Systemic Risk-Taking
Amplification Effects, Externalities, and Regulatory Responses

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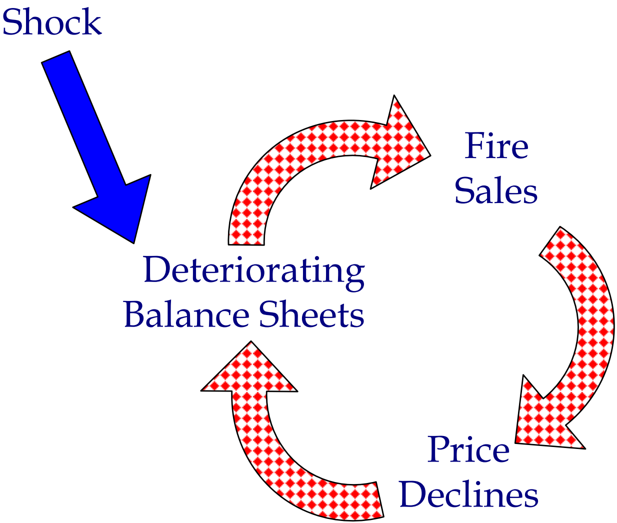
What is Systemic Risk?

Standard definition:

Systemic risk [is the] danger that problems in a single financial institution might spread and [...] disrupt the normal functioning of the entire financial system (BIS, 2002)

⇒ underlines importance of feedback loops & fire-sale externalities

Systemic Feedback Loops



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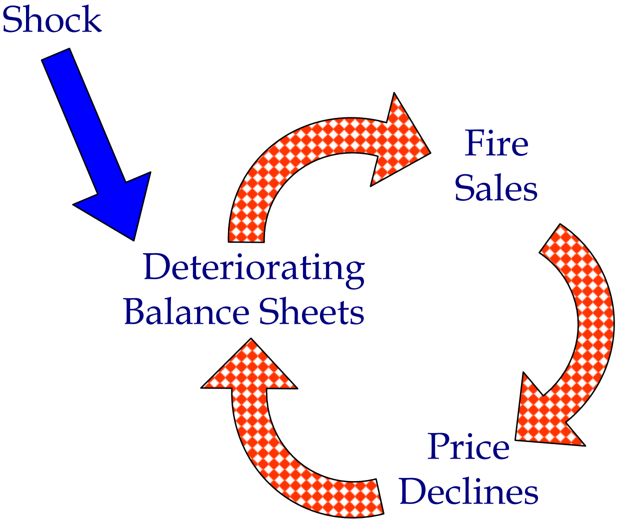

Key Questions

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- *Efficiency of risk-taking decisions in market economy with feedback loops*
- *Regulatory response*

Key Results

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Individual market participants:

- *take market prices and financial crises as given*
- *do not internalize* ***pecuniary externalities***
  that affect tightness of constraints for all agents
- *excessive systemic risk-taking*

$\Rightarrow$ ***theoretical foundations for macro-prudential regulation as Pigouvian taxation***

Relationship to Literature

- **Financial accelerator effects:** Fisher (1933), Kiyotaki-Moore (1998), Bernanke-Gertler-Gilchrist (1999), etc.
- **Economic efficiency under incomplete markets:** Stiglitz (1982), Geanakoplos and Polemarchakis (1986)
- **Frictions in insurance markets and overborrowing:** Krishnamurthy (2003), Lorenzoni (2008), Gai et al. (2008)
- **Insufficient liquidity provision:** Holmström and Tirole (1998), Wagner (2007), Kahn and Santos (2008), etc.
- **Empirical importance of amplification:** Adrian and Brunnermeier (2008), Adrian and Shin (2008), etc.

Model Setup

Two sets of agents:

- Bankers (consolidated productive sector):
  - risk-neutral
  - operate risky productive asset t
  - finance operations through borrowing
  - face borrowing constraints
- Two generations of households:
  - risk-averse $\rightarrow$ prefer smooth consumption
  - generation 0 (time $t = 0$ and 1):
    - provide finance & insurance to bankers
  - generation 1 (time $t = 1$ and 2):
    - buy up fire-sales
    - less productive than bankers
      $\rightarrow$ downward-sloping demand for assets t

Model Setup: Timing

0. **Period 0: Risk allocation**
   - bankers enter insurance contracts with generation 0 households
     $\rightarrow$ full set of Arrow securities
1. **Period 1: Feedback loop** (when borrowing constraint binding)
   - risky production is realized
   - bankers fire-sell productive assets
   - fire sales depress asset prices
   - declining asset prices tighten constraint further
2. **Period 2: Resolution**
   - final production and consumption

