Self-fulfilling Fire Sales

Fragility of Collateralised Short-term Debt Markets

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Motivation: Instability in market-based banking system

Collateralised short-term financing is an important source of funding for financial institutions.

Typical contracts:

- Repurchase agreement (Repo) and asset-backed commercial paper (ABCP)
- Collateralised with high-rate mortgage-backed securities (MBS), corporate bond, sovereign debt

Features:

- Lenders decide whether to roll-over when the debt matures, usually before the asset matures.
- In repo, lenders can seize the collateral and sell it when borrowers default

Motivation: Systemic run & illiquid collateral

Observations in the Global Financial Crisis 07-09:

(1) "Systemic runs" on short-term debt collateralised with

- private-label ABS, corporate bond, agency bond
- debt yields and borrower default risks increased
- margin increased and/or borrowing collapsed ▸ more evidence

(2) Fire sales of illiquid collateral: e.g. He, Khang and Krishnamurthy (2010), from 2007Q4 to 2009Q1

- Hedge fund and broker/dealer holdings of securitised asset decreased by $800 billion
- Commercial banks absorbed $550 billion. Remaining by gov't

What's new to be explained?

Difference from traditional bank run: no first-come-first-served nature as in deposit contract.

E.g. a quote from Gary Gorton (2012) (emphasis by me)

> *...we know that crises are exits from bank debt... In this form of money (repo), each "depositor" receives a bond as collateral. There is no common pool of assets on which bank debt holders have a claim. So, strategic considerations about coordinating with other agents do not arise. This is a challenge for theory and raises issues concerning notions of liquidity and collateral...*

This paper: Self-fulfilling Fire Sales

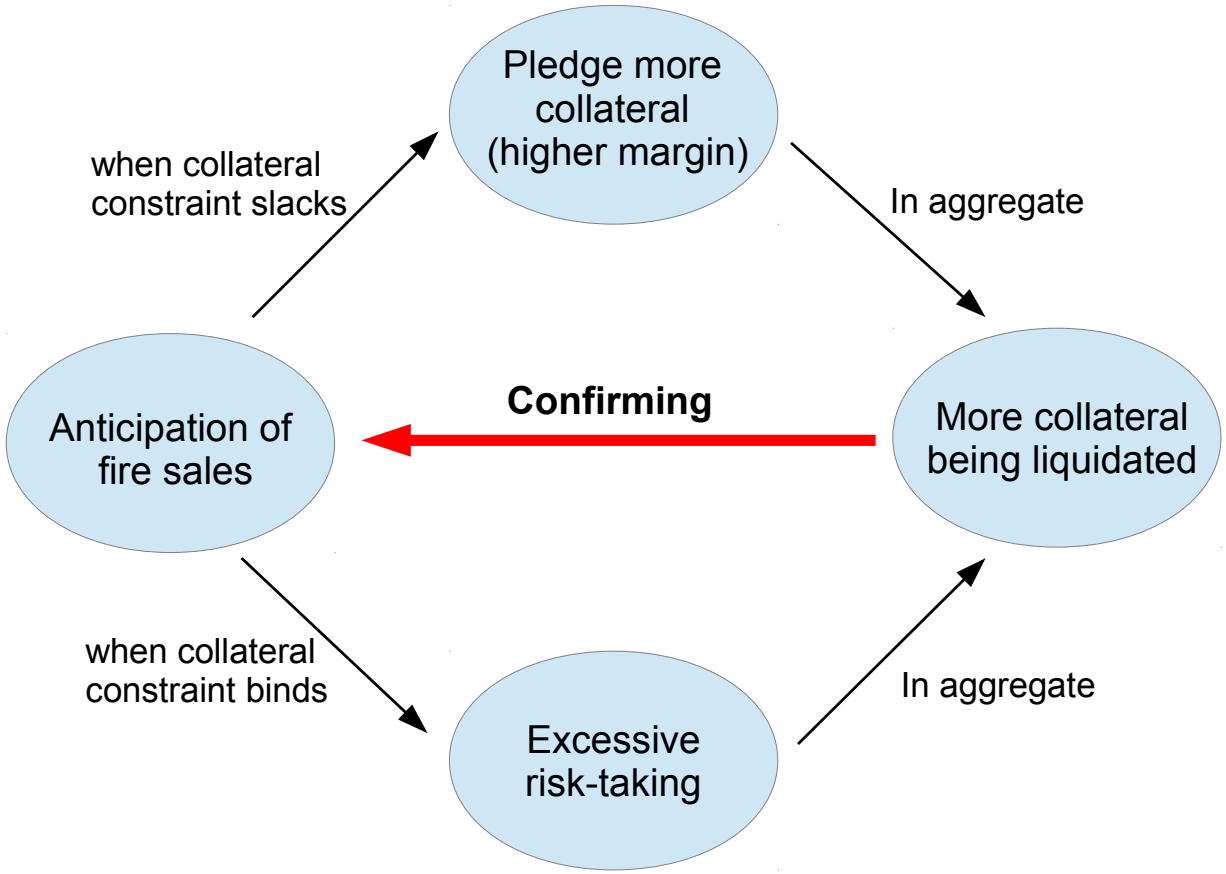
Mechanism: a feedback between borrowers' risk-taking incentives and the endogenous fire-sale discount of the collateral

Result: Collateralised short-term debt is privately optimal but in equilibrium can lead to fragility (multiple equilibria).

