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

Shock

Deteriorating Balance Sheets

Price Declines

Fire Sales
Systemic Feedback Loops

Shock → Deteriorating Balance Sheets → Price Declines → Fire Sales → Shock

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Key Questions

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

**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

⇒ 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.
- **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.
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 \( b_1^\omega \) (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 \( f^\omega \) assets at price \( q_1^\omega \)
- 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
  → bankers cannot borrow at \( t = 1 \), i.e. set \( b_2^\omega = 0 \)
  (asset is worthless at the end of period 2 → no collateral)

Budget constraints:

\[
\begin{align*}
    c_1^\omega + b_1^\omega &= A_1^\omega t_1 + q_1^\omega f^\omega \\
    c_2^\omega &= \bar{A} (t_1 - f^\omega)
\end{align*}
\]

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 $T_2^\omega$ 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:

$$V^{DE}(b_1^\omega) = \max_{\{c_1^\omega, f_1^\omega\}} \left( c_1^\omega + \bar{A}(t_1 - f_1^\omega) + \lambda^\omega c_1^\omega - \mu^\omega \left[ c_1^\omega - A_1^\omega t_1 + b_1^\omega - q_1^\omega f_1^\omega \right] \right)$$

FOC($c_1^\omega$) : 
$$\mu^\omega = 1 + \lambda^\omega$$

FOC($f_1^\omega$) : 
$$\bar{A} = \mu^\omega q_1^\omega$$

Valuation of liquidity in period 1 is $\mu^\omega$:

- 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 $\lambda^{DE}_\omega = \mu^{DE}_\omega - 1$
Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Liquidity
- Debt

- Asset holdings \( \tau_2 \)

- Asset prices \( q_1 \)
Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Debt
- Liquidity
- Asset prices $q_1$
- Asset holdings $t_2$

Graphs illustrating the relationship between debt, liquidity, and asset prices under binding constraints.
Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Binding constraints
- Debt
- Liquidity

- Asset holdings $t_2$
- Shock $A_1^σ$

- Asset prices $q_1$
- Fire sales

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Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Asset prices $q_1$
- Asset holdings $t_2$
- Debt
- Binding constraints
- Liquidity
- Fire sales
- Shock $A_1^0$
- Price decline

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Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- **Debt**
- **Liquidity**
- **Asset prices** $q_1$
- **Asset holdings** $t_2$

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Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Debt
- Liquidity
- Asset prices $q_1$
- Asset holdings $t_2$
- Price decline
- Binding constraints

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Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Binding constraints
- Debt
- Liquidity
- Asset prices $q_1$
- Asset holdings $t_2$
- Price decline
- Fire sales
- Shock $A_1^*$

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Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- **Liquidity**
- **Debt**
- **Asset holdings** $t_2$
- **Asset prices** $q_1$

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Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Liquidity
- Debt
- Asset holdings $t_2$
- Asset prices $q_1$
- Binding constraints
- Fire sales
- Shock $A_i$
- Price decline

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Determination of Equilibrium

Fire-Sales and Asset Price Effects:

- Liquidity
- Debt
- Asset holdings $t_2$
- Asset prices $q_1$

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Social Planner’s Strategy

Social planner: solves the same optimization problem

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

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

- 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:

\[ \mu_{SP}^\omega > \mu_{DE}^\omega \quad \text{and} \quad \lambda_{SP}^\omega > \lambda_{DE}^\omega \]
Private and Social Pricing Kernel

Valuation of liquidity

- Social valuation
- Private valuation

Productivity shock $A^\omega_1$

binding financing constraints

externality
Period 0: Risk Allocation

Analysis of period 0 financing decisions:

- Assume bankers invest $\alpha t_1$ to produce $t_1$ productive assets
- borrow in period 0 Arrow markets to finance investment
- $b_1^\omega$ specifies contingent repayment in state $\omega$
- 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:

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

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

Common FOC($b_1^\omega$):

$\frac{dV}{db_1^\omega} - \nu \cdot m_1^\omega = 0$ or $\frac{\mu^\omega}{E[\mu^\omega]} = m_1^\omega$
Period 0: Characterization of Equilibrium

- For small variance $\text{Var}(A_1^\omega)$:
  - 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 $\text{Var}(A_1^\omega)$:
  - $\exists \hat{A}$ 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 $b_1^\omega$ is increasing in $A_1^\omega$
    - 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
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
What does *not* work:
Assume government announces state-contingent transfers $T^\omega$ from generation 0 households to bankers s.t. $E[m^\omega_1 T^\omega] = 0$

**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)**

\[ X_i^\omega \text{ ... vector of state-contingent payoffs of security } i \]

**Definition (Externality Kernel)**

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

**Optimal Pigovian tax** on security \( i \) with payoffs \( X_i^\omega \):

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

\( \Rightarrow \) precisely offsets expected risk externality
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 $\tau^\omega$
  in risk management models
Schematic Example of Risk Externalities

Valuation of payoffs

- Social valuation
- Private valuation

Payoff

- Equity
- Bonds
- Credit default swap

Productivity shock $A_1^\omega$

binding financing constraints
Incentives for raising new capital:

- **Problem**: undervaluation of liquidity in crisis
  \[ \Rightarrow \] reduced incentives for raising capital

- Raising new capital:
  - relieves financing constraints on affected institution
  - reduces amplification effects (fire-sales etc.)
  - mitigates decline in asset prices
  - relieves 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. Macropudential regulation based on externality kernel can contain systemic risk