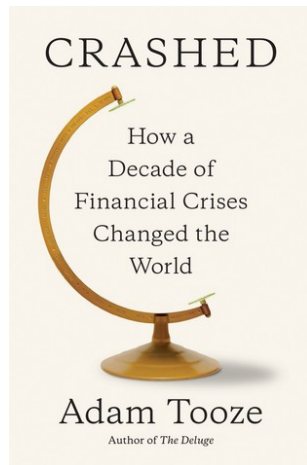
[Guardian - 2012]

- Sorry Ma'am — we just didn't see it coming



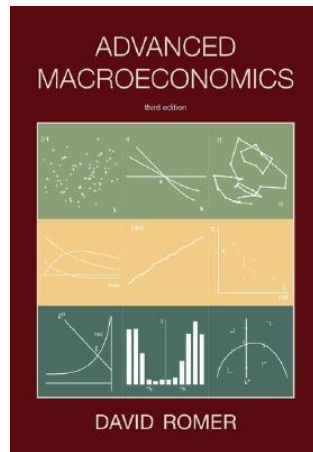
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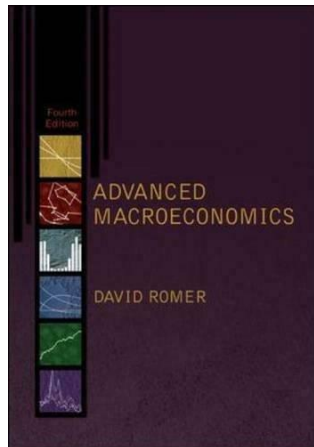
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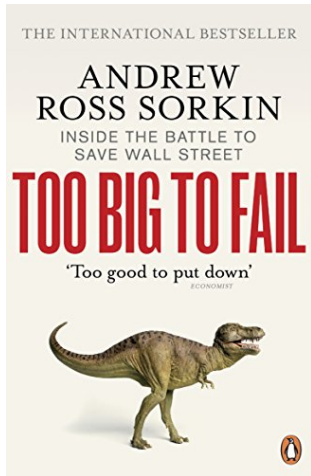
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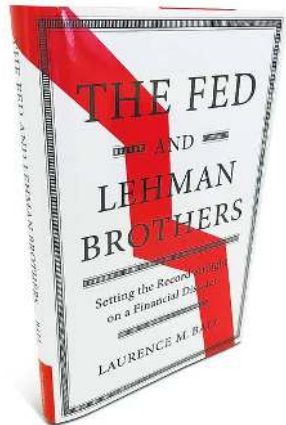
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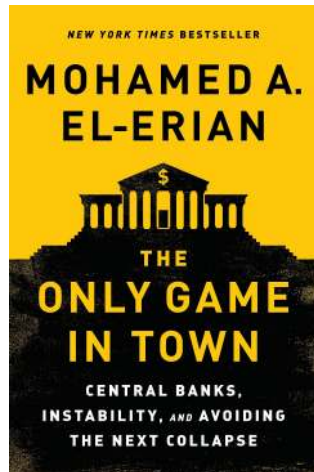


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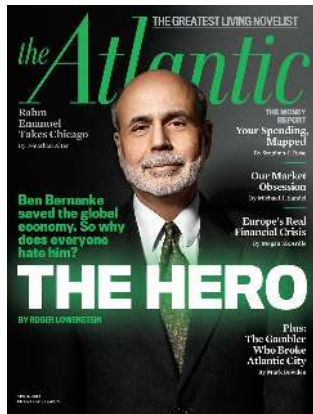


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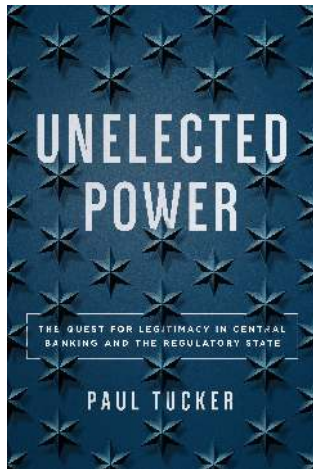


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- Central banks & bankers became the central figures.
- The new & most powerful main decision maker.
- Unelected Power.



Introduction

- In the models that we've seen so far the financial markets are perfect:
 - Households save or borrow to satisfy their Euler equations.
 - Firms borrow until the marginal product of capital = interest rate.
 - There are no defaults or borrowing constraints.
- The Crisis of 2007-8 demonstrated that even in the advanced modern economies this description could not be further away from the truth.
- There has been a tremendous increase in macro-finance research.
- Major issues this research is interested in:
 - Do financial markets amplify and propagate macroeconomic shocks?
 - Are financial markets an independent source of shocks to the economy?
 - Why do financial crises happen, and what should policymakers do? etc.

Bear Stearns reported adequate capital and lost its funding in a week

Bear Stearns was a major US investment bank and primary dealer that depended heavily on short-term secured wholesale funding.

Fiscal year-end 2007

$$A = \$395.4\text{bn},$$

$$L = \$383.6\text{bn},$$

$$N = A - L = \$11.8\text{bn}.$$

The reported balance sheet was highly leveraged.

Week of 10 March 2008

The holding-company liquidity pool fell from **\$18.1bn** to **about \$2bn** as counterparties withdrew customary secured funding. Bear reported capital above the standards then applied to it.

How can a firm report positive capital and still lose the ability to finance itself within days?

Bear Stearns 2007 Form 10-K; SEC liquidity chronology, 20 March 2008; Federal Reserve testimony, 3 April 2008.

Four conditions must hold before an asset loss reduces lending

The lecture asks what else must be true before firms lose access to credit.

1. **Loss absorption:** leverage must make the asset mark large relative to equity.
2. **Credibility:** lower equity must tighten credible outside funding.
3. **Equilibrium:** prices or alternative funders must not replace the lost capacity.
4. **Transmission:** loans must absorb the adjustment and borrowers must lack substitutes.

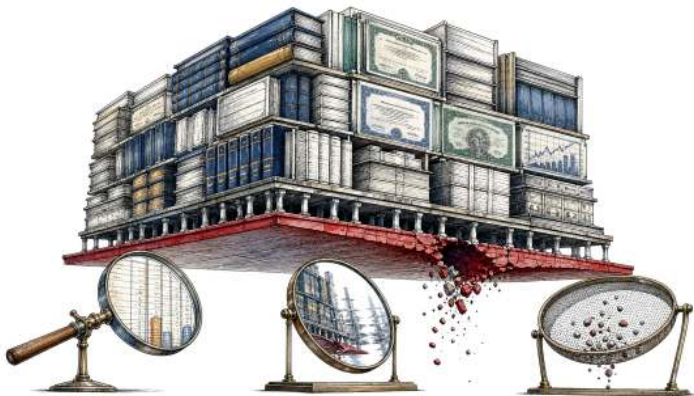
Each arrow needs different evidence. No capital ratio, funding statistic, or lending correlation establishes the entire chain.

Part II

Losses, leverage, and the equity buffer

How small can an asset loss be
and still destroy a bank?

One bank, one loss, followed from the
bond market to the capital ratio.



Equity is the residual that absorbs the first loss

The balance sheet contains one identity:

$$\underbrace{A}_{\text{assets}} = \underbrace{D}_{\text{promised claims}} + \underbrace{N}_{\text{equity}}.$$

For Bear Stearns at fiscal year-end 2007,

$$395.4 = 383.6 + 11.8 \quad (\$bn).$$

The promised claims do not absorb the first loss. Equity is the residual that does.

Notation used throughout Day 1: A , economic value of assets; D , deposits and other promised claims; $N = A - D$, equity or net worth.

Bear Stearns 2007 Form 10-K, fiscal year ended 30 November 2007. Figures in \$bn; values rounded to one decimal place.

This record supplies the scale for the loss arithmetic. It does not yet explain why Bear failed in March 2008.



Capital absorbs losses; cash settles payments

Two balance-sheet objects answer different questions:

Capital or equity N is the residual claim. It absorbs losses because promised creditors are paid first.

Cash and liquid assets sit inside A . They meet payments because they can be transferred or sold quickly.

A bank can therefore be well capitalised but short of cash, or liquid today but economically insolvent.

N is a claim, not a holding: it records who bears a loss, and no cash is set aside for it. Liquidity is a property of items inside A : how fast they convert into settlement.

Capital asks who ultimately bears a loss. Liquidity asks whether a payment can be made now.

Bank of England (2013), *Bank capital and liquidity*.



Equity must be measured against the assets it supports

The number alone decides nothing. It has to be measured against the balance sheet it is protecting.

$$\kappa \equiv \frac{N}{A} = 2.98\% \qquad \ell \equiv \frac{A}{N} = 33.53$$

$\equiv$ means “is defined as”. κ is the capital ratio, equity per unit of assets; ℓ is leverage, assets carried per unit of equity.

How far to the edge?

Just under three cents of cushion for every dollar of assets.

How fast do we get there?

Every dollar of equity is carrying \$33.53 of assets.

One fact, two questions. $\kappa = 1/\ell$.

Debt is a fixed promise, so the whole loss lands on equity

Take the same bank, $\kappa = 2.98\%$ and $\ell = 33.53$, and rescale it to $A = 100$. Now give it a loss.

before the loss: $A = 100$, $D = 97.02$, $N = 2.98$,

after a 2% asset loss: $A' = 98$, $D' = 97.02$, $N' = 0.98$.

$N = \kappa A = 2.98$ and $D = A - N = 97.02$. Only A is revalued.