$\Rightarrow$ **Solution by backward induction**

Basic Setup of Bankers

Banker = Kiyotaki-Moore-style farmer

- two time periods $t = 1, 2$ and initial debt b_1^ω (for now)
- utility $u = c_1^\omega + c_2^\omega$
- born with t_1 units of productive assets
- produces output $A_1^\omega t_1$
- can raise funds by fire-selling f^ω assets at price q_1^ω
- period 2 production is risk-free $\bar{A} t_2^\omega = \bar{A}(t_1 - f^\omega)$
- **distortion:** future production cannot be pledged to lenders
  $\rightarrow$ bankers cannot borrow at $t = 1$, i.e. set $b_2^\omega = 0$
  (asset is worthless at the end of period 2 $\rightarrow$ no collateral)

Budget constraints:

$$\begin{aligned} c_1^\omega + b_1^\omega &= A_1^\omega t_1 + q_1^\omega f^\omega \\ c_2^\omega &= \bar{A}(t_1 - f^\omega) \end{aligned}$$

Note: impose $c_1^\omega \geq 0$ to capture borrowing constraint

Basic Setup of Households

Setup of households:

- risk-averse utility $u(C_1^\omega) + u(C_2^\omega)$
- receive endowment e every period
- buy T_2^ω land from entrepreneurs in case of fire-sale
- production function $F(T_2^\omega)$ with $F'(0) = \bar{A}$
  $\Rightarrow$ households use assets less productively than entrepreneurs

$$\max_{T_2^\omega} u(e - q_1^\omega \cdot T_2^\omega) + u(e + F(T_2^\omega))$$

Demand for fire-sales: $q_1^\omega = \frac{u'(C_2^\omega)}{u'(C_1^\omega)} \cdot F'(T_2^\omega)$

- at $T_2^\omega = 0$, $q_1^\omega = F'(0) = \bar{A}$
- $dq_1^\omega / dT_2^\omega < 0$

Bankers' Strategy

Strategy of decentralized bankers:

$$V^{DE}(b_1^\omega) = \max_{\{c_1^\omega, f^\omega\}} c_1^\omega + \bar{A}(t_1 - f^\omega) + \lambda^\omega c_1^\omega -$$
$$- \mu^\omega [c_1^\omega - A_1^\omega t_1 + b_1^\omega - q_1^\omega f^\omega]$$

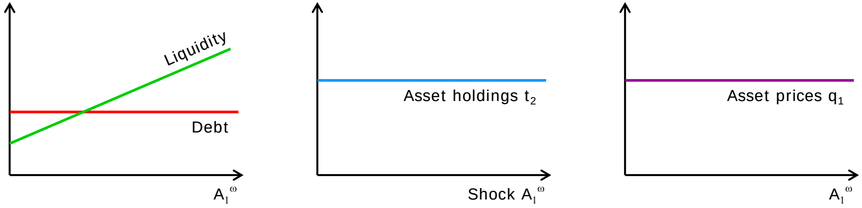
$$FOC(c_1^\omega): \quad \mu^\omega = 1 + \lambda^\omega$$
$$FOC(f^\omega): \quad \bar{A} = \mu^\omega q_1^\omega$$

Valuation of liquidity in period 1 is μ^ω:

- with loose constraints: $\mu^\omega = 1 \rightarrow q_1^\omega = \bar{A}$
- with binding constraints: $\mu_{DE}^\omega = \frac{\bar{A}}{q_1^\omega}$

Shadow cost borrowing constraint $\lambda_{DE}^\omega = \mu_{DE}^\omega - 1$

Fire-Sales and Asset Price Effects:



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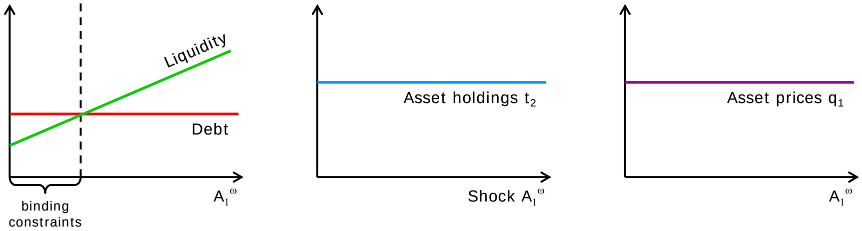

