Illiquidity Component of Credit Risk

Stephen Morris and Hyun Song Shin

Princeton University and Bank of International Settlements
NBER and NYU conference on Multiple Equilibria and
Financial Crises, February 2016
An Old Distinction

- Insolvency versus Illiquidity problems
Solvency View

- Banks get in trouble when borrowers default
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- Focus on asset side of balance sheet
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  - Problem is shortfall in asset values
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Classical Solution:
  Capital is buffer to protect creditors
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- Classical Solution:
  - Capital is buffer to protect creditors
  - Basel-style approach to bank capital regulation
Liquidity View

- Banks get in trouble when lenders withdraw or (equivalently) fail to rollover deposits / short term lending
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Classical Solutions:
- Longer term funding / remove liquidity mismatch
- Lender of Last Resort
- Liquidity Regulation: assets that are more easily liquidated
A Classical Statement of the Liquidity View

Christopher Cox, (then) SEC chairman, on Bear Stearns in March 2008.

“[T]he fate of Bear Stearns was the result of a lack of confidence, not a lack of capital. When the tumult began last week, and at all times until its agreement to be acquired by JP Morgan Chase during the weekend, the firm had a capital cushion well above what is required to meet supervisory standards calculated using the Basel II standard.

Specifically, even at the time of its sale on Sunday, Bear Stearns’ capital, and its broker-dealers’ capital, exceeded supervisory standards. Counterparty withdrawals and credit denials, resulting in a loss of liquidity - not inadequate capital - caused Bear’s demise.”
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Geitner, Bernanke and every central banker, finance minister and regulator in history?
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  - given that solvency and liquidity problems are tightly entwined in practise, let’s focus on capital requirements and move on....
The (Nuanced) View of This Paper

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- Nonetheless, it is feasible and insightful to distinguish them in theory and identify "the illiquidity component of credit risk"
- Yes, policies targetted at insolvency (e.g., increased capital requirements) are excellent at preventing runs
- But other policies targetting illiquidity might also be effective in preventing runs IF the illiquidity component of credit risk is important
Theoretical Decomposition of Credit Risk

- Provides a theoretical accounting framework to decompose credit risk into:
  1. Insolvency Risk: probability that creditors would not get paid even in the absence of a run.
  2. Illiquidity Risk: probability that creditors do not get paid because of a run, when they would have been paid in the absence of a run.
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1. Insolvency Risk is the credit risk in the counterfactual world where short term funding was converted into long term funding
2. Illiquidity Risk is the extra credit risk in the actual world where funding remains short term
Comparative Statics (and Policy Analysis?)

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  - funding is less short term
  - there is more uncertainty about insolvency
- Marginal return to making assets more liquid is decreasing in the level of liquid assets
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Balance Sheet Impairment

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   2.1 "run risk" (probability bank will fail before asset returns are realized)
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2. ...how we can decompose illiquidity risk into.....
   2.1 "run risk" (probability bank will fail before asset returns are realized)
   2.2 "fire sale risk" (balance sheet is impaired by short run funding needs)
A couple of key things that are exogenous in our analysis:

1. Balance Sheet
Provisos

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1. Balance Sheet
2. Interest Rates
Three views of illiquidity versus insolvency:

- Disconnected models of insolvency and illiquidity
- Illiquidity Risk pinned down as difference between unique equilibrium under incomplete information with best equilibrium under complete information
- Decomposition of illiquidity risk and insolvency risk in the same unique equilibrium


I will return to literature later...
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Benchmark Model

- Want to identify the simplest model in which we can carry out the conceptual decomposition of credit risk described above
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- Very stark model with lots of extreme assumptions
Benchmark Model

- Two periods

Re-...nancing / liquidity problems arise at date 1

Asset values realized at date 2
Benchmark Model

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- Asset values realized at date 2
## Balance Sheet

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash $M$</td>
<td>Equity $E$</td>
</tr>
<tr>
<td>Risky Asset $Y$</td>
<td>Short Debt $S$</td>
</tr>
<tr>
<td></td>
<td>Long Debt $L$</td>
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Balance Sheet Assumptions

- **Assets:**
  
- "Cash" is safe and fully liquid ("Treasuries")
- Risky assets cannot be sold
- Interest on safe assets and all liabilities normalized to zero
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- Assumption 1. (Possibility of Runs)

\[
\frac{M}{S} < 1.
\]
Risky Asset Returns

- Total return on the risky asset at date 2 is $\theta$
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Risky Asset Returns

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  $$\theta \geq \theta^{**} = \frac{S + L - M}{Y}.$$  \hfill (1)
- Call $\theta^{**}$ the solvency point
Insolvency Risk