A deposit or a bond promises a stated amount. It does not fall because the bank had a bad day, so the loss has nowhere else to go:

$$N' = \underbrace{A'}_{(1-x)A} - D = N - xA.$$

	level	%
assets A	-2	-2.0
equity N	-2	-67.1

The same two units. Equity is the smaller base, so it takes the whole percentage shock: $x\ell = 67.1\%$ of the equity is gone. That is also x/κ , so the bank is 67.1% of the way to the edge.

Here $x = 0.02$ is the proportional asset-value loss. This is a value shock, not a creditor withdrawal: D is therefore held fixed.

The equity loss equals the asset loss times leverage

One case is not a rule. Take $N' = N - xA$ from the previous slide and divide the equity loss by the equity you started with:

$$\frac{-\Delta N}{N} = x \frac{A}{N} = x \ell$$

Nothing new is assumed. This is the same arithmetic, written as a fraction of equity instead of a level.

asset loss x	equity lost $x \times 33.53$	equity left
1%	33.5%	two thirds
2%	67.1%	one third
2.98%	100%	nothing

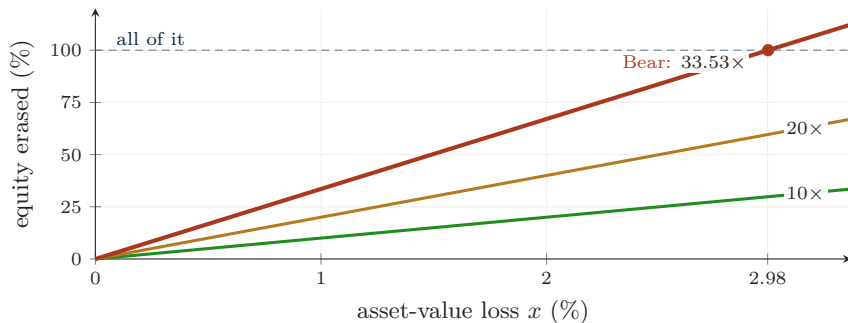
The middle row is the bank we have just marked down.

Leverage does not cause the loss. It decides how much equity each unit of loss uses up. Equity runs out when $x\ell = 1$, that is at $x = 1/\ell = \kappa$.

Zero book equity is not failure: it can come sooner through liquidity, or later through support or forbearance.

Higher leverage makes the same asset loss destroy more equity

optional extension



The asset shock is held fixed on all three lines. Higher balance-sheet leverage makes the equity response steeper.

For intuition only, Bear's book-equity/assets ratio was 2.98%. Modern Basel III instead uses Tier 1 capital over a prescribed exposure measure and sets a 3% minimum; the two ratios are not directly comparable.

Basel Committee, leverage-ratio definition and minimum.

Final maturity does not measure interest-rate risk

Now leave Bear Stearns and consider a stylised fixed-rate bond. You lend at 1% for ten years; market rates then rise and new bonds pay 4%. Every payment still arrives in full and on time, yet nobody will now buy your 1% claim at face value:

$$100 \longrightarrow 75.7.$$

Ten-year bond, 1% coupon, priced at the new 4% market yield. Nothing defaults.

- The loss depends on **how long your money is out**.
- Final maturity misses the timing of interim coupons: a bond paying large coupons returns much of its present value early.
- What is needed is the *average* time you wait, each payment weighted by what it is worth today.

That average has a name.

Duration measures waiting time; modified duration measures the loss

Duration is the average time you wait for your money, each payment weighted by what it is worth today. All the money here arrives at year 5, so the wait is 5 years.

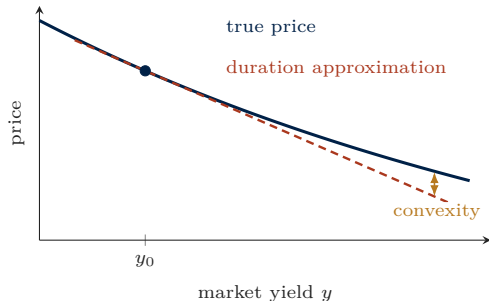
Years are not a loss. One year of extra waiting is one more round of discounting, worth $1/(1+y)$:

$$D_{\text{mod}} = \frac{5}{1+y} = \frac{5}{1.03} = 4.85, \quad \frac{\Delta P}{P} \approx -D_{\text{mod}} \Delta y.$$

$y = 3\%$. Differentiating $P = 100/(1+y)^5$ gives the $1+y$.

A 40 basis point rise costs $4.85 \times 0.004 = 1.94\%$. The line is the estimate, the curve is the truth: they separate as Δy grows, and duration overstates the loss.

Annual compounding, small parallel shift; 40 basis points is 0.004. A worked calculation, not a mark on Bear's book.



A bank's interest-rate loss depends on exposure, duration, and hedges

optional extension

Not everything a bank owns moves with interest rates. Let s be the share of assets that does.

The duration rule applies to that share, and leverage does the rest:

$$\underbrace{-s D_{\text{mod}} \Delta y}_{\text{asset loss } x} = -0.30(5)(0.004) = -0.6\% \implies \underbrace{-x \ell}_{\text{equity loss}} = -0.6\% \times 20 = -12\%$$

Stylised bank: 30% of assets exposed, $D_{\text{mod}} = 5$, a 40 basis point rise in y , and leverage $\ell = 20$.

A rate move of less than half a percentage point has taken an eighth of the bank's capital, and no borrower has missed a payment.

This is the asset side only. The bank's own debts also have duration, and hedges pay out when rates rise, so $\Delta N = \Delta A - \Delta D$. A bank's loss cannot be read from asset duration alone.

Economic value falls before accounting and regulatory capital record it

1. **Economic value.** Under a stated valuation rule, rates or expected cash flows change the asset value immediately even if recognition is delayed.
2. **Accounting recognition.** Fair value, impairment, provisions decide when it enters the books.
3. **Regulatory mapping.** Eligible-capital definitions decide whether the ratio moves at all.

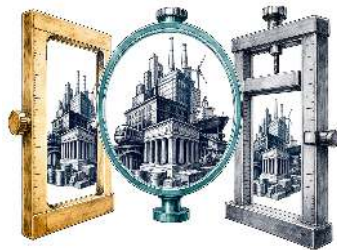
Hold to maturity can defer recognition under specified accounting rules; it does not remove the economic-value loss, the opportunity cost of a below-market yield, or the risk of a forced sale.

Three different numbers are called capital

- **Book equity:** the accounting residual.
- **Market equity:** what the shares actually trade for.
- **Regulatory capital:** eligible instruments over risk-weighted assets or exposure.

They diverge when accounting recognition, market prices, and regulatory eligibility respond differently. The gap between them can itself be informative.

$\kappa = N/A$ is used here. It is not CET1/RWA or market-to-book.



Three ways back to 8%, and each one hurts somebody different

An 8% target means every 1 of your own money may carry **12.50 of assets**. The bank has 0.98 of equity left, so it is allowed to hold 12.25. It is holding **98**.

After the 2% mark, $A = 98$ and $N = 0.98$. The 8% figure is an illustrative market target, not the Basel leverage minimum. Working in appendix A3.

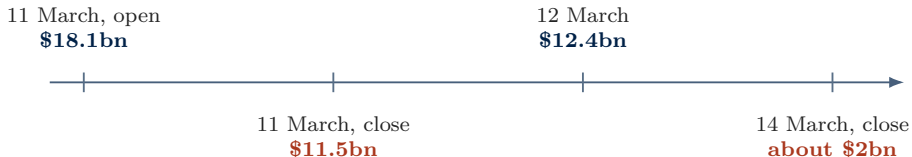
what the bank does	how much	who pays for it
sell assets	shed 85.75, which is 87% of the balance sheet	borrowers whose loans are not renewed, and the bank itself, selling into a falling market
raise new equity	find 7.46 of cash, nearly eight times the equity left	existing shareholders, whose stake is diluted away
convert creditors	turn 6.86 of debt into shares	the creditors, and no new cash arrives at all

None of these is a plan. They are this severe because leverage was 33 times: the loss removed two thirds of the equity, and the ratio then multiplies the shortfall by 12.5.

This is the arithmetic case for public intervention in 2008. Funding runs, uncertainty, and spillovers are the rest of it.

Bear's capital ratios did not prevent a wholesale funding run

At the start of the week, Bear reported capital above prevailing regulatory standards. Its holding-company liquidity pool nevertheless changed as follows:



Counterparties became unwilling to provide secured funding on customary terms, even against high-quality collateral. The confidence shock became a cash-timing constraint within days.

The 2007 balance sheet establishes leverage. The March chronology establishes a funding collapse. Neither record by itself proves that lower equity caused a contraction in bank lending.

The duration calculation is a teaching counterfactual, not an estimate of Bear's portfolio loss.
Bear Stearns 2007 Form 10-K; SEC liquidity chronology, 20 March 2008.

Accounting identifies who bears the loss, not why outsiders fund a bank

- Selling 87% of total assets is a balance-sheet contraction. It becomes a credit contraction only if loans, rather than cash or securities, absorb the adjustment.
- Issuing equity needs an investor willing to hand over cash.

Accounting has told us who absorbs the loss. It cannot tell us why an outsider would fund a bank at all.



Why should an outsider continue to finance a highly leveraged intermediary after its own stake has fallen? Section II introduces the credibility problem.

We followed the value channel, $\Delta A = \Delta N$. Absent a loss on asset sales, a creditor leaving instead gives $\Delta A = \Delta D$ and leaves N untouched: that is liquidity, and it is Day 2.