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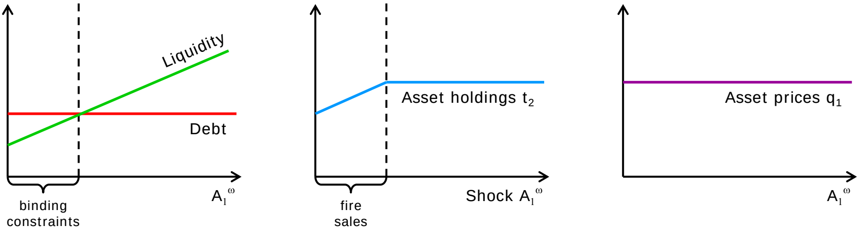

Determination of Equilibrium

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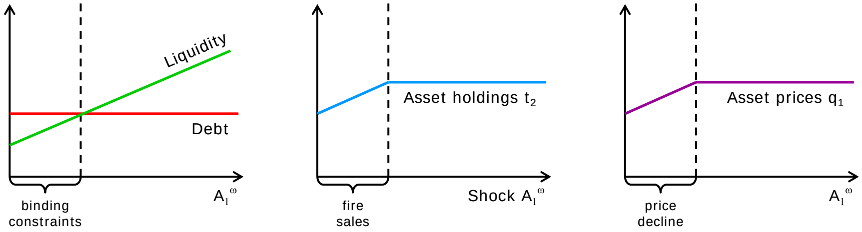

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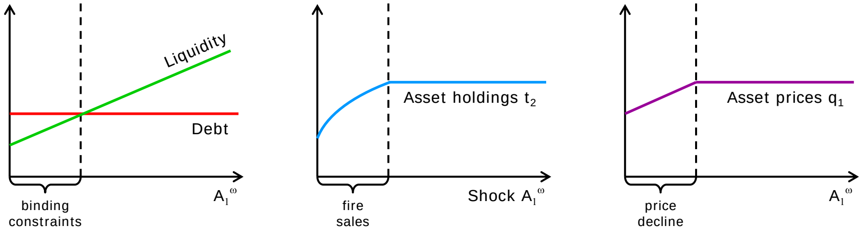

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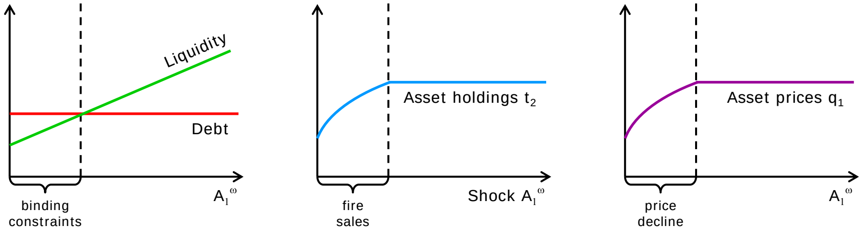

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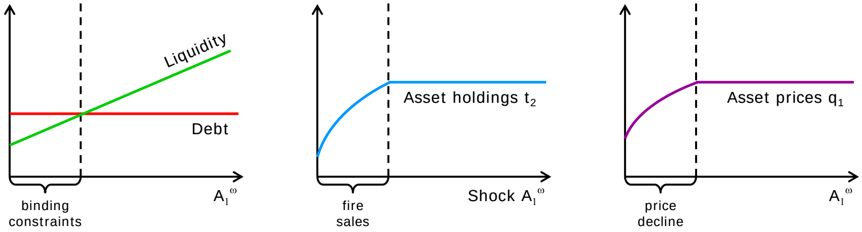

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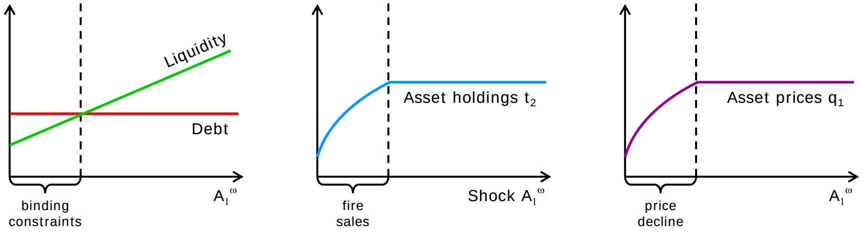

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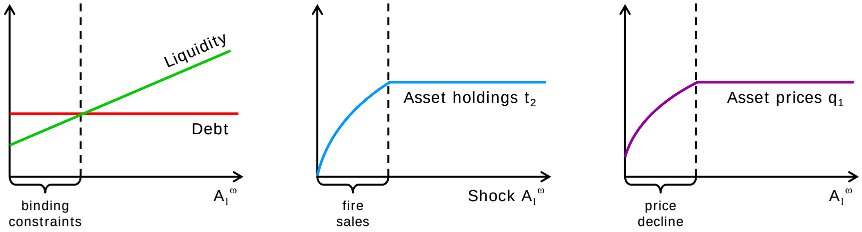