Contribution: A new form of coordination failure between borrowers' ex-ante **margin** and **risk-taking decision**, generating

- self-fulfilling fire sales of certain collateral
- 'systemic run' phenomenon in debt markets

Mechanism of the self-fulfilling fire sales equilibrium



Model Setup

Timing & Preferences: Three dates ($t = 0, 1, 2$). Zero riskfree rate. Risk-neutral agents

Agents: A continuum of **firm-creditor** pairs, and a representative **collateral buyer**

Goods: one goods, i.e. cash

Firms with moral hazard problem

Each firm starts with no cash and debt but is endowed with:

1. **a divisible asset-in-place** that pays an expected dividend v at $t = 2$
2. **a project** which needs \$1 investment and pays X at $t = 2$ when succeeds and 0 otherwise.

Risk-taking: each firm can choose the success probability $p_1 > p_2 > p_3$ by incurring a private effort cost $c(p_i) = c_i$, where

$$p_1 X - c_1 > p_2 X - c_2 > 1 > p_3 X - c_3$$

e.g. hedge funds that could manage its portfolio risk

Project risk is independent

Collateralised short-term debt

The firm borrows from its creditor (who has \$1) in the form collateralised short-term debt. (Optimality discussed later)

- pledges $k \in [0, 1]$ fraction of the collateral (**margin**) and promises to repay $r \geq 0$ (**debt yield**) at $t = 1$
- At $t = 1$, both the firm and its creditor know whether the project has succeeded. Creditor seizes the collateral if failed.

Creditors' liquidation decision and fire sales

Assumption: Creditors' expected utility from receiving the risky collateral dividend at $t = 2$ is $\underline{l} \leq v$

- interpretation: less sophisticated and highly regulated creditors. Think of money market mutual fund.
- I will interpret $\underline{l}$ as **collateral quality**. For instance, $\underline{l} \simeq v$ for safe collateral like US Treasuries.
- Sell at $t = 1$ when market clearing price $l \geq \underline{l}$.

Finally, a competitive collateral buyer clears the market with a downward sloping demand function. (More later)

Roadmap

Equilibrium concept: symmetric (mixed-strategy) rational expectation equilibria.

I first study the individual firm investment and contracting problem at $t = 0$, for any conjectured liquidation value l.

Then I discuss how the collateral liquidation value is determined at $t = 1$ in equilibrium.

In equilibrium, the conjecture is correct.

Analysis: Individual firm-creditor contracting problem

Taking I as given, at $t = 0$ each firm offers a contract $\{r, k\}$ to its creditor to maximise the net utility from investing $U(I)$, subject to **Firm's incentive constraint** (IC):

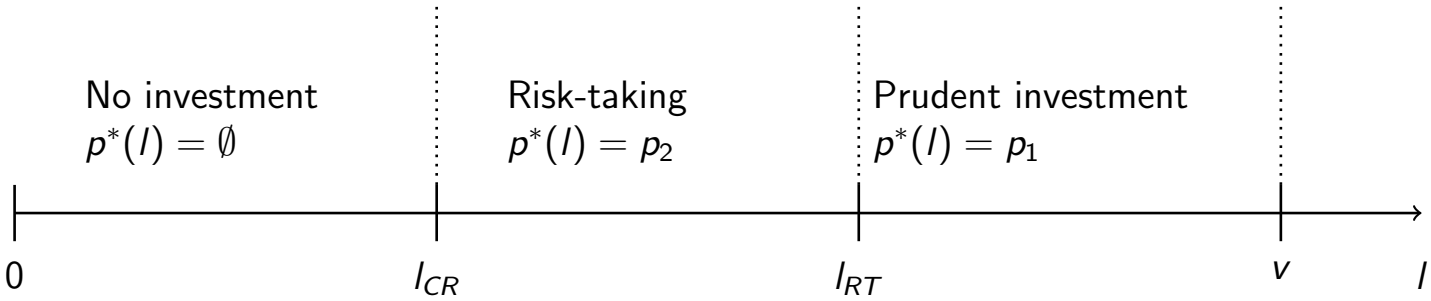
$$p(r,k) \equiv \underset{p \in \{p_1,p_2,p_3\}}{\text{argmax}} \quad p(X-r) - (1-p)kv - c(p)$$

$$\text{or} \quad p(r,k) = \begin{cases} p_1 & \text{for} \quad r \leq \bar{r}_1(k) \\ p_2 & \text{for} \quad r \in (\bar{r}_1(k), \bar{r}_2(k)] \\ p_3 & \text{otherwise} \end{cases} \tag{1}$$

$\bar{r}_i(k)$ increase in $k \rightarrow$ pledging collateral discourages risk-taking

Result: Anticipation of fire sales induces risk-taking

Under some parameter restrictions ▸ parametric assumptions, the optimal investment strategy $p^*(l)$