Part III

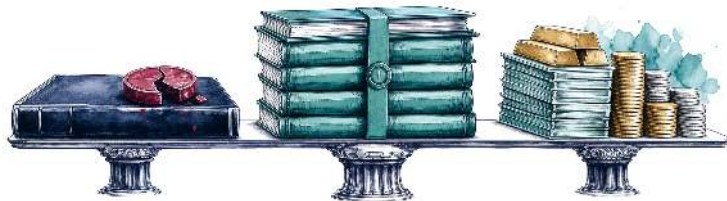
Why intermediary net worth matters

Why does intermediary net
worth affect credible outside
funding?

The institution that monitors borrowers
must itself remain credible to funders.



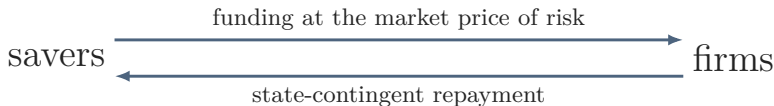
Accounting does not determine lending



- New equity can replace the lost net worth.
- Securities or cash can adjust while the loan book is preserved.
- If funding remains available at unchanged terms, lower N need not change scale.

A balance-sheet loss becomes a lending contraction only after an economic constraint and an adjustment margin are specified.

Without frictions, savers can fund firms directly



No intermediary is required to create information or enforce the contract.

Direct finance is sufficient when project quality is observable, actions and outcomes are contractible, verification is costless, and promises are enforceable.

Lending at scale requires solving four contracting problems

Information Who can distinguish a productive borrower from a weak one?

Incentives Which action will be chosen after funding is committed?

Verification Can outsiders observe cash flows, collateral, and losses?

Enforcement Which repayment promises can actually be imposed?

Intermediation creates value when it solves these problems more cheaply than direct finance. It also creates a new contract between the intermediary and its own funders.

The model below isolates the incentive problem in that second contract.

Outside funding finances assets; it does not become net worth

Starting from

$$A = N + D,$$

N : intermediary equity/net worth; D : deposits plus other outside claims; A : assets financed.

From this point onward, D is the model's outside promised funding; it is not being set equal to every liability reported on Bear's 2007 balance sheet.

one additional unit of outside funding gives

$$\Delta A = 1, \quad \Delta D = 1, \quad \Delta N = 0.$$

Borrowing expands both sides of the balance sheet. It does not rebuild the first-loss stake unless an outside claim is converted into equity.

Agency separates the decision-maker from the risk-bearer

An **agency problem** arises when one party chooses an action while another bears part of its consequences. The **principal** supplies resources and delegates an action; the **agent** takes that action with information or incentives the principal cannot fully contract on.

Borrower–bank borrowers know more about project quality and effort; the bank screens and monitors.

Bank–saver the bank controls monitoring and risk after savers supply funding; savers need credible repayment.

Day 1 formalises the second conflict: who monitors the intermediary?

One intermediary replaces duplicated monitoring by every saver

optional extension

- The intermediary screens and monitors many borrowers.
- Outside funders hold simpler claims on the intermediary.
- One information producer can replace duplicated bilateral monitoring.

Bilateral monitoring: $100 \times 50 = 5,000$ links,

Delegated monitoring: $100 + 50 = 150$ links.

Illustrative relationship count: 100 savers and 50 borrowers. It is not a monitoring-cost theorem.

Diamond (1984), delegated monitoring.



Net worth makes intermediation credible

The intermediary solves one information problem and creates another:

Who monitors the monitor?

- Own net worth absorbs the first loss.
- A larger equity stake raises the payoff from honouring outside claims relative to diversion.
- Outside funders can therefore credibly finance a larger balance sheet.

How much outside funding can a given level of N support?

Gertler and Kiyotaki (2010); Gertler and Karadi (2011).



Low net worth does not force the loan book to contract

After a loss, three adjustments can preserve existing loans:

1. New common equity supplies cash and rebuilds the loss-absorbing stake.
2. Cash or securities can fall while the stock of loans remains unchanged.
3. A borrower can replace this bank with another bank, a bond, or internal funds.

The accounting identity permits all three. A prediction for lending requires a behavioural constraint and a statement about the adjustment margin.

Prediction: if desired assets are below the funding ceiling, a fall in N changes capacity but not the chosen balance sheet.

Net worth matters only when the credibility constraint binds

Lower intermediary net worth reduces realised finance only when:

1. outside funders cannot contract on every action and payoff;
2. the intermediary needs outside claims to reach desired scale; and
3. the resulting credibility ceiling binds before another adjustment absorbs the loss.

skin in the game $\implies$ credible promise $\implies$ funding capacity.

The next section turns this intuition into an inequality.

How does a credibility problem become a numerical debt limit? Section III compares the banker's honest and diversion payoffs.

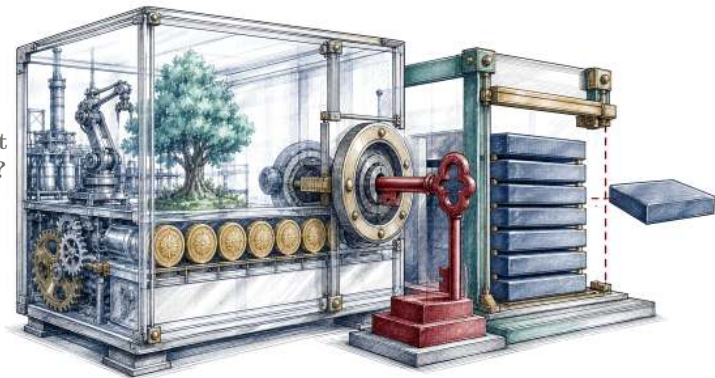
Four-link map: credibility is now the candidate second link; the model must still derive it and show when it binds.

Part IV

The incentive constraint and the debt limit

How does an incentive constraint turn net worth into a debt limit?

First hold promised returns fixed; market clearing comes only after capacity is understood.



The model links savers, an intermediary, and productive assets

Savers provide outside funding D and are promised the gross payment $R_D D$.

Intermediary contributes equity/net worth N and finances assets $A = N + D$.

Productive assets represent loans or claims on firms and pay the gross amount $R_A A$.

R_A : gross asset return; R_D : gross promised funding return. For example, $R_A = 1.10$ means a 10% net asset return. The outside claim D may represent deposits, repo, bonds, or other promised funding.

What the model determines, holds fixed, and leaves out

Determined inside credible outside funding D , asset scale $A = N + D$, and whether the incentive constraint binds.

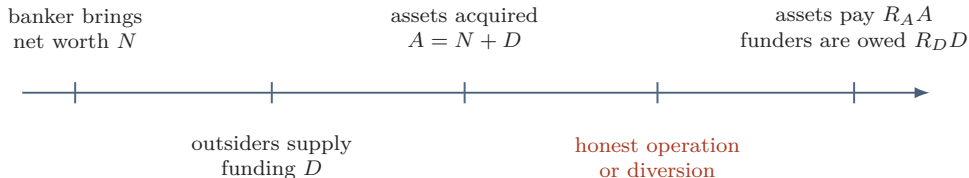
Held fixed first net worth N , asset return R_A , promised funding return R_D , and the diversion share λ .

Deliberately absent stochastic default, maturity, runs, regulation, market power, and endogenous asset prices.

This narrow contract is a feature: one mechanism is solved before other frictions are layered on. It is a teaching adaptation of the intermediary agency mechanism, not the full dynamic Gertler–Kiyotaki environment.

Gertler and Kiyotaki (2010); Gertler and Karadi (2011).

Diversion occurs after funding and before repayment



Funding arrives before the hidden action. Outsiders must therefore make repayment credible before they observe how the assets are operated.

The core model is deterministic and one-period. Market clearing is introduced only after the funding constraint is derived.

Stocks are chosen today; gross payments occur tomorrow

optional extension

$$\underbrace{N, D, A}_{\text{date-0 currency stocks}} \longrightarrow \underbrace{R_A A, R_D D}_{\text{date-1 currency payments}} .$$

- R_A , R_D , and λ are dimensionless; R_A and R_D are gross returns.
- $A = N + D$ is a date-0 financing identity; it is not a payoff equation.
- Diversion is a date-1 option, not a probability attached to date 0.

Keeping stocks and payments separate prevents the most common algebraic error in the incentive constraint.

The banker can divert a share of the asset payoff

After funding is committed, the banker can operate honestly or repudiate outside claims and retain

$$\lambda R_A A, \quad 0 < \lambda < 1.$$

- λ is a reduced-form **diversion share**.
- It is not a default probability, fraud frequency, or loss given default.
- It is not directly observed; it summarises private benefits, weak monitoring, and limited pledgeability.
- Diversion is an off-equilibrium option that restricts credible promises.

With $R_A = 1.10$, $\lambda = .15$, and $A = 100$, diversion yields 16.5, leaving 93.5 as the payoff potentially pledgeable under honest operation.

Risk shifting, weak monitoring, and private benefits motivate agency more broadly; the model compresses them into one reduced-form parameter.

Diversion leaves only part of the payoff pledgeable

$$R_A A = \underbrace{(1 - \lambda) R_A A}_{\text{pledgeable under honest operation}} + \underbrace{\lambda R_A A}_{\text{private diversion payoff}} .$$

Outside promises cannot exceed the pledgeable component while preserving the banker's incentive to operate honestly.

If an asset produces 110 but 15 can be privately retained, outsiders cannot treat the full 110 as reliable backing for repayment.

Higher λ leaves less payoff that can credibly back outside funding.

Pledgeable means promisable and believed. A payoff the banker could simply keep cannot be promised to anyone, whatever the contract says.

