Systemic Risk in Financial Systems

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Cascades and Systemic Risk

Systemic Risk is a term used to describe fragility in interconnected systems that result in cascades of failures due to either relatively small shocks at the subsystem level or larger and more malicious types of disruptions affecting the whole system.

Air Traffic Congestion: $31.2B

Power Outages: $80B-$150B

Financial Crisis 2008: $500B + …

Major Disruptions: Fukushima, H1N1

Market Expectations and Economic Activity

- **Aggregate expectations** play a key role in credit markets and **macroeconomic activity**

- **Optimism** results in **credit booms**; **pessimism** leads to **credit crunches**, and potential recession

  - Most recent financial crisis

- **Fluctuations** in market **sentiments** often seem to happen without apparent reason; they seem to be driven by **animal spirits**

Animal Spirits and Regulation

"History –including recent history– shows that without regulation, animal spirits will drive the economic activity to extremes."

G. Akerlof and R. Shiller

"Good Government and Animal Spirits." WSJ, Apr. 24, 2009

Related Literature

- Dominant theory to justify regulation is based on **fire sales** and **pecuniary externalities**:
  - Occasionally binding **collateral constraint**
  - **Over-borrowing** during credit booms

  Caballero & Krishnamurthy'03; Lorenzoni'08; Bianchi'11; **Stein'12**
  - **Silent about credit crunches**

- **In this model:**
  - Collateral constraint + (binding) **credit risk constraint**
  - **Endogenous** state of the economy: **booms** and **crunches**

Preview of the Model

$t = 0$

Banks raise funds from creditors to invest in risky asset

They choose a mix of short and long-term debt

$t = 1$

Short-term creditors receive noisy signal about banks outlooks

They decide whether to rollover credit or not

Banks that experience runs can liquidate assets in a fire sale

$t = 2$

Pay off from investment is realized

Insolvent banks fail, and creditors receive zero

Households

- Initial endowment of consumption good

- Consume endowment at date 0, or invest in financial assets (lend to banks) and consume proceeds at date 2

- **Two financial assets:** $(m, 1-m)$
  - Risky "bonds" with gross real return R_B (lend long-term)
  - **Riskless "money"** with gross real return R_M (lend short-term)

- Linear preferences over consumption:

$$U(\{C_t\}) = C_0 + \beta\mathbb{E}[C_2] + \gamma m R_M \quad \text{with} \quad \beta + \gamma < 1$$

- Derive utility from **"monetary" services** provided by **safe assets**

Banks

- Continuum of identical banks, with total mass one

- **Risky investment opportunity** at date 0, with real return $\theta \sim F$ with mean $\overline{\theta} > \frac{1}{\beta}$ and support over $[\theta_{\min}, \theta_{\max}]$

- Banks need 1 unit of consumption good to undertake investment. They raise money (short-term debt)
- and finance issuing bonds (long-term debt): $(m, 1-m)$

- Short-term debt claims need to be **rolled over** at date 1

- To meet redemption demands, banks can sell any fraction of their assets in a **secondary market**.