Optimal contract: $\{r_i(l), k_i(l)\}$ when $p^*(l) = p_i$

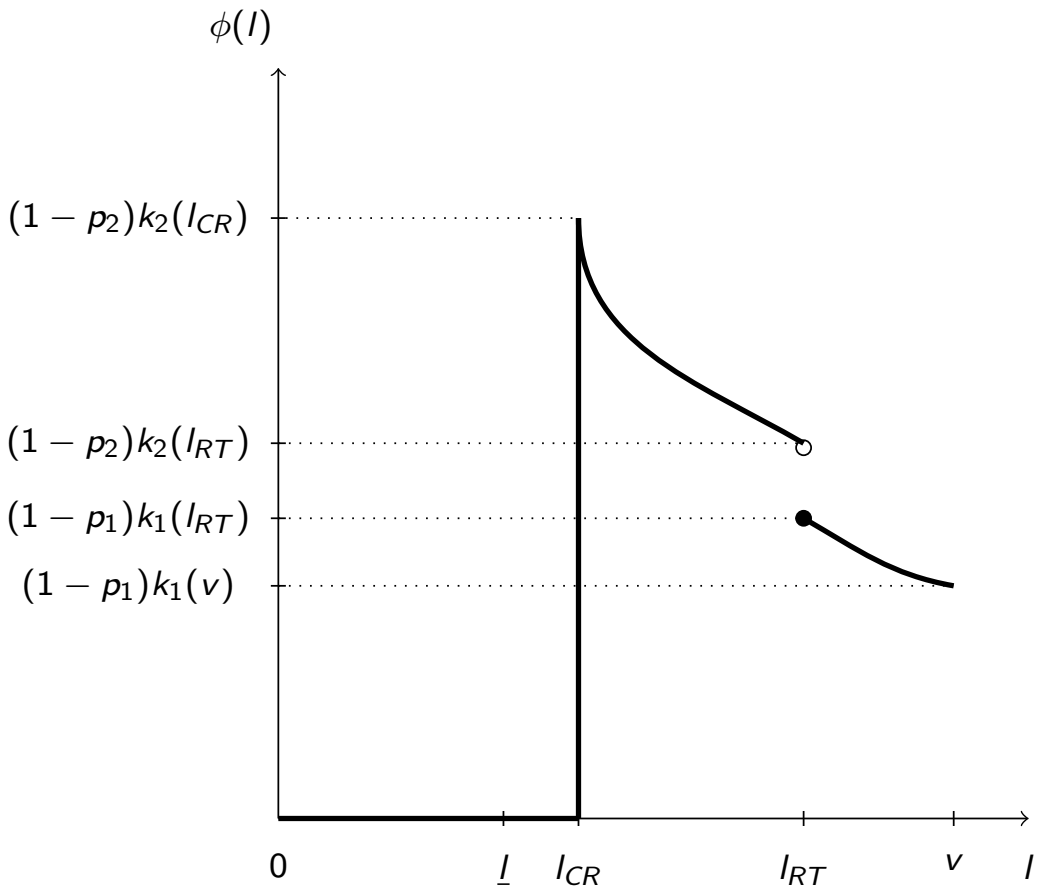
- Margin $k_i(l)$: decreasing and convex in l
- Debt yields $r_i(l) = \bar{r}_i(k_i(l))$: decreasing in l.

Lower l leads to higher margin $k_i^*(l)$ and risk-taking.

Next, the illiquid collateral asset market

Amount of collateral liquidated $\phi(l)$

At $t = 1$, by symmetry $\lambda(l)(1 - p^*(l))k(l)$ collateral transferred to creditors, who sell when $l \geq \underline{l}$ hence



Collateral buyer and endogenous liquidation value

There is a competitive collateral buyer to clear the market.

He has an exogenous amount of cash $\theta \in (0, +\infty)$ at $t = 0$

- can invest in a decreasing return to scale technology with return $F(\theta)$ at $t = 2$
- to clear the market, he has to hoard cash ϕI
- Optimal investment decision

$$F'(\theta - \phi I) = \frac{v}{I}$$

Thus the market-clearing price function $L(\phi; \theta)$ is

- decreasing in ϕ the amount of collateral supplied
- increasing in θ

θ is a common knowledge and an important state variable.

Equilibrium

For any given θ, a symmetric, competitive REE consists of an $\{I^*\}$ such that

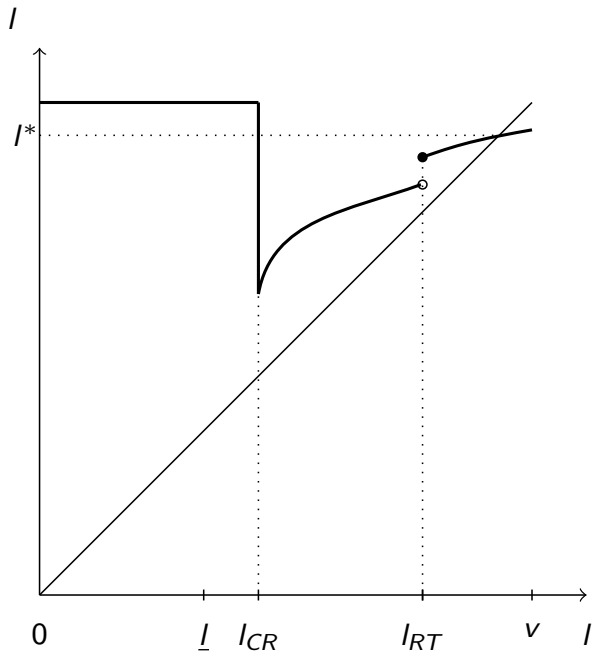
1. At $t = 0$, agents conjecture the equilibrium liquidation value to be I^*. Firms maximise profit with $p^*(I^*)$ and $\{r(I^*), k(I^*)\}$;
2. At $t = 1$, creditors sell $\phi(I^*)$ units of collateral ;
3. Collateral buyer with θ clears the market at price $L(\phi(I^*); \theta)$;
4. In equilibrium, agents' conjecture is correct. That is,

$$I^* = L(\phi(I^*); \theta)$$

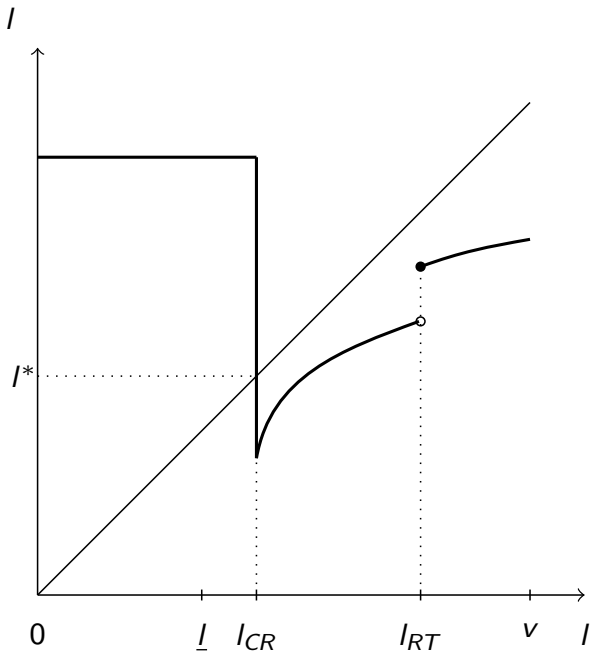
Self-fulfilling fire sales: multiple solutions I^*.
Existence of equilibria proved in the paper.