The banker compares the honest payoff with the diversion payoff

$$\Pi^{\text{hon}} = \underbrace{R_A(N + D)}_{\text{asset payoff}} - \underbrace{R_D D}_{\text{promised outside payment}},$$

$$\Pi^{\text{div}} = \underbrace{\lambda R_A(N + D)}_{\text{payoff privately retained after repudiation}}.$$

Π : the banker's end-of-period payoff under the indicated action.

Both choices operate the same asset base $A = N + D$. What differs is whether outside claims are honoured.

A return spread creates a motive to expand the balance sheet

Using the honest payoff just defined,

$$\Pi^{\text{hon}} = R_A N + (R_A - R_D) D.$$

If $R_A > R_D$, an additional unit of outside funding raises honest payoff by

$$R_A - R_D > 0.$$

With constant returns and $R_A > R_D$, desired scale is unbounded unless some constraint intervenes. Credibility determines how much of that scale outsiders will actually finance.

Every borrowed pound earns $1.10 - 1.04 = 0.06$ and the rate never falls, so the bank never chooses to stop. Whatever limits it must come from outside its own preferences.

Each extra pound of outside funding uses incentive surplus

An extra unit of D changes both actions' payoffs:

$$\Delta \Pi^{\text{hon}} = R_A - R_D, \quad \Delta \Pi^{\text{div}} = \lambda R_A.$$

S is the amount by which honesty beats diversion, defined in full on the next slide. Here only its change per extra pound of D is needed.

Hence its effect on the surplus from remaining honest is

$$\begin{aligned} \Delta S &= (R_A - R_D) - \lambda R_A \\ &= - \underbrace{[R_D - (1 - \lambda)R_A]}_g. \end{aligned}$$

When $g > 0$, each extra pound of outside finance uses scarce incentive surplus. Net worth supplies that surplus before any outsider is paid.

Honesty gains 0.06 per extra pound; walking away gains $\lambda R_A = 0.165$, because the prize scales with the whole balance sheet. So $g = 0.105$ is the rate at which the advantage of honesty is used up.

Outside funding can erode the incentive to remain honest

Define the honest-operation surplus:

$$\begin{aligned} S(D) &\equiv \Pi^{\text{hon}} - \Pi^{\text{div}} \\ &= (1 - \lambda)R_A N - \underbrace{[R_D - (1 - \lambda)R_A] D}_g. \end{aligned}$$

The new object g is the **incentive funding gap**: the surplus used by one additional unit of outside finance.

When $g > 0$,

$$\frac{\partial S}{\partial N} = (1 - \lambda)R_A > 0, \quad \frac{\partial S}{\partial D} = -g < 0.$$

Net worth supplies incentive surplus; outside funding uses it.

S is how much better honesty is than diversion. At $D = 0$ the banker's own money buys $S = (1 - \lambda)R_A N = 9.35$; each borrowed pound spends $g = 0.105$ of it.

Honest operation must pay at least as much as diversion

$$\boxed{R_A(N + D) - R_D D \geq \lambda R_A(N + D)} \quad (\text{IC})$$

- If (IC) holds, honest intermediation gives the banker at least as much as diversion.
- If (IC) fails, that scale D cannot be financed on the stated terms (R_A, R_D) .

The inequality restricts **credible scale**; it is not a probability of default.

In words: what the assets pay, less what the savers are owed, must be at least what the banker could walk away with. Nobody diverts in equilibrium because no one offers a contract where diversion would pay.

Funding capacity is finite only when $g > 0$

The sign of

$$g \equiv R_D - (1 - \lambda)R_A$$

determines whether this incentive constraint alone produces a finite limit.

$$\begin{aligned} g > 0 &\implies \text{finite outside-funding capacity,} \\ g = 0 &\implies \text{no funding gap per extra unit of } D, \\ g < 0 &\implies \text{(IC) alone supplies no finite cap.} \end{aligned}$$

The debt-capacity formula is valid only in the first case.

$g > 0$ says each borrowed pound genuinely eats into the honesty advantage. If it does not, borrowing never exhausts anything and this constraint alone never stops the bank.

Net worth sets a ceiling on credible outside funding

For $R_D > (1 - \lambda)R_A$, holding R_A , R_D , and λ fixed:

$$D^{\max} = \frac{(1 - \lambda)R_A}{R_D - (1 - \lambda)R_A} N \equiv \phi N,$$
$$A^{\max} = N + D^{\max} = (1 + \phi)N \equiv \psi N.$$

Here ϕ is the **outside-funding multiplier** and $\psi = 1 + \phi$ is the **total-asset capacity multiplier**. Both are defined only on the finite-capacity domain established on the preceding slide.

ϕ : pounds of other people's money per pound of the banker's own. ψ : total assets per pound of the banker's own. Here $\phi = 8.90$ and $\psi = 9.90$.

Net worth is valuable because it supports credible outside claims. The result is a **capacity proposition**, not a statement that the bank necessarily chooses $A^{\max}$.

Read ϕ as starting advantage divided by erosion rate: the stock of honesty N buys, over the amount each borrowed pound spends.

Capacity rises only when credible repayment improves

For fixed returns and $g > 0$,

$$D^{\max} = \phi N, \quad \phi = \frac{(1 - \lambda)R_A}{R_D - (1 - \lambda)R_A}.$$

$R_A \uparrow$ raises the payoff available under honest operation, so more outside repayment becomes pledgeable.

$R_D \uparrow$ makes each promised pound more expensive and widens the funding gap g .

$\lambda \uparrow$ raises the private benefit of diversion and reduces the pledgeable share.

These are fixed-return capacity effects. Equilibrium responses are smaller or different when the funding price and desired scale move.

Capacity is a ceiling, not the chosen balance sheet

Let A^{des} denote the scale the bank would choose without the financing constraint; it is a maintained demand object, not derived in this model. Then

$$A^* = \min\{A^{\text{des}}, A^{\text{max}}\}.$$

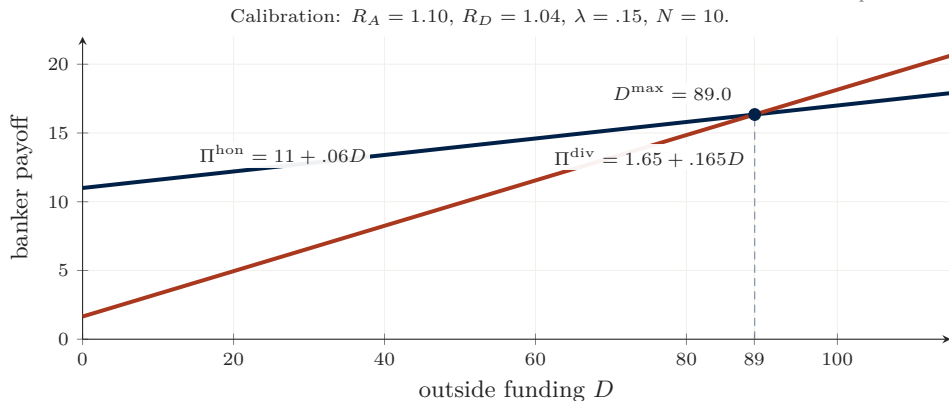
$$A^{\text{des}} < A^{\text{max}} \quad \Rightarrow \quad \text{constraint slack,}$$

$$A^{\text{des}} \geq A^{\text{max}} \quad \Rightarrow \quad \text{constraint binding.}$$

A fall in net worth changes realised scale only after the capacity ceiling crosses desired scale.

Funding stops where honest and diversion payoffs cross

optional extension



Left of the crossing, honesty dominates. At the crossing, the banker is indifferent and the incentive constraint binds. The lines start 9.35 apart, bought by the banker's own N . The red line climbs 0.165 per pound against the navy line's 0.06, so the gap closes at 0.105 and runs out at $D = 89$.

A worked example: $N = 10$ supports $D^{\max} = 89$

optional extension

Let

$$R_A = 1.10, \quad R_D = 1.04, \quad \lambda = .15, \quad N = 10.$$

$$(1 - \lambda)R_A = .935, \quad g = 1.04 - .935 = .105,$$

$$\phi = \frac{.935}{.105} = 8.90, \quad D^{\max} = 89.0, \quad A^{\max} = 99.0.$$

$$R_A \uparrow \Rightarrow \phi \uparrow, \quad R_D \uparrow \Rightarrow \phi \downarrow, \quad \lambda \uparrow \Rightarrow \phi \downarrow.$$

This is a **partial-equilibrium capacity calculation**: the returns and the agency parameter are held fixed.

The one division that matters: $9.35/0.105 = 89$. Honesty starts 9.35 ahead and loses 0.105 of that lead per pound borrowed.

The model isolates credibility, not runs, prices, or default

Inside the model

- hidden action after funding;
- limited pledgeability;
- net-worth-dependent capacity;
- an incentive wedge when (IC) binds.

Requires additional structure

- stochastic default and recovery;
- funding runs and deposit insurance;
- regulation and market power;
- maturity and term structure;
- endogenous asset prices.

The section has answered its question: net worth becomes debt capacity because it raises honest-operation surplus relative to diversion. We have derived a ceiling at quoted returns, not an equilibrium quantity. For Bear Stearns, this is a **credibility lens**, not a causal account: the historical record also requires short-term funding, collateral, and a run.

At what quantity and return will outsiders actually fund the bank? Section IV adds funding supply and market clearing.

Four-link map: the credibility link is derived; equilibrium and transmission remain open.

Part V

Equilibrium amplification

When does lower net worth reduce equilibrium lending and activity?