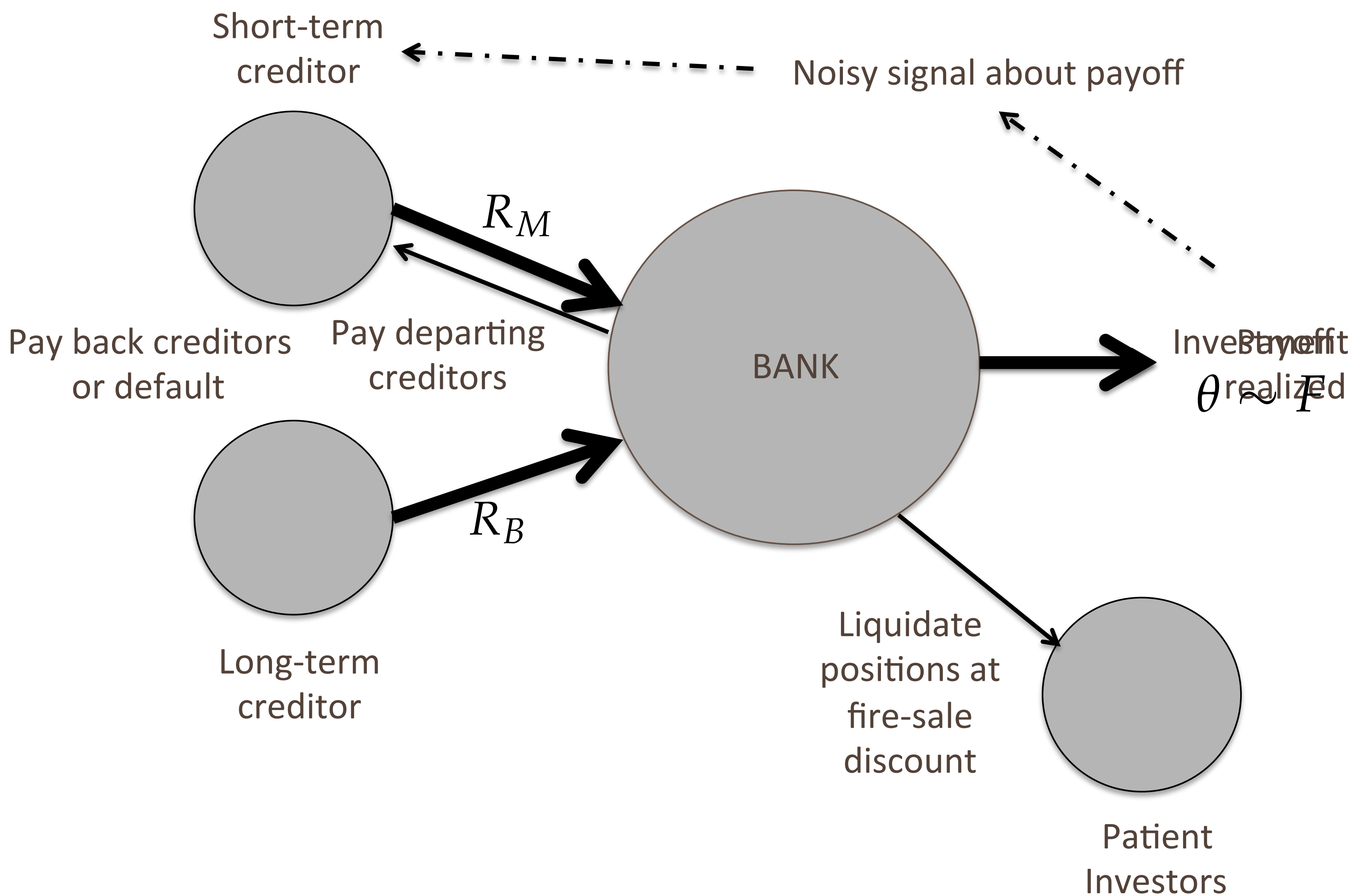
Fire Sales and Patient Investors

- Sales yield $k\theta$ per unit liquidated. **Fire-sale discount** $k \in [0, 1]$
- **Collateral constraint:** Short-term debt has to be **riskless**. If a bank issues m units of short-term finance, then

$$mR_M \leq k\theta_{\min}$$

- Patient investors receive **fixed** endowment $I > \frac{1}{\beta + \gamma}$ at **date 1**
- Investment technology: $g(\cdot)$ increasing and strictly concave
- **No Crisis:** they invest all resources in new, late arriving projects that yield total output of $g(I)$
- **Crisis:** they provide liquidity to banks purchasing assets at fire-sale discount, and invest the rest of resources in projects

Recap


Short-term creditor
Noisy signal about payoff
R_M
Pay back creditors or default
Pay departing creditors
BANK
Investment
Payoff realized
$\theta \sim F$
R_B
Long-term creditor
Liquidate positions at fire-sale discount
Patient Investors