Results: equilibria under different θ

Results: Unique equilibrium under extreme values of θ



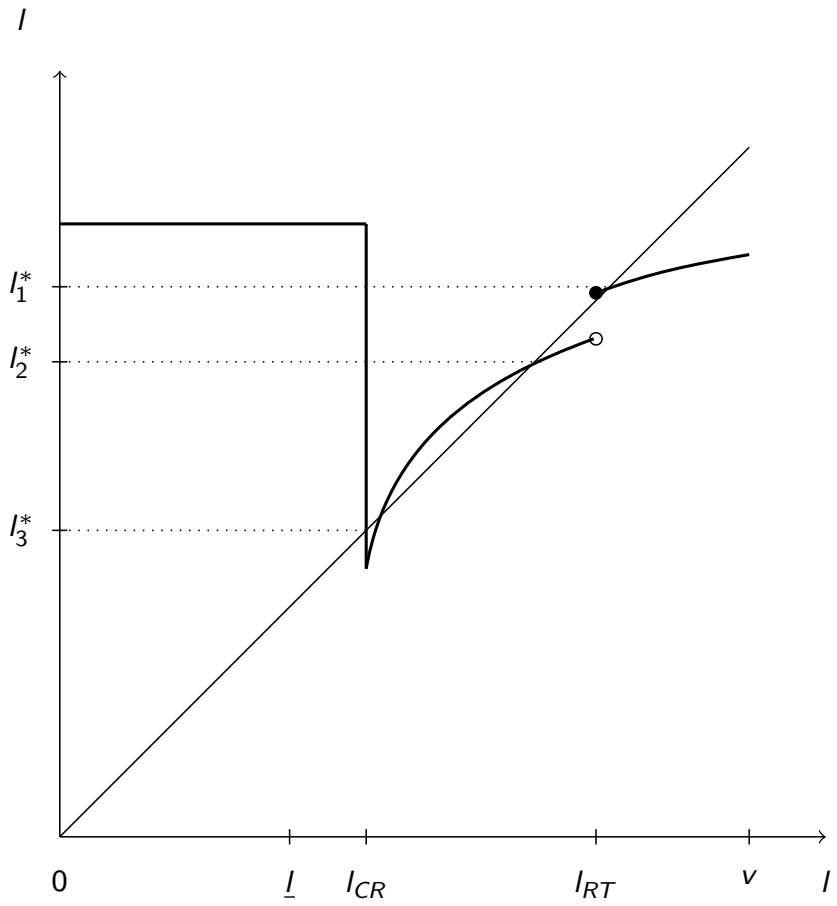
(a) when $\theta \geq \bar{\theta}$



(b) when $\theta \leq \underline{\theta}$

Amplification: effects of changes in liquidity for collateral amplified by moral hazard problem.

Multiple equilibria for $\theta \in (\underline{\theta}, \bar{\theta})$



Self-fulfilling fire sales via

1. **Risk-taking channel** $I_1^* \to I_2^*$ and
2. **Margin channel** $I_2^* \to I_3^*$

Differences in the two channels

Risk-taking channel

1. changes in default risk but undetermined in margin $(k_1^*(l_1^*) - k_2^*(l_2^*))$ can't be signed
2. default risk correlates positively with debt yield and negatively with collateral prices
3. consistent with Gorton & Metrick (2010)

Margin channel

1. changes in margin but not default risks.
2. margin correlates positively with debt yield and negatively with collateral prices

Source of fragility

Strategic complementarities stem from the feedback between moral hazard problem and collateral fire sales

- When a firm takes excessive risk or increases margin, it exerts a pecuniary externality on others through fire-sale.
- lower liquidation value tightens others' incentive constraint
- triggering more margin requirement or risk-taking

Differences from Diamond-Dybvig type fragility:

- 'Systemic run': coordination failure among different institutions in a collateral market, in the **ex-ante investment and contracting stage**.
- Not from first-come-first-served constraint (or variants of it).

Welfare

Social welfare in multiple equilibria: **equilibria with higher liquidation value are more efficient**

- fire sales crowd out collateral buyer's productive investment.
- distort firms' incentives
- lead to credit rationing or costly transfer of collateral to lower valuation creditors

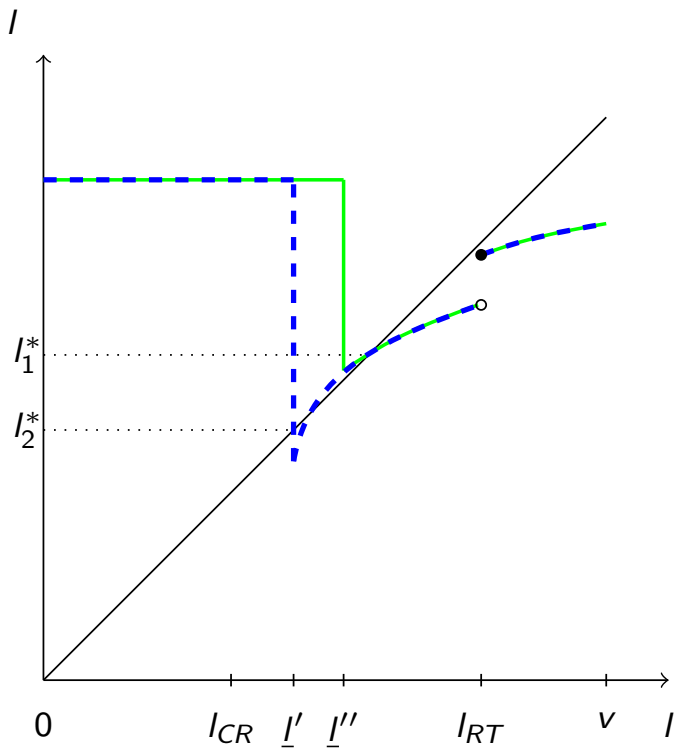
Market Maker of Last Resort: Asset price guarantee