- At date 1, $\theta$ is believed to be uniformly distributed on the interval $[\overline{\theta} - \frac{1}{2}\sigma, \overline{\theta} + \frac{1}{2}\sigma]$.
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- Insolvency risk $S(\bar{\theta})$ is then the probability that $\theta \leq \theta^{**}$ or

$$S(\bar{\theta}) = \begin{cases} 1, & \text{if } \bar{\theta} \leq \theta^{**} - \frac{1}{2}\sigma \\ \frac{1}{2} + \frac{\bar{\theta} - \theta^{**}}{\sigma}, & \text{if } \theta^{**} - \frac{1}{2}\sigma \leq \bar{\theta} \leq \theta^{**} + \frac{1}{2}\sigma \\ 0, & \text{if } \theta^{**} + \frac{1}{2}\sigma \leq \bar{\theta} \end{cases}$$
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- see next slide....
Insolvency Risk

Insolvency risk, uniform case
Illiquidity Risk: Short Term Creditors’ Decisions

- Outside option $\alpha$ with $0 < \alpha < 1$ for creditors who do not rollover
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Illiquidity Risk: Short Term Creditors’ Decisions

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    \[ \alpha < \frac{M}{S} \]

- Key Implicit Assumption
  - no balance sheet impairment from meeting liquidity needs, e.g., if you sell bonds, you can buy them back at the same price; if you repo bonds, no haircut...
Illiquidity Risk: Short Term Creditors’ Decisions

- If proportion $\pi$ of creditors do not rollover, then the bank will survive if

$$\pi S \leq M.$$
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- Assume short term creditors at the critical point where runs occur have uniform belief ("Laplacian belief") over the proportion of creditors running ("global game" foundation following shortly... )
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- The probability of the bank surviving a run will be

$$\frac{M}{S}.$$
The expected return of short term debt is the probability that there is no run times the probability that the bank is solvent, i.e.,

$$\frac{M}{S} \left(1 - S(\bar{\theta})\right)$$
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Write \( \theta_0^* \) for the "run point", i.e., unique value of \( \bar{\theta} \) solving

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Can show

\[ \theta_0^* = \theta^{**} + \sigma \left(\frac{\alpha S}{M} - \frac{1}{2}\right). \]
"Global Game" Foundations for "Laplacian" Beliefs

- Suppose each creditor observed mean $\bar{\theta}$ with a small amount of noise $\varepsilon \sim f(\cdot)$, so $x_i = \bar{\theta} + \tau \varepsilon$
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If $g(\cdot)$ is uniform, or if $\tau$ is small, the creditor has (approximately) uniform beliefs on $\pi$ independent of $x_i$.

Intuition:
- If creditor's signal conveys no information about the rank of creditor's signal, then he must have uniform belief by principle of insuficient reason.
- If $g(\cdot)$ is uniform, or if $\tau$ is small, creditor's signal conveys little information about rank of creditor's signal.

Now at run point $x_\theta = \theta_0$, marginal creditor will have uniform beliefs over proportion of creditors running.

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  - If $g(\cdot)$ is uniform, or if $\tau$ is small, creditor’s signal conveys little information about rank of creditor’s signal
- Now at run point $x^* \approx \theta_0^*$, marginal creditor will have uniform beliefs over proportion of creditors running
- Global games afficianados: See Morris, Shin and Yildiz (2015) on uniform rank beliefs and "common belief foundations of global games"
Illiquidity Risk

- Illiquidity risk is the probability that the bank fails due to a run when it would have survived in the event of a run.

\[
\mathcal{R}(\bar{\theta}) = \begin{cases} 
0, & \text{if } \bar{\theta} \leq \theta^{**} - \frac{1}{2}\sigma \\
\frac{1}{2} - \frac{1}{\sigma} (\theta^{**} - \bar{\theta}), & \text{if } \bar{\theta} \in \left[\theta^{**} - \frac{1}{2}\sigma, \sigma \left(\frac{\alpha S}{M+X} - \frac{1}{2}\right)\right] \\
0, & \text{if } \bar{\theta} > \theta^{**} + \sigma \left(\frac{\alpha S}{M+X} - \frac{1}{2}\right)
\end{cases}
\]
Illiquidity Risk

Insolvency risk, uniform case

Default probability

$\theta^{**} - \frac{\sigma}{2}$ $\theta^{**}$ $\theta^{*}$ $\theta^{**} + \frac{\sigma}{2}$
Ex Ante Illiquidity Risk

- Write $\lambda = \frac{M}{S}$ for the "liquidity ratio"
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Ex Ante Illiquidity Risk

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- Suppose that at prior time 0, $\bar{\theta}$ is distributed with uniformly on $\left[\theta_0 - \frac{1}{2} \xi, \theta_0 + \frac{1}{2} \xi\right]$

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$$\left[ \theta_0 - \frac{1}{2} \xi, \theta_0 + \frac{1}{2} \xi \right]$$

- Assume that $