Coordination Problem

- A bank **fails** at date 2 when unable to honor its liabilities
- **Assumption (Zero recovery value).** In case of failure, **all creditors** holding debt claims at date 2 receive a payoff of 0
- Suppose the capital structure of a bank is $(m, 1-m)$
- At date 1, θ is realized and its value revealed to banks and patient investors. Each creditor j receives a **noisy private signal**: $\theta_j = \theta + \epsilon_j$ with $\epsilon_j \sim \mathcal{U}[-\epsilon, \epsilon]$ iid
- If a fraction λ of creditors decide to withdraw, the bank needs to liquidate a fraction q: $qk\theta = \lambda m R_M$. The bank fails if:

$$(1-q)\theta < (1-\lambda)mR_M + (1-m)R_B$$

Defines: $\theta_{\text{run}}(\lambda)$

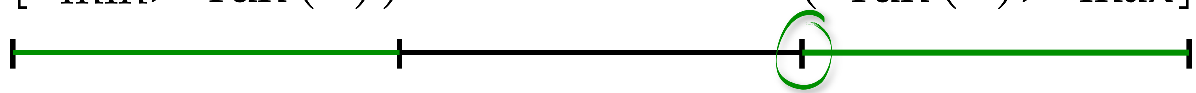
Panic Runs

- The bank fails if

$$\theta < \theta_{\text{run}}(\lambda) \equiv mR_M + (1-m)R_B + \lambda m R_M \left(\frac{1}{k} - 1\right)$$

Lower dominance region $[\theta_{\min}, \theta_{\text{run}}(0))$

Upper dominance region $(\theta_{\text{run}}(1), \theta_{\max}]$



- **Switching strategy.** In the limit as $\epsilon \to 0$, the coordination game has a **unique (symmetric) equilibrium** in which agents run whenever their signal is below the threshold:

$$\theta^* = mR_M + (1-m)R_B + mR_M \left(\frac{1}{k} - 1\right)$$

Insolvency threshold

Illiquidity component

Self-fulfilling illiquidity fears may drive a solvent bank to failure

Prices

- **Credit Market:** households indifference condition

$$R_M = \frac{1}{\beta + \gamma} \quad < \quad R_B = \frac{1}{\beta(1 - F(\theta^*))}$$

Cheaper because of convenience yield

- **Fire Sales:** patient investors indifference condition; investment activities should yield same marginal returns

$$\frac{1}{k} = g'(I - mR_M)$$

Captures how funding decisions at the individual level affect the whole system $\frac{dk}{dm} < 0$

Private Money Creation

- **Assumption (Looting).** The owner of a bankrupt bank steals any remaining assets for personal consumption

- Taking k as given, banks choose m to maximize profits:

$$\Pi(m;k) = \left(\bar{\theta} - \frac{1}{\beta}\right) + m\left(\frac{1}{\beta} - R_M\right) - F(\theta^*)mR_M\left(\frac{1}{k} - 1\right)$$

Gains — Fire-sale cost

subject to:

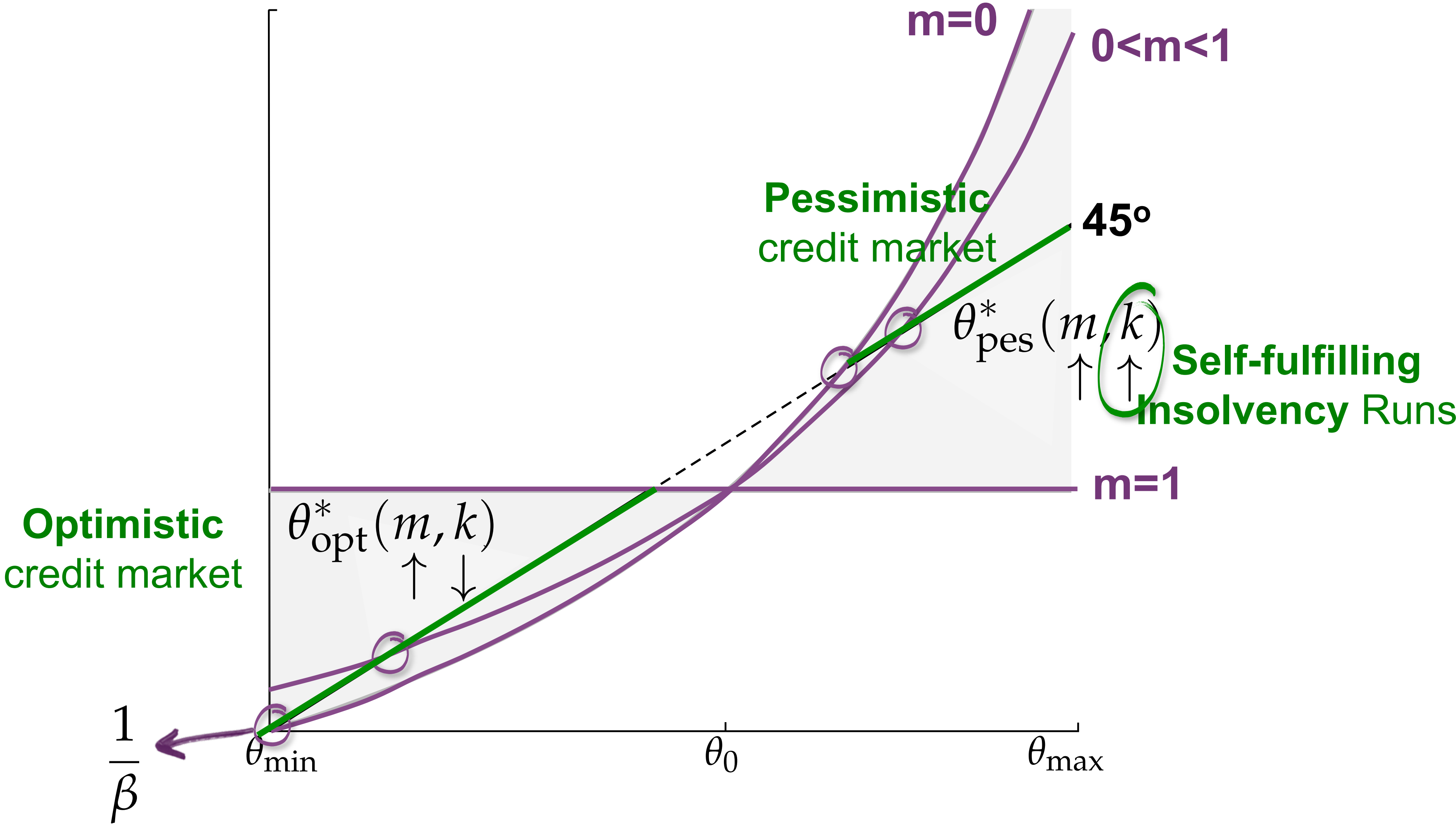
$$mR_M \leq k\theta_{\min} \quad \textbf{(collateral)}$$

$$\theta^* = \frac{mR_M}{k} + \frac{1-m}{\beta(1-F(\theta^*))} \quad \textbf{(credit risk)}$$

- **First term:** expected profits if only long-term debt
- **Second term:** gains from moving to cheaper short-term debt
- **Third term:** cost (risk) that comes along with short-term debt

Sentiments

$$\theta^* = \frac{mR_M}{k} + \frac{1-m}{\beta(1-F(\theta^*))}$$ has **two solutions**



Competitive Equilibrium

- **Definition.** A CE is a pair $(m^*, k^*,)$such that,

  - m^*maximizes:

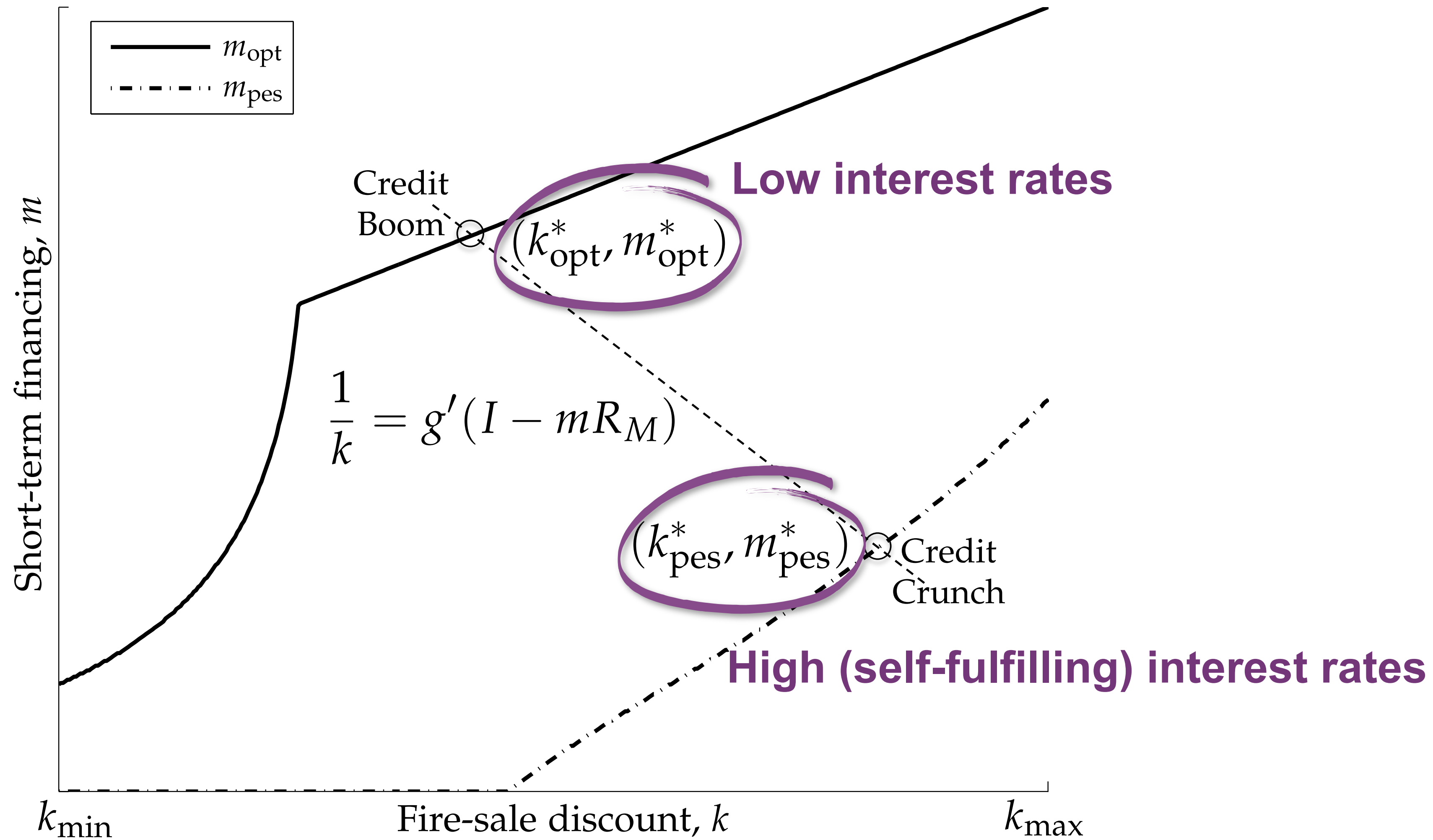
$$\left(\bar{\theta} - \frac{1}{\beta}\right) + m\left(\frac{1}{\beta} - R_M\right) - F(\theta_s^*)mR_M\left(\frac{1}{k} - 1\right)$$

subject to:
$$\begin{cases} mR_M \leq k\theta_{\min} & \textbf{(collateral)} \\ s \in \{\text{opt}, \text{pes}\} & \textbf{(sentiment)} \end{cases}$$