Central banks can eliminate the inefficient equilibria by **committing to buy any amount of the collateral at some price** l_{PG}

- If the multiple equilibria involve risk-taking like $l_1^* \geq l_{RT} > l_2^*$, set $l_{PG} \geq l_{RT}$ to *prevent* risk-taking
- **Market Maker of Last Resort** coined by Willem Buiter
- As long as $l_{PG} < l_1^*$, the facility will not be used in equilibrium
- Credibility issues: fire sales are ex-post efficient.

Collateral quality and fragility

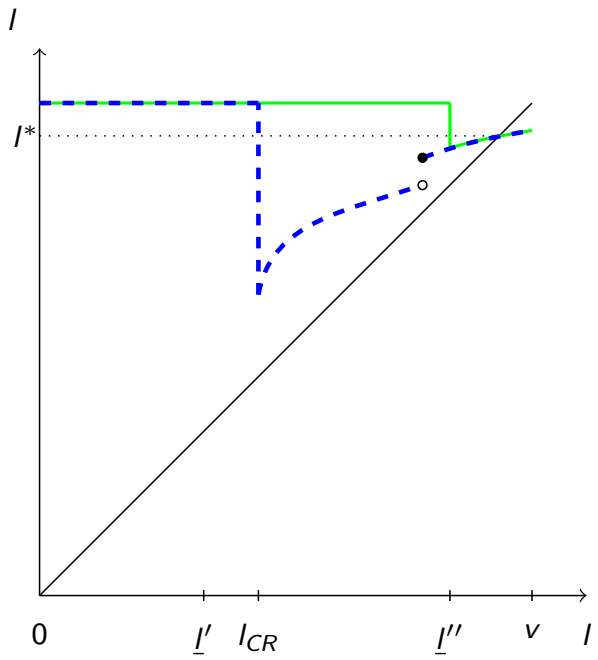
Cross-section: Fix a state θ', low quality collateral breeds fragility.



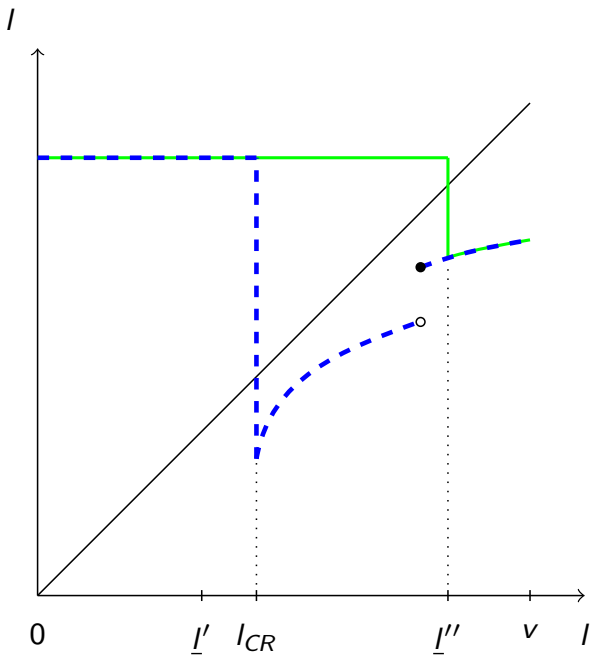
Implication: possible jumps in spreads and borrowing terms for lower quality collateral.

Counter-cyclical credit spreads

Business-cycles: Compare two collateral in different states θ



(a) when $\theta \geq \bar{\theta}$



(b) when $\theta \leq \underline{\theta}$

Implication: differences in spreads and borrowing terms between two collateral are more apparent in bad states.

Repo as optimal contract

Optimality:

- Debt: wipes out downside payoff $\rightarrow$ motivates effort
- Collateralised: increases 'liability' when failed $\rightarrow$ relax IC
- Short-term: creditors value the option to liquidate early

Cost of automatic stay

Common repo contract in the market has an **exemption from automatic stay** provision

- Automatic stay inhibits creditor from collecting debt when a firm files for Chapter 11 bankruptcy protection
- Exemption from stay allows repo lender to timely seize and liquidate the collateral in the market.

With automatic stay, the firm can threaten to invoke bankruptcy protection and renegotiate with the lender

- Suppose k units of collateral is pledged, the firm can make a take-it-or-leave-it offer to the lender with a new k' such that

$$k' l^* = k \underline{l}$$

- reducing the amount of collateral that the firm can **credibly** pledge. Incentive problem worsened.