A debt limit matters only if market prices and real adjustment cannot offset it.



Equilibrium adds a funding price and an adjustment margin

The capacity result alone leaves three objects unresolved:

1. **Desired assets** A^{des} : productive opportunities, borrower demand, and risk appetite determine the unconstrained scale.
2. **Funding supply** $R_D^s(D)$: outsiders require a return for holding an increasing quantity of bank claims.
3. **Adjustment margin**: cash, securities, loans, prices, and borrower substitution determine how a smaller balance sheet reaches the economy.

Market clearing can determine D^* . It still cannot tell us, without more structure, which asset or borrower absorbs the change.

A funding-supply schedule closes the model

The fixed-return analysis gives a capacity boundary. Market equilibrium adds an inverse funding-supply schedule:

$$R_D = R_D^s(D), \quad (R_D^s)'(D) > 0.$$

For the numerical example, use

$$R_D^s(D) = 1 + .00125D, \quad R_A = 1.10, \quad \lambda = .15.$$

Equilibrium outside funding satisfies

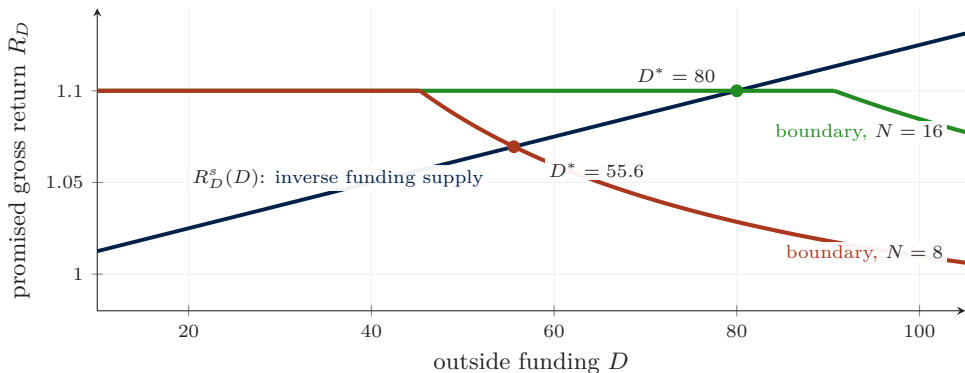
$$R_D^s(D^*) = R_D^d(D^*; N).$$

Superscript *s*: inverse funding supply; superscript *d*: the bank's incentive-compatible funding boundary, derived next.

The upward slope is a maintained reduced-form assumption about scarce risk-bearing and portfolio allocation; concavity alone does not imply it.

In words: savers hold more bank debt only if they are paid more. At $D = 80$ the schedule asks $R_D = 1.10$, exactly the asset return.

Lower net worth shifts the funding boundary inward



$$R_D^d(D; N) = \min \left\{ R_A, (1 - \lambda) R_A \left(1 + \frac{N}{D} \right) \right\}.$$

The same supply schedule meets a lower incentive-compatible boundary when intermediary net worth falls. The boundary is (IC) solved for R_D : the most the bank can credibly promise per pound borrowed, given N . More D on the same N means less can be promised, so it slopes down; the flat part is the cap at R_A .

Appendix A8

Appendix A10

Net worth determines when the agency wedge disappears

optional extension

Let $D^0 \equiv (R_D^s)^{-1}(R_A)$ be the quantity supplied when the promised funding return equals the asset return. We call this the **competitive no-agency benchmark**: asset finance carries no agency wedge. It is feasible when

$$D^0 \leq \frac{1-\lambda}{\lambda} N.$$

Equivalently,

$$N_{\text{crit}} = \frac{\lambda}{1-\lambda} D^0.$$

For the stated calibration, $D^0 = 80$ and $N_{\text{crit}} = 14.12$.

$N > N_{\text{crit}} \Rightarrow$ no-agency benchmark and (IC) strictly slack,

$N = N_{\text{crit}} \Rightarrow$ benchmark feasible and (IC) exactly binding,

$N < N_{\text{crit}} \Rightarrow$ constrained equilibrium.

$D^0 = 80$ is what savers supply if paid the full asset return.

Lower net worth changes quantity and the funding return

Using $R_D^s(D) = 1 + .00125D$, $R_A = 1.10$, and $\lambda = .15$:

N	D^*	$A^* = N + D^*$	R_D^*
16	80.0	96.0	1.1000
8	55.6	63.6	1.0695

$$\Delta N = -8, \quad \Delta D^* = -24.4, \quad \Delta A^* = -32.4.$$

The fall in funding quantity lowers its promised return. In this calibration, the fixed-return multiplier overstates the local marginal response on the constrained segment; the displayed high-to-low comparison also crosses the kink.

Eight pounds less net worth costs 24.4 of funding and 32.4 of assets: about three pounds of funding per pound of capital. The fixed-return multiplier is larger because it holds R_D still.

The return spread is an agency wedge, not a profit margin

optional extension

On the constrained segment,

$$\frac{R_A - R_D^*}{R_A} = \lambda - (1 - \lambda) \frac{N}{D^*}.$$

For $N = 8$, $D^* = 55.6$, and $\lambda = .15$:

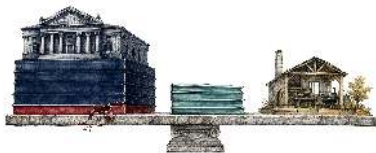
$$\frac{1.10 - 1.0695}{1.10} = 2.77\%.$$

The wedge measures the return not pledgeable to outside funders; it is not an observed net interest margin. The model has determined funding, not which assets shrink when funding falls.

The gap between what the assets earn and what funders are paid is not profit. It is the part of the return the banker cannot credibly hand over, and more net worth shrinks it.

An observed crisis spread also contains expected default loss, liquidity compensation, risk premia, and market power. It cannot be read directly as the model's agency wedge.

A capacity loss reduces credit only if loans absorb the adjustment



The balance-sheet identity implies

$$A = C + S + L, \quad \Delta A = \Delta C + \Delta S + \Delta L,$$

the same 20-unit contraction can be allocated differently:

$$(\Delta C, \Delta S, \Delta L) = (-5, -10, -5),$$

$$(\Delta C, \Delta S, \Delta L) = (0, 0, -20).$$

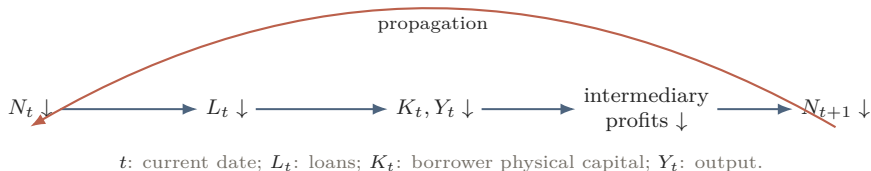
C : cash and reserves; S : securities; L : loans.

Only the second allocation makes the balance-sheet contraction a one-for-one loan contraction.
Borrower substitution then determines the real effect.

Same 20-unit shrinkage, two different economies: in the first the loan book barely moves, in the second every unit is a loan not made.

Lower net worth cuts lending, which lowers net worth again

optional extension



This is a dynamic extension. A solved equilibrium also needs expectations, entry, survival, prices, and market clearing.

Bernanke, Gertler and Gilchrist (1999), financial accelerator.

Falling collateral prices reduce net worth and force more sales

optional extension

In a one-asset balance-sheet illustration, let the bank hold H units of collateral at price q , financed by outside claims D :

$$N = qH - D.$$

If $qH = 100$ and $D = 90$, then $N = 10$. A 5% fall in q gives

$$N' = 95 - 90 = 5.$$

The asset-price change halves net worth.

The Part I arithmetic again: $\ell = 100/10$, so a 5% price fall takes half the net worth. What is new is that N falling pushes q down again.

Forced sales lower q only when demand slopes downward, arbitrage capital is limited, or another price-setting mechanism is specified.

$$q \downarrow \Rightarrow N \downarrow \Rightarrow \underbrace{\text{capacity} \downarrow \Rightarrow \text{forced sales} \uparrow \Rightarrow q \downarrow}_{\text{when a balance-sheet constraint binds}}.$$

Kiyotaki and Moore (1997); Shleifer and Vishny (2011).



A higher haircut cuts secured funding without any price fall

optional extension

For collateral with market value V , the maximum secured funding F at haircut h is

$$F = (1 - h)V.$$

For the illustrative value $V = 100$:

$$h : 2\% \rightarrow 10\% \quad \implies \quad F : 98 \rightarrow 90.$$

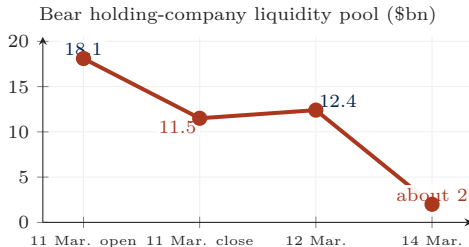
The collateral need not default or fall in price; the lender has changed the advance rate. Bear's

counterparties then withdrew customary secured funding even against high-quality collateral.

h is the haircut: the share of collateral value the lender will not advance. Nothing about the collateral changed. The lender's terms did.

Bear's collapse therefore cannot be read from capital arithmetic alone. The one-period agency model does not generate this run; Day 2 develops that liquidity mechanism.

SEC, 20 March 2008 liquidity chronology.



A capital–lending correlation does not identify credit supply



common macro shock $\rightarrow$ {asset losses, loan demand},
recognition and expected losses $\rightarrow$ {measured capital, lending},
policy and recapitalisation $\rightarrow$ {capital, funding conditions}.