→ **multiplicity**

  - and: $\dfrac{1}{k^*} = g'\left(I - m^* R_M\right)$

Credit Booms and Crunches



Fluctuations in market sentiment are driven by **animal spirits**

Welfare

- Proceeds from investments by banks and patient investors are rebated back to households

- Welfare at date 2 is $W(m)$:

$$\left(\bar{\theta} - \frac{1}{\beta}\right) + m\left(\frac{1}{\beta} - R_M\right)$$
$$+ \left\{(1 - F(\theta^*))g(I) + F(\theta^*)\left(g(I - mR_M) + mR_M\right) - \frac{I}{\beta}\right\}$$

  - **First term:** net expected return to investment by banks
  - **Second term:** monetary services
  - **Third term:** net expected return to investment by patient investors

Welfare

- Proceeds from investments by banks and patient investors are rebated back to households

- **Consumption at date 2:**

probability

$$\mathbb{E}[\theta|\theta > \theta^*] + g(I) \qquad 1 - F(\theta^*)$$

$$\mathbb{E}[(1-q)\theta|\theta < \theta^*] + g(I - mR_M) + mR_M + \mathbb{E}[q\theta|\theta < \theta^*] \qquad F(\theta^*)$$

- Welfare at date 2 is $W(m)$:

$$\left(\bar{\theta} - \frac{1}{\beta}\right) + m\left(\frac{1}{\beta} - R_M\right) + \left\{(1 - F(\theta^*))g(I) + F(\theta^*)\left(g(I - mR_M) + mR_M\right) - \frac{I}{\beta}\right\}$$

Planning Problem

- The planner solves:

$$\max_{m \in [0,1]} W(m)$$ subject to:

$$\begin{cases} mR_M \leq k\theta_{\min} & \text{(collateral)} \\ \theta_s^* = \theta_s^*(m,k) \quad s \in \{\text{opt}, \text{pes}\} & \text{(sentiment)} \\ \frac{1}{k} = g'(I - mR_M) & \text{(fire sale discount)} \end{cases}$$

multiplicity

Inefficiency

- **Theorem.** CE, in general, not constrained efficient.

- **Wedge** between private and social solutions:

$$\tau_s^* = -\mu_s^P \frac{\theta_{\min}}{R_M} \frac{dk}{dm} + C(m) \frac{dF(\theta_s^*)}{dm} - mR_M \left(\frac{1}{k} - 1 \right) \frac{\partial F(\theta_s^*)}{\partial m}$$