Related Literature (incomplete)

Fragility in secured debt market: Martin et al. (2014)

- OLG Diamond-Dybvig with large unanticipated shocks

Self-fulfilling crises and financial market runs:

- Malherbe (2014): adverse selection and cash-hoarding
- Bernardo and Welch (2004), Morris and Shin (2004): first-come-first-serve + liquidity shock or loss limit

Fire sales and aggregate uncertainty: Lorenzoni (2008), Stein (2012), Eisenbach (2013)

- Excessive (short-term) debt under aggregate uncertainty

Amplifying mechanism: Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009), Danielsson et al. (2011)

- exogenous margin constraints with unanticipated shocks

Endogenous margins and externality:

- Biais et al. (2014): excessive margining in insurance-derivative market
- Hombert (2009): fire sales *lessen* incentive problem by rewarding prudent firms
- Acharya and Viswanathan (2011): more highly leveraged firms being financed in good times caused more severe bust in bad times

Conclusion

- This paper shows a panic-like financial fragility in modern collateral-based financial system.
- Stems from a feedback loop between firms' ex-ante risk-taking incentives and fire-sale discount of collateral asset
- Can generate non-linear cross-sectional and time-series variations in collateral credit spreads, firms' default risk, debt yields, and credit rationing.
- Policy implication: Central Bank as Market-Maker of Last Resort. Asset Price Guarantee can maintain stability and *reduce* risk-taking.
- Imposing automatic stay may worsen incentives and *increases* fire sales.

Thank you!

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Assumption

(NPV and moral hazard intensity of the project) Define $\Delta p_i \equiv p_i - p_{i+1}$, $\Delta c_i \equiv c(p_i) - c(p_{i+1})$, *and* $A_i \equiv 1 - p_i(X - \frac{\Delta c_i}{\Delta p_i})$ *for* $i = 1, 2$

(i) $A_1 > A_2 > 0$ *and*

(ii) $(1 - p_1)A_1 \leq (1 - p_2)A_2$

Assumption

(Parameter assumptions on v *and the NPV of risk-taking)*

(i) $v \in (A_1, \bar{v})$ *where*

$$\bar{v} = \frac{A_1}{1 - [(1 - p_1)(NPV_2)]/[(1 - p_2)(A_2 + NPV_2)]}$$

(ii) $NPV_2 \leq \min\{v - A_2, \frac{1 - p_2}{p_2} A_2\}$

back

Spreads for CMBS escalate

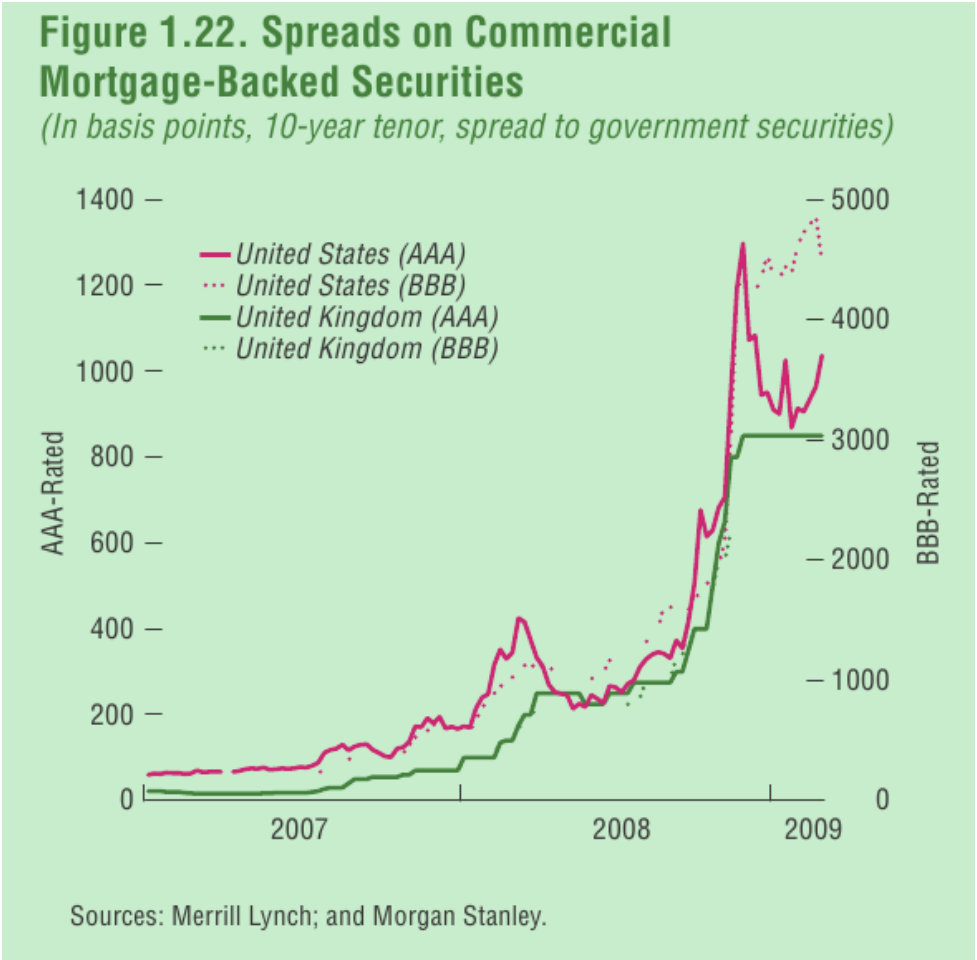

Figure: From IMF Global Financial Stability Report (2009, January)