A capital–lending correlation is compatible with several causal structures. Timing alone does not identify a bank-credit-supply effect. Policy must first identify which balance-sheet margin has failed.

Khwaja and Mian (2008), tracing bank liquidity shocks through matched borrowers.

A tighter capital constraint can reallocate credit across banks

Berrospide and Edge compare U.S. banks exposed to different post-stress-test capital-buffer requirements. A one-percentage-point larger buffer is associated with approximately

2.0 pp lower growth in utilised loans,
1.5 pp lower growth in commitments.

over the following four quarters.

The estimated bank-level response does *not* translate one-for-one into firm-level contraction: exposed firms largely replaced the missing bank credit, so overall debt, investment, and employment changed little on average.

Capital requirements can shift which bank supplies a loan. The real effect depends on whether the borrower can substitute toward another lender or market.

The empirical design uses cross-bank variation in stress-capital buffers and borrower-level credit data; it is evidence about an average bank-credit-supply response, not a universal multiplier.

Berrospide and Edge (2019), Federal Reserve FEDS 2019-050.

Bank-equity losses predict contractions; panics amplify them

optional extension

Baron, Verner, and Xiong assemble bank-equity and panic histories for **46 countries from 1870 to 2016**. In their historical panel, a bank-equity decline of at least 30% predicts, after three years,

real GDP 3.4% lower and credit/GDP 5.7 percentage points lower.

Large bank-equity declines without creditor panics are also followed by substantial contractions: after three years, real GDP is about 2.7% lower and bank credit/GDP about 3.5 percentage points lower in the no-panic episodes.

This is broad historical predictive evidence, not a clean single-bank causal estimate. It shows that panic is an amplifier, not a necessary definition of banking-sector distress.

If distress can reach output through more than one margin, policy must diagnose the broken link before choosing the repair.

Baron, Verner, and Xiong (2021), *Quarterly Journal of Economics*, 136(1).

Part VI

Capital repair and policy

How can capital be rebuilt
without forcing an unnecessary
credit contraction?

Capital, liquidity, and asset-price
interventions repair different margins.



Banks may choose less capital than society prefers

Debt and deposits provide funding and liquidity services, but the private price of leverage need not include its full social cost.

1. Limited liability protects shareholders from losses beyond their stake.
2. Deposit insurance and expected support can reduce creditors' required compensation for downside risk.
3. Fire sales, disrupted payments, and credit contraction affect agents outside the bank.

For a common marginal-benefit schedule and increasing marginal costs, partial externalisation of losses can produce

$$MC_{\text{private}}(\ell) < MC_{\text{social}}(\ell) \quad \implies \quad \ell_{\text{private}} > \ell_{\text{social}}.$$

ℓ : bank leverage; MC_{private} : marginal cost borne by the bank; MC_{social} : marginal cost including spillovers.

Hanson, Kashyap and Stein (2011), macroprudential rationale.

Risk weights and leverage ratios answer different questions

stylised asset	exposure	risk weight	risk-weighted assets
cash and reserves	20	0%	0
mortgages	50	50%	25
corporate loans	30	100%	30
total	100		55

Let $E_C = 6$ denote eligible common equity:

$$\underbrace{\frac{E_C}{A} = 6.0\%}_{\text{non-risk-weighted view}}, \quad \underbrace{\frac{E_C}{RWA} = 10.9\%}_{\text{risk-weighted view}}.$$

Here E_C/A is a simplified unweighted exposure ratio. A regulatory leverage ratio uses its prescribed exposure measure; the risk-weighted ratio responds to measured portfolio risk. The two constraints are complements, not substitutes.

Teaching weights, not the current Basel schedule. Basel Committee: the leverage ratio is a non-risk-based backstop to the risk-based capital framework.

Capital regulation can move risk instead of removing it

optional extension

The resilience case for capital is strong, but implementation changes behaviour:

1. **Risk measurement:** a risk-weighted rule creates incentives to shift toward exposures with low measured weights.
2. **Procyclicality:** recognised losses and rising measured risk can tighten constraints during a downturn.
3. **Regulatory perimeter:** activity can migrate to less-regulated intermediaries while the underlying maturity or credit risk remains.

The leverage ratio limits model and weight error; risk-weighted ratios preserve risk sensitivity. Neither makes supervision or liquidity regulation redundant.

Basel Committee; Hanson, Kashyap, and Stein (2011).

A two percent loss removes almost the entire capital buffer

For an illustrative unweighted threshold $\kappa_{\min}$, define the buffer in units of equity:

$$B \equiv N - \kappa_{\min} A.$$

If $A = 100$, $N = 10$, and $\kappa_{\min} = 8\%$:

$$B = 10 - .08(100) = 2.$$

A two-unit asset loss, holding promised claims fixed initially, gives

$$A' = 98, \quad N' = 8, \quad B' = 8 - .08(98) = 0.16.$$

The bank remains above zero book equity, but almost all of its discretionary capital cushion has disappeared. A further marked loss of about 0.17 would exhaust the remaining buffer if promised claims were initially unchanged.

A regulatory minimum, a supervisory stress buffer, and a bank's management or market target are distinct thresholds; crossing any one has a different economic and legal meaning.

The illustrative 8% threshold is a teaching assumption, not the Basel leverage minimum. [Appendix A13](#) [Appendix A14](#)

A stress test asks whether capital survives a future scenario

The 2009 SCAP did not ask only whether banks met current minimum ratios. It applied the same adverse macroeconomic scenario to all major institutions.

1. project losses, revenues, reserves, and resources over the horizon;
2. calculate the resulting common-equity buffer under stress;
3. disclose the methodology and firm-level capital need;
4. require remediation by a deadline, with a public backstop available.

$$\text{capital need} = \max\{0, \text{required stressed buffer} - \text{projected stressed capital}\}.$$

The policy innovation combined loss recognition, comparable information, and a credible repair plan; it was not a declaration that every firm was currently insolvent.

Federal Reserve, SCAP design and results, May 2009.

The 2009 stress test required \$74.6bn of new capital

The Supervisory Capital Assessment Program examined the 19 largest US bank holding companies under a more adverse macroeconomic scenario.

19	10	\$74.6bn
firms assessed	needed a larger or higher-quality buffer	required capital augmentation

By November 2009, the 10 firms had increased Tier 1 Common equity by more than \$77bn through:

- \$39bn of new common equity or other eligible securities;
- \$23bn of preferred-to-common conversions;
- \$9bn from business or portfolio sales, plus other actions.

Tier 1 Common was the stress test's common-equity measure; it is not the model's unweighted ratio N/A .

The exercise combined loss recognition, a forward scenario, a public capital standard, and a deadline for remedial action, reducing uncertainty about heterogeneous institutions.

Federal Reserve, Supervisory Capital Assessment Program, 9 November 2009.

The 2026 stress test tracks the minimum ratio along the path

optional extension

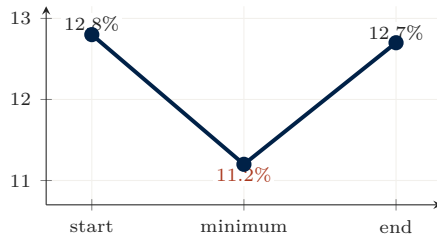
The Federal Reserve's 2026 exercise applied a severely adverse, hypothetical nine-quarter scenario to 32 large banks. For the aggregate

common equity tier 1 ratio:

12.8% → 11.2% minimum → 12.7%.

The relevant object is the **minimum along the path**, not only the starting or ending ratio.

A stress test is a conditional capital calculation, not a forecast and not proof that short-term funding cannot run.



Board of Governors of the Federal Reserve System, *2026 Federal Reserve Stress Test Results*, 24 June 2026.

Capital repair changes cash, claims, and ownership differently

New common equity	cash and net worth rise; existing owners are diluted.
Creditor bail-in	a liability becomes equity; no new cash enters and the creditor bears the conversion.
Public-sector equity	cash and net worth rise; the state receives a claim and bears investment risk.

All three can raise measured capital. They do not allocate losses, control, or fiscal risk in the same way.

Diagnosis determines the policy instrument

diagnosis	primary instrument	first-order effect
capital shortfall	common equity, conversion, or bail-in	raises loss-absorbing net worth N
funding run	liquidity facility or temporary guarantee for a solvent but illiquid institution	replaces withdrawals or stabilises funding terms
fire-sale market	market-liquidity operation or asset purchase	supplies cash or supports q ; risk transfer depends on price

A fair-value liquidity operation and a subsidised risk transfer can share the same policy label but have different loss incidence. A liquidity facility cannot repair negative net worth.

Hanson, Kashyap and Stein (2011); Federal Reserve SCAP materials.

Bear Stearns and SCAP repaired different margins

Bear Stearns, March 2008

Observed secured funding vanished and the liquidity pool fell from \$18.1bn to about \$2bn.

Repair bridge funding through JPMorgan, then acquisition support. Maiden Lane acquired about \$30bn of Bear mortgage-desk assets; the PDCF was a separate market-wide liquidity backstop.

Boundary liquidity support buys time; it does not make an economically insolvent portfolio solvent.

SCAP, 2009

Observed uncertainty about future losses and the quality of capital weakened confidence across major banks.

Repair one adverse scenario, comparable disclosure, a common-equity requirement, and a credible public backstop.

Boundary a capital exercise does not by itself prevent a short-term funding run.

Both episodes involved deleveraging pressure. The correct instrument followed from the failed margin, not from the word “crisis”.