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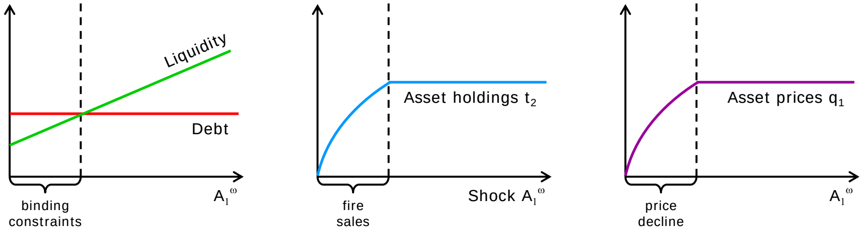


Social Planner's Strategy

Social planner: solves the same optimization problem

$$FOC(c_1^\omega): \qquad \mu^\omega = 1 + \lambda^\omega \quad \rightarrow \lambda_{SP}^\omega = \mu^\omega - 1$$

$$FOC(f^\omega): \qquad \bar{A} = \mu_1^\omega \left[q_1^\omega + \frac{dq_1^\omega}{df^\omega} \cdot f^\omega \right]$$

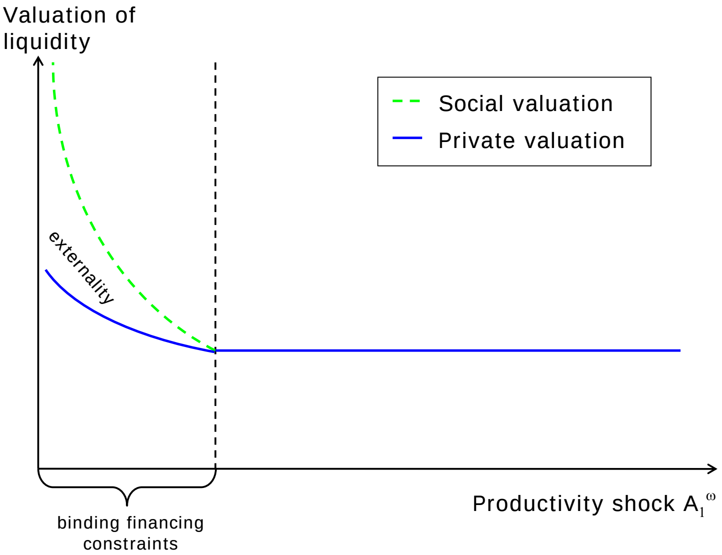
- with loose constraints: $\mu^\omega = 1 \;\rightarrow\; q_1^\omega = \bar{A}$
- with binding constraints: $\mu_{SP}^\omega = \frac{\bar{A}}{q_1^\omega + dq_1^\omega / df^\omega \cdot f^\omega} > \mu_{DE}^\omega$

Proposition

The social planner values liquidity in constrained states more highly:

$$\mu_{SP}^\omega > \mu_{DE}^\omega \qquad \textit{and} \qquad \lambda_{SP}^\omega > \lambda_{DE}^\omega$$

Private and Social Pricing Kernel



Period 0: Risk Allocation

Analysis of period 0 financing decisions:

- Assume bankers invest αt_1 to produce t_1 produtive assets
- borrow in period 0 Arrow markets to finance investment
- b_1^ω specifies contingent repayment in state ω
- Generation 0 of risk-averse households:
  $\max_{\{b_1^\omega\}} u(e - E[m_1^\omega b_1^\omega]) + E[u(e + b_1^\omega)] \ \rightarrow m_1^\omega = \frac{u'(C_1^\omega)}{u'(C_0)}$

Bankers'/social planner's optimization problem:

$$\mathcal{L}^{DE}_{\{b_1^\omega\}} = E\{V^{DE}(b_1^\omega)\} - \nu\{\alpha t_1 - E[m_1^\omega b_1^\omega]\}$$

$$\mathcal{L}^{SP}_{\{b_1^\omega\}} = E\{V^{SP}(b_1^\omega)\} - \nu\{\alpha t_1 - E[m_1^\omega b_1^\omega]\}$$

$$\text{Common FOC}(b_1^\omega): \quad \frac{dV}{db_1^\omega} - \nu \cdot m_1^\omega = 0 \quad \text{or} \quad \frac{\mu^\omega}{E[\mu^\omega]} = m_1^\omega$$

Period 0: Characterization of Equilibrium

- For small variance $\mathrm{Var}(A_1^\omega)$:
  - bankers carry all risk
  - generation 0 households lend a fixed amount across all states
  - generation 1 households do not buy any assets

- For sufficiently large variance $\mathrm{Var}(A_1^\omega)$:
  - $\exists \hat{A}$ s.t. for $A_1^\omega \geq \hat{A}$, bankers promise a fixed amount $\bar{b}_1$ to generation 0 households
  - for $A_1^\omega < \hat{A}$, bankers share risk with households:
    - repay an amount $b_1^\omega < \bar{b}_1$ to generation 0 households, where b_1^ω is increasing in A_1^ω
    - fire-sell assets $f_1^\omega > 0$ to generation 1 households

Period 0: Interpretation of Risk Allocation

Decentralized Equilibrium:

- privately optimal trade-off between risk and return
- takes prices (and binding constraints) as given

Constrained Social Optimum:

- planner accounts for systemic cost of risk-taking, i.e. feedback loops during crises
- chooses less systemic risk-taking

Policy Measures

Externality stems from financial amplification effects

First-best policy measures: break amplification effects

- inject liquidity into constrained firms (bailout)
- stabilize asset prices by buying up fire-sales

BUT: both measure create large moral hazard concerns

Bailouts

What does *not* work:
Assume government announces state-contingent transfers T^ω from generation 0 households to bankers s.t. $E[m_1^\omega T^\omega] = 0$

Proposition (Ineffectiveness of Anticipated Bailouts)

Bankers will undo anticipated government transfers that aim to provide insurance against constrained states

Reason: state-contingent form of Ricardian equivalence

- decentralized equilibrium = privately optimal
- bankers will undo government's intratemporal reallocations
- expected bailout is precisely offset by increased risk-taking

Stabilization of asset prices: similar argument

Macroprudential Regulation

Definition (Securities)

X_i^ω ... *vector of state-contingent payoffs of security i*

Definition (Externality Kernel)

$\tau^\omega = \mu_{SP}^\omega - \mu_{DE}^\omega$ ... *wedge between private and social valuation of payoffs*

Optimal Pigovian tax on security i with payoffs X_i^ω:

$$t_i^* = \int \tau^\omega X_i^\omega d\omega = E[\tau^\omega X_i^\omega]$$

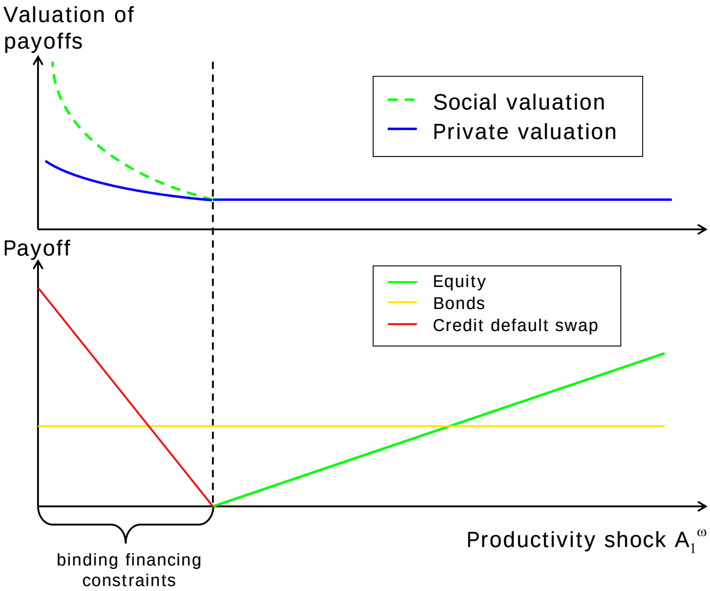
$\Rightarrow$ precisely offsets expected risk externality

Practical Implementation

Implementation of Pigouvian Tax:

- raise capital adequacy requirements by t_i^*
- limit leverage in accordance with t_i^*
- use 'socially risk-neutral' probabilities based on τ^ω in risk management models

Schematic Example of Risk Externalities



Raising New Capital

Incentives for raising new capital:

- **problem:** undervaluation of liquidity in crisis
  $\Rightarrow$ reduced incentives for raising capital

- raising new capital:
  - relaxes financing constraints on affected institution
  - reduces amplification effects (fire-sales etc.)
  - mitigates decline in asset prices
  - relaxes financing constraints on everybody else
    = uninternalized social benefit of capital injections

$\Rightarrow$ Rationale for obliging banks to raise capital
or accept equity injections from government

Conclusions

1. Feedback effects in financial markets create externality
2. Private agents take on excessive systemic risk
3. Economy exhibits socially excessive volatility
4. Macroprudential regulation based on externality kernel can contain systemic risk