Counterparty risk and fire sales

Figure 9: LIB-OIS and Non-Subprime-Related Asset Classes

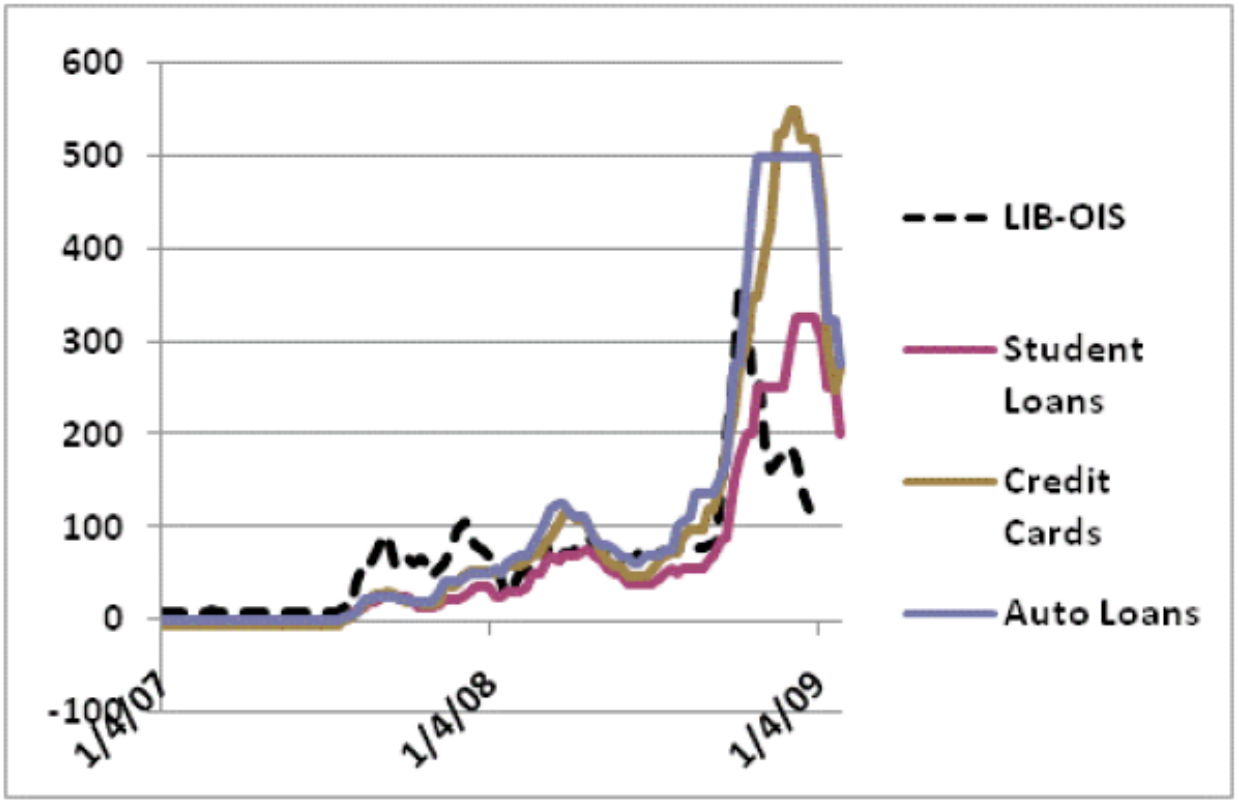

Figure: From Gorton & Metrick (2010). LIBOR-OIS and AAA-rated asset-backed securities spreads. Scale is basis point.