Federal Reserve Bank of New York, Bear Stearns support; Federal Reserve, 2009 SCAP materials.

Capital policy changes incentives before the crisis

optional extension

Before distress Shareholders choose leverage, asset risk, and the size of their own loss-absorbing stake.

During distress Authorities may find intervention optimal because disorderly deleveraging imposes costs on borrowers, markets, and the payments system.

After intervention Expected future support can reduce market discipline unless regulation, supervision, pricing, and resolution rules make private risk-bearers absorb losses.

The ex-post case for support and the ex-ante case for discipline can both be valid. Capital policy is therefore partly a commitment problem.

A small loss becomes a contraction only when all four links hold

In the mechanism studied today, a small asset loss becomes a large economic contraction only when four statements hold together:

1. **Leverage:** the asset loss is large relative to initial equity.
2. **Credibility:** lower net worth tightens a binding incentive constraint.
3. **Equilibrium:** outside funding does not replace the lost capacity at unchanged terms.
4. **Transmission:** loans absorb the adjustment and borrowers cannot substitute toward other finance.

$$\text{asset loss} \neq \text{credit contraction} \neq \text{output loss}.$$

The agency mechanism supplies the credibility-to-capacity link. Portfolio adjustment, substitute finance, and real transmission require additional assumptions. Capital policy can weaken the mechanism, but also changes incentives.

Bear resolves the opening tension: its thin equity made losses dangerous, but the decisive March record is a wholesale funding collapse. Capital and liquidity are connected in crises without being the same mechanism.

The mechanism determines what should be measured

The four links turn a general crisis narrative into distinct empirical questions:

Loss absorption How large is the plausible asset mark relative to equity, after duration, hedges, and accounting treatment?

Credibility Does lower net worth change the quantity or terms of outside funding?

Equilibrium Do other funders or prices offset the original funding loss?

Transmission Which assets shrink, and can borrowers substitute toward another bank or market?

AI can organise documents, extract exposures, and estimate conditional risk. It becomes useful only after the economic target and decision are clear.

Prediction and causal identification are different tasks: a warning signal need not reveal the effect of a capital or liquidity intervention.

Technical appendix: derivation map

1. A1–A3: losses, duration, and capital-ratio repair
2. A4–A7: incentives, finite capacity, and the numerical solution
3. A8–A12: funding equilibrium, threshold, and wedge
4. A13–A15: buffers, debt overhang, and recapitalisation
5. A16: funding supply as a maintained assumption
6. A17: collateral-price loss
7. A18: haircut and secured funding
8. A19: risk-weighted assets and capital ratios
9. A20: fixed-return capacity comparative statics

Each central algebraic result is worked from its starting equation. Institutional claims and maintained assumptions are labelled separately.

[Back to lecture](#)

A1 – Leverage maps an asset mark into equity loss

Let initial outside claims be $D = A - N$. Mark a fraction x from asset value while holding those promised claims fixed at that instant:

$$A' = A - xA,$$

$$N' = A' - D = (A - xA) - (A - N) = N - xA,$$

$$\Delta N = N' - N = -xA,$$

$$\frac{-\Delta N}{N} = x \frac{A}{N} = x\ell.$$

Equity is exhausted when $N' = 0$:

$$0 = N - xA \implies x_{\text{wipeout}} = \frac{N}{A} = \frac{1}{\ell}.$$

For Bear Stearns, $\ell = 33.53$, hence $x_{\text{wipeout}} = 2.98\%$.

A2 – The duration approximation

For promised cash flows CF_t , price is

$$P(y) = \sum_{t=1}^T \frac{CF_t}{(1+y)^t}.$$

Differentiate with respect to the yield:

$$\frac{dP}{dy} = - \sum_{t=1}^T \frac{tCF_t}{(1+y)^{t+1}}.$$

Define modified duration

$$D_{\text{mod}} \equiv -\frac{1}{P} \frac{dP}{dy}.$$

A first-order Taylor approximation around the current yield gives

$$\Delta P \approx \frac{dP}{dy} \Delta y \quad \implies \quad \frac{\Delta P}{P} \approx -D_{\text{mod}} \Delta y.$$

For a five-year zero-coupon claim at $y = .03$, Macaulay duration is 5 and

$$D_{\text{mod}} = \frac{5}{1.03} = 4.854.$$

With $\Delta y = 40\text{bp} = .004$, the local price change is therefore $-4.854(.004) = -1.94\%$.

This first-order calculation assumes fixed contractual cash flows, annual compounding, and a small parallel shift in the relevant yield curve. Convexity and changes in credit or liquidity spreads are omitted.

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A2b – From asset duration to the bank's net-worth exposure

Let asset and liability values be A and L , with modified durations D_A and D_L . For a small common yield change Δy ,

$$\Delta A \approx -D_A A \Delta y, \quad \Delta L \approx -D_L L \Delta y.$$

Because net worth is $N = A - L$,

$$\Delta N \approx (-D_A A + D_L L) \Delta y + \Delta H,$$

where ΔH is the value change of the bank's interest-rate hedges. Equivalently, dividing by assets,

$$\frac{\Delta N}{A} \approx -\left(D_A - \frac{L}{A} D_L\right) \Delta y + \frac{\Delta H}{A}.$$

Thus a long asset duration alone does not determine the equity loss: liability duration, leverage, basis risk, and hedges determine the net exposure.

A common parallel shift is still a teaching approximation. Different curves, option-adjusted durations, and non-rate marks require separate shocks.

A3 – Three capital-ratio repair calculations

Bear scaled to $A = 100$ gives $N = 2.98$. After a 2% mark, $(A_1, N_1) = (98, 0.98)$. Target $\bar{\kappa} = .08$.

$$\text{Asset reduction: } \frac{N_1}{A_1 - s} = \bar{\kappa} \quad \implies \quad s = A_1 - \frac{N_1}{\bar{\kappa}} = 98 - 12.25 = 85.75.$$

$$\text{New cash equity: } \frac{N_1 + e}{A_1 + e} = \bar{\kappa} \quad \implies \quad e = \frac{\bar{\kappa}A_1 - N_1}{1 - \bar{\kappa}} = \frac{6.86}{0.92} = 7.46.$$

$$\text{Liability bail-in: } \frac{N_1 + b}{A_1} = \bar{\kappa} \quad \implies \quad b = \bar{\kappa}A_1 - N_1 = 6.86.$$

Asset reduction uses proceeds to repay claims, equity issuance adds cash to both sides, and bail-in converts an existing claim into equity. At $\ell = 33.53$ each route is large relative to the balance sheet: the same target ratio is reached by selling 87% of the assets, by raising eight times the remaining equity, or by writing down 7% of the claims.

A4 – Rearranging the incentive constraint

Start from honest and diversion payoffs:

$$R_A(N + D) - R_D D \geq \lambda R_A(N + D).$$

Move diversion payoff to the left:

$$(1 - \lambda)R_A(N + D) \geq R_D D.$$

Expand the left side and move the outside-funding term:

$$(1 - \lambda)R_A N + (1 - \lambda)R_A D \geq R_D D,$$

$$(1 - \lambda)R_A N \geq [R_D - (1 - \lambda)R_A] D.$$

The left side is incentive surplus supplied by inside net worth. The bracketed term is the funding gap created by one additional unit of outside finance.

A5 – Why capacity is finite only in one case

Define the per-unit funding gap

$$g \equiv R_D - (1 - \lambda)R_A.$$

Then the incentive constraint is

$$(1 - \lambda)R_A N \geq gD.$$

$g > 0 :$	$D \leq \frac{(1 - \lambda)R_A}{g} N$	finite capacity,
$g = 0 :$	$(1 - \lambda)R_A N \geq 0$	no cap from this constraint,
$g < 0 :$	$gD < 0$ for $D > 0$	no finite cap from this constraint.

The familiar debt-limit formula must not be used when $g \leq 0$; additional frictions would be needed to determine scale.

A6 – Deriving debt and asset capacity

For $g > 0$, divide the incentive constraint by the positive funding gap:

$$(1 - \lambda)R_A N \geq gD,$$

$$D \leq \frac{(1 - \lambda)R_A}{g} N,$$

$$D^{\max} = \frac{(1 - \lambda)R_A}{R_D - (1 - \lambda)R_A} N \equiv \phi N.$$

Use $A = N + D$:

$$A^{\max} = N + D^{\max} = (1 + \phi)N \equiv \psi N.$$

At fixed (R_A, R_D, λ) , one additional unit of net worth supports ϕ additional units of outside funding and ψ units of total assets. This is capacity, not necessarily chosen scale.

A7 – Numerical capacity solution and payoff check

Let $R_A = 1.10$, $R_D = 1.04$, $\lambda = .15$, and $N = 10$:

$$(1 - \lambda)R_A = .85(1.10) = .935,$$

$$g = 1.04 - .935 = .105,$$

$$\phi = .935/.105 = 8.9048,$$

$$D^{\max} = 8.9048(10) = 89.048,$$

$$A^{\max} = 99.048.$$

At the boundary, up to rounding,

$$\Pi^{\text{hon}} = 1.10(99.048) - 1.04(89.048) = 16.343,$$

$$\Pi^{\text{div}} = .15(1.10)(99.048) = 16.343.$$

The payoff equality verifies that the reported capacity is the crossing point.

A8 – The bank funding-demand boundary

When the constraint binds,

$$(1 - \lambda)R_A(N + D) = R_D D.$$

Divide by $D > 0$:

$$R_D = (1 - \lambda)R_A \left(1 + \frac{N}{D}\right).$$

Maintain the competitive benchmark assumption that the bank does not promise more than the asset return. Its boundary is

$$R_D^d(D) = \min \left\{ R_A, (1 - \lambda)R_A \left(1 + \frac{N}{D}\right) \right\}.$$

At the kink, set the two expressions equal and cancel $R_A > 0$:

$$1 = (1 - \lambda) \left(1 + \frac{N}{D_k}\right) \implies D_k = \frac{1 - \lambda}{\lambda} N.$$

A9 – Deriving the no-agency-wedge threshold

Let $D^0 = (R_D^s)^{-1}(R_A)$ be funding supplied when the promised return equals the asset return. The no-agency benchmark is feasible if it lies on the flat segment:

$$D^0 \leq D_k = \frac{1 - \lambda}{\lambda} N.$$

Multiply by $\lambda/(1 - \lambda) > 0$:

$$\frac{\lambda}{1 - \lambda} D^0 \leq N.$$

Therefore

$$N_{\text{crit}} \equiv \frac{\lambda}{1 - \lambda} D^0.$$

$N > N_{\text{crit}}$: no-agency benchmark, constraint slack,

$N = N_{\text{crit}}$: benchmark, constraint exactly binding,

$N < N_{\text{crit}}$: market clearing occurs on the constrained segment.

A10 – Solving the high- and low-net-worth equilibria

Use $R_D^s(D) = 1 + .00125D$, $R_A = 1.10$, and $\lambda = .15$. No-agency-benchmark funding solves

$$1 + .00125D^0 = 1.10 \implies D^0 = 80,$$

so $N_{\text{crit}} = (.15/.85)80 = 14.12$. For $N = 16 > N_{\text{crit}}$, $D^* = 80$ and $R_D^* = 1.10$. For $N = 8 < N_{\text{crit}}$, solve market clearing on the binding segment:

$$1 + .00125D = .935 \left(1 + \frac{8}{D} \right),$$

$$.00125D^2 + .065D - 7.48 = 0,$$

$$D^* = \frac{-.065 + \sqrt{.065^2 + 4(.00125)(7.48)}}{.0025} = 55.6,$$

$$R_D^* = 1 + .00125(55.6) = 1.0695.$$

The negative quadratic root is economically inadmissible.

A11 – Deriving the intermediation wedge

On the constrained segment,

$$R_D = (1 - \lambda)R_A \left(1 + \frac{N}{D}\right).$$

Subtract this expression from R_A and divide by $R_A > 0$:

$$\begin{aligned}\frac{R_A - R_D}{R_A} &= 1 - (1 - \lambda) \left(1 + \frac{N}{D}\right), \\ &= 1 - (1 - \lambda) - (1 - \lambda) \frac{N}{D}, \\ &= \lambda - (1 - \lambda) \frac{N}{D}.\end{aligned}$$

At $N = 8$, $D = 55.6$, and $\lambda = .15$:

$$.15 - .85 \left(\frac{8}{55.6}\right) = .0277 = 2.77\%.$$

This is an incentive wedge in the model, not an observed net interest margin.

A12 – The equilibrium net-worth derivative

Write constrained market clearing as

$$F(D, N) = R_D^s(D) - (1 - \lambda)R_A \left(1 + \frac{N}{D}\right) = 0.$$

Implicit differentiation gives

$$F_D \frac{dD}{dN} + F_N = 0,$$

where

$$F_D = (R_D^s)'(D) + \frac{(1 - \lambda)R_A N}{D^2}, \quad F_N = -\frac{(1 - \lambda)R_A}{D}.$$

Hence, after using the binding condition,

$$\frac{dD}{dN} = \frac{(1 - \lambda)R_A}{D(R_D^s)'(D) + R_D^s(D) - (1 - \lambda)R_A}.$$

At the low- N equilibrium this equals 4.58, so $dA/dN = 1 + dD/dN = 5.58$, below the fixed-return multiplier 9.90.

A13 – Capital-buffer arithmetic

Let the equity buffer above a fixed minimum be

$$B = N - \kappa_{\min} A.$$

Its exact finite change is

$$\Delta B = \Delta N - \kappa_{\min} \Delta A - A \Delta \kappa_{\min} - \Delta \kappa_{\min} \Delta A.$$

For a fixed minimum and an immediate asset mark m ,

$$\Delta A = -m, \quad \Delta N = -m, \quad \Delta \kappa_{\min} = 0.$$

Substitute:

$$\Delta B = -m + \kappa_{\min} m = -(1 - \kappa_{\min})m.$$

With $\kappa_{\min} = 8\%$ and $m = 2$, the buffer falls by 1.84, because the denominator falls along with equity.

A14 – Debt-overhang solution

Assume one-period, risk-neutral, same-date valuation. Existing assets pay 80 or 120, each with probability 1/2; debt has face value 100. Existing equity is

$$E_0 = \frac{1}{2} \max(80 - 100, 0) + \frac{1}{2} \max(120 - 100, 0) = 10.$$

A project costs 10 and pays 15 in either state, so

$$NPV = 15 - 10 = 5 > 0.$$

After investment, equity values are $\max(95 - 100, 0) = 0$ and $135 - 100 = 35$:

$$E_1 = \frac{1}{2}(0) + \frac{1}{2}(35) = 17.5.$$

Existing owners pay 10 but gain only $E_1 - E_0 = 7.5$. They reject the positive-NPV project because the remaining expected gain accrues to creditors in the low state.

Stylised debt-overhang example after Myers (1977).

A15 – Two recapitalisation multipliers

For fixed promised returns,

$$A^{\max} = \psi N \quad \implies \quad \Delta A^{\max} = \psi \Delta N.$$

With $\psi = 9.90$ and $\Delta N = 2$:

$$\Delta A^{\max} = 9.90(2) = 19.8.$$

When funding supply is endogenous, use the local equilibrium response derived in A12:

$$\Delta A^* \approx \frac{dA}{dN} \Delta N = 5.58(2) = 11.2.$$

Both exceed the two-unit injection because net worth supports additional outside funding. The equilibrium response is smaller because the funding price moves with quantity; neither calculation says that all additional assets are loans.

A16 – Household funding supply is a maintained assumption

A representative two-period household chooses saving d_h :

$$\max_{0 \leq d_h \leq W} u(W - d_h) + \beta u(R_D d_h).$$

For an interior solution,

$$-u'(W - d_h) + \beta R_D u'(R_D d_h) = 0,$$

or

$$u'(W - d_h) = \beta R_D u'(R_D d_h).$$

The return changes both the reward to saving and the resources needed to reach future consumption. Concavity alone therefore does not guarantee that saving rises with R_D . With CRRA coefficient γ ,

$$\text{sign}\left(\frac{dd_h}{dR_D}\right) = \text{sign}(1 - \gamma).$$

With M identical households, aggregate funding is $D = Md_h$. The upward inverse schedule in the core remains a reduced-form assumption, not a theorem from concavity alone.

A17 – Collateral prices and intermediary equity

Let H be fixed collateral holdings, q the price per unit, and D promised outside claims:

$$N = qH - D.$$

Its change is

$$\Delta N = H\Delta q + q\Delta H - \Delta D.$$

Holding holdings and promised claims fixed at the mark gives

$$\Delta N = H\Delta q.$$

If $q_0H = 100$ and $D = 90$, then $N_0 = 10$. A 5% price fall implies

$$q_1H = .95(100) = 95, \quad N_1 = 95 - 90 = 5.$$

The collateral price falls by 5%; equity falls by 50%.

A18 – Haircuts and secured funding capacity

For collateral value V and haircut h , maximum secured funding is

$$F = (1 - h)V.$$

Holding collateral value fixed,

$$\frac{\partial F}{\partial h} = -V < 0.$$

With $V = 100$:

$$h_0 = .02 \implies F_0 = .98(100) = 98,$$

$$h_1 = .10 \implies F_1 = .90(100) = 90,$$

$$\Delta F = F_1 - F_0 = -8.$$

The haircut shock removes eight units of funding without requiring a change in the collateral's price or expected payoff.

A19 – Risk-weighted and unweighted capital ratios

Risk-weighted assets are the weighted sum of exposures:

$$RWA = \sum_i w_i A_i.$$

For cash (20, $w = 0$), mortgages (50, $w = .5$), and corporate loans (30, $w = 1$):

$$RWA = 0(20) + .5(50) + 1(30) = 55.$$

Total exposure is

$$A = 20 + 50 + 30 = 100.$$

With eligible common equity $E_C = 6$:

$$\frac{E_C}{A} = 6.0\%, \quad \frac{E_C}{RWA} = \frac{6}{55} = 10.9\%.$$

Different denominators produce different constraints from the same numerator.

A20 – Comparative statics of fixed-return capacity

Let $b \equiv (1 - \lambda)R_A$ and $g \equiv R_D - b > 0$. Then

$$\phi = \frac{b}{g} = \frac{(1 - \lambda)R_A}{R_D - (1 - \lambda)R_A}.$$

Differentiate while holding the other arguments fixed:

$$\frac{\partial \phi}{\partial R_A} = \frac{(1 - \lambda)R_D}{g^2} > 0,$$

$$\frac{\partial \phi}{\partial R_D} = -\frac{(1 - \lambda)R_A}{g^2} < 0,$$

$$\frac{\partial \phi}{\partial \lambda} = -\frac{R_A R_D}{g^2} < 0.$$

Since $A^{\max} = (1 + \phi)N = (R_D/g)N$, these derivatives describe a fixed-return capacity boundary. They are not equilibrium derivatives when R_D , desired assets, or asset prices respond to the shock.

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