with $C(m) \equiv \left(g(I) - g(I - mR_M) - mR_M \right) \geq 0$

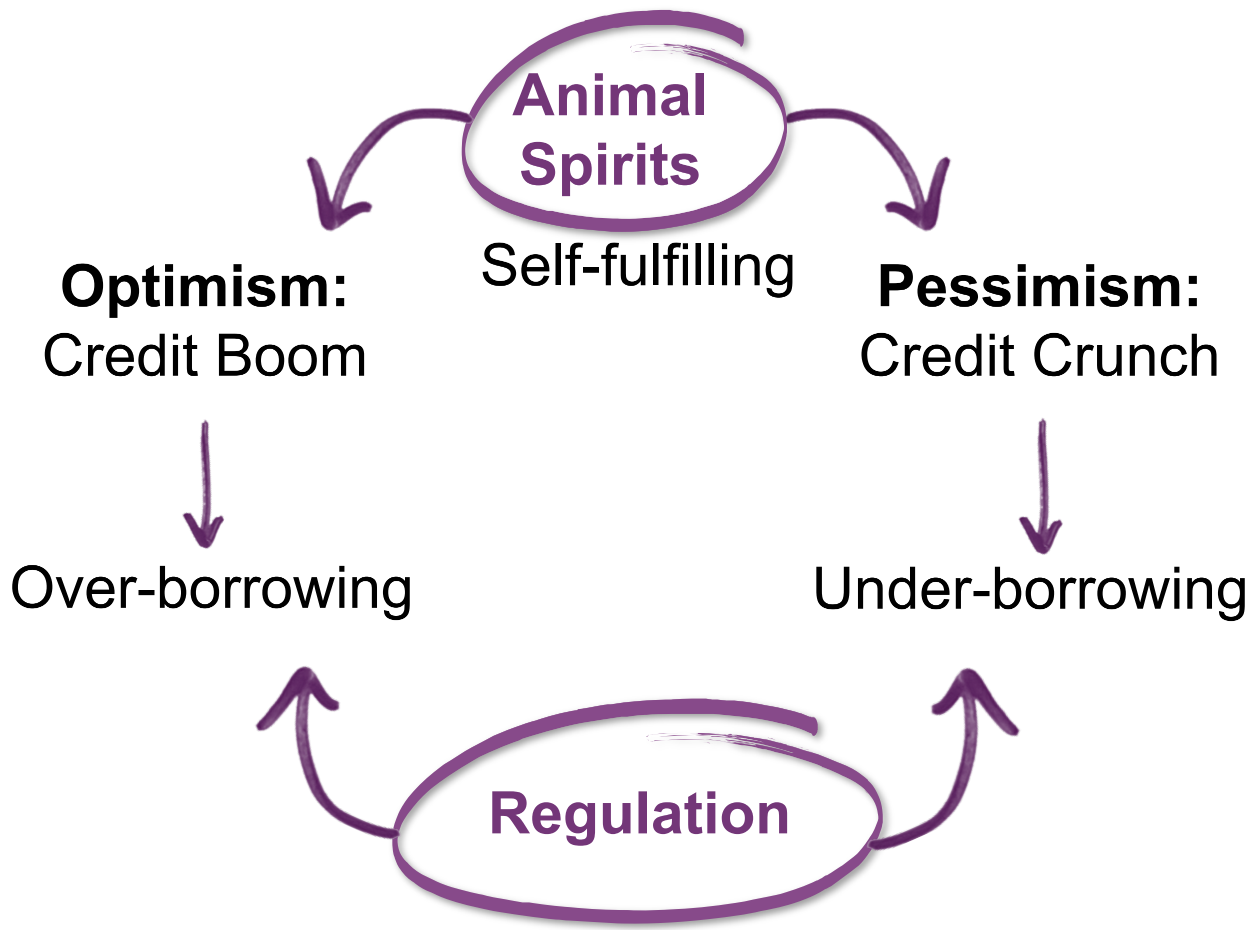
  - $\tau_{\text{opt}}^* \geq 0 \iff$ **excessive** money creation
  - $\tau_{\text{pes}}^* \leq 0 \iff$ **insufficient** money creation

- **Efficiency-restoring tax:**

$$\max_m W(m) = \max_m \{\Pi_s(m; k^*) - \tau_s^* m\}$$

Key Results

Sign of restoring tax depends on the collective **sentiment** in the credit market:



Concluding Remarks

- The economy benefits from private money creation, but **banks incentives are often distorted** because they don't internalize cost of runs and fire sales
- State of the economy is endogenous: interaction between insolvency risk and rollover risk. **Multiple equilibria**
- **Unified setting (boom/crunch)** to justify interventions; direction depends on the sentiment in the credit market
- Highlights the need for **dynamic regulatory frameworks**
- Restoring tax/subsidy **doesn't prevent ups/downs, but prevents the economy from swinging to extremes**

questions

- Where does the money go if the bank is insolvent? Would be an incentive to always fail
- Can we induce a dynamic behavior between equilibria that says theta_opt changes as a function of k