Repo rates increase

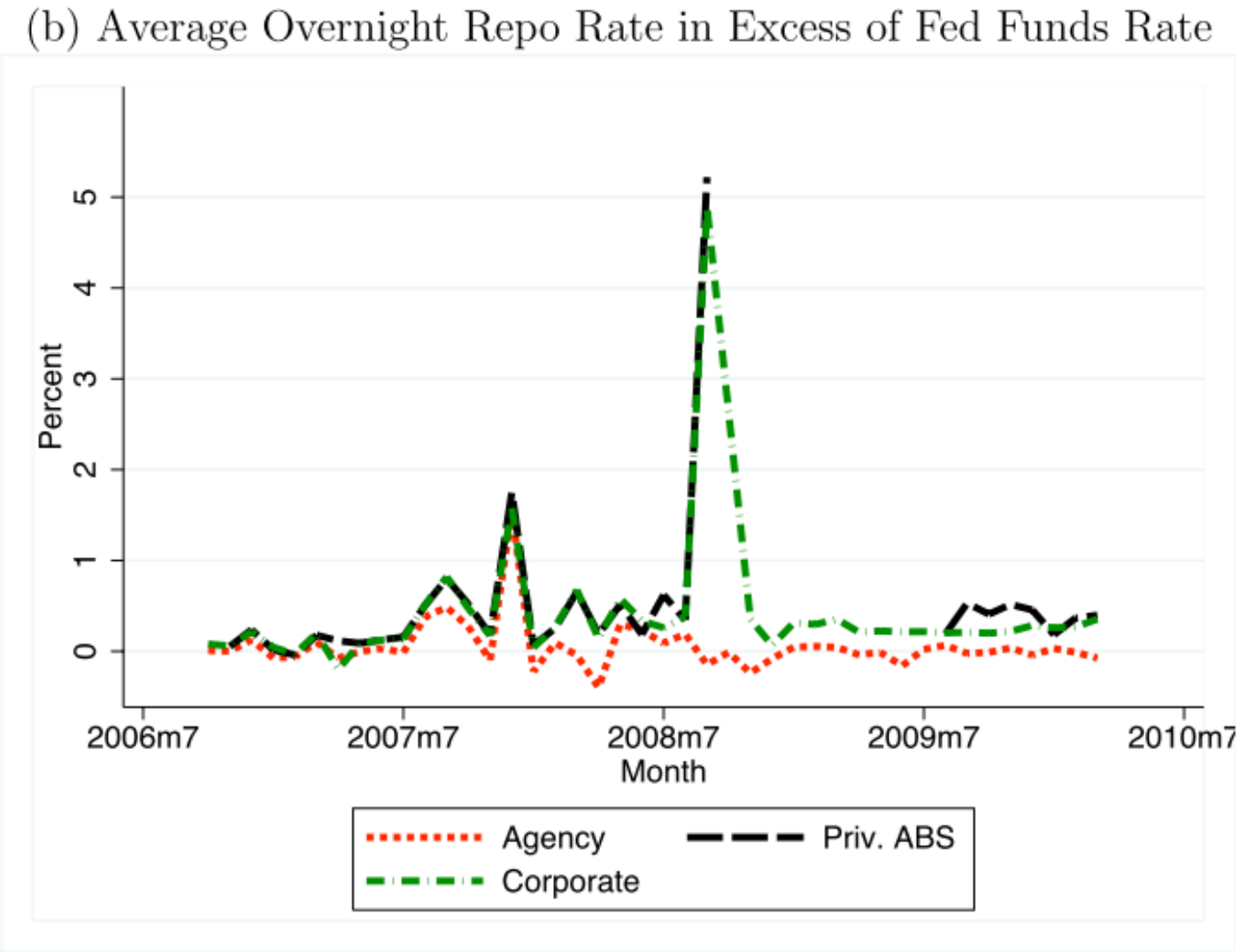

Figure: Average Overnight Repo Rates (Weighted by notional value) from Krishnamurthy et al (2013)

Repo haircuts differ

Table 4

Repo Haircuts

(percent)

	Repo haircuts (%)			
	Spring 2007	*Spring 2008*	*Fall 2008*	*Spring 2009*
U.S. Treasuries (short-term)	2	2	2	2
U.S. Treasuries (long-term)	5	5	6	6
Agency mortgage-backed securities	2.5	6	8.5	6.5
Corporate bonds, A–/A3 or above	5	10	20	20
Collateralized mortgage obligations, AAA	10	30	40	40
Asset-backed securities, AA/Aa2 and above	10	25	30	35

Figure: From Krishnamurthy (2010). Data from Depository Trust and Clearing Corporation.

ABCP yield spreads increase

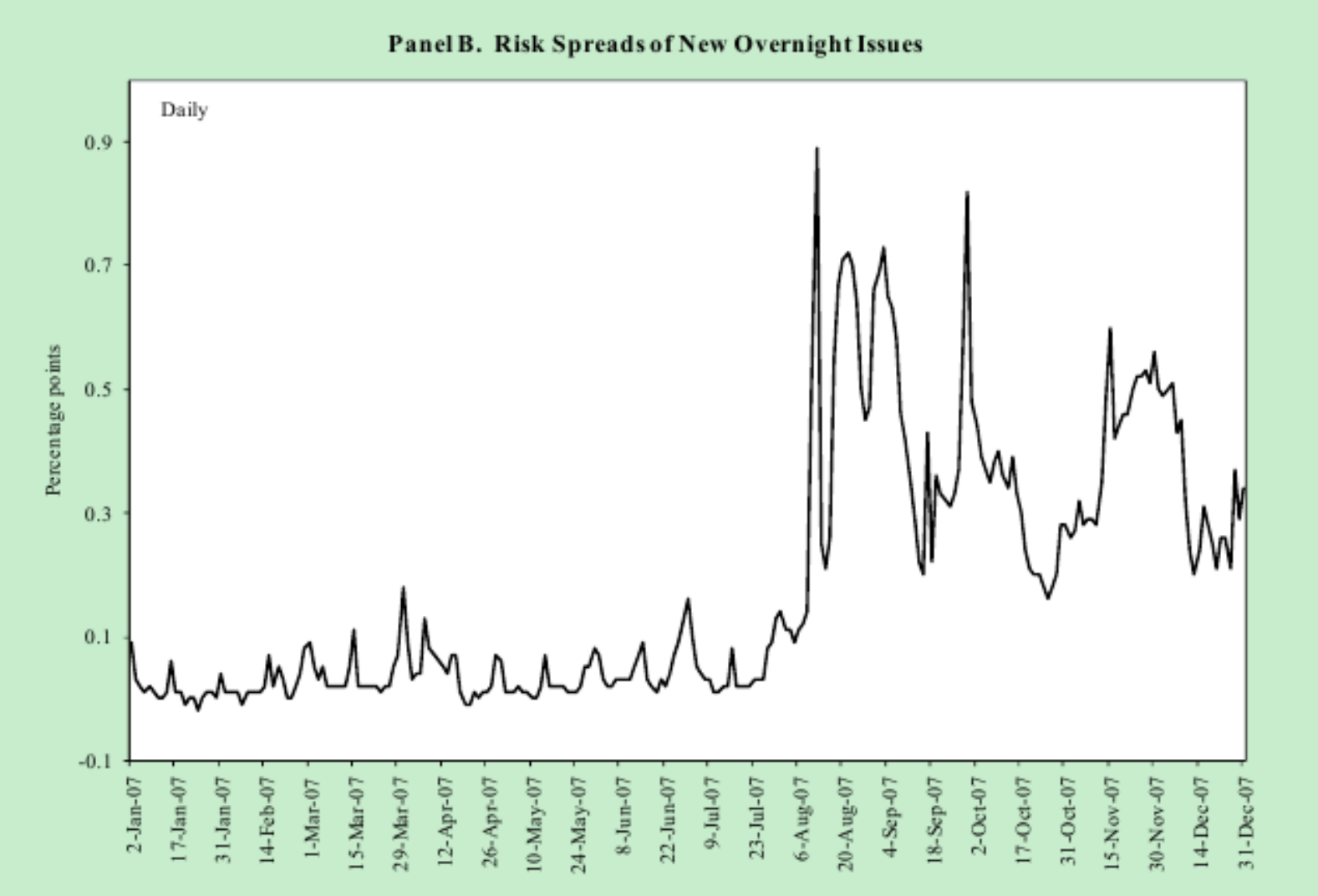

Figure: Spread of rates on AA-rated ABCP over target fund rate for paper with 1-4 day maturity from Covitz et al (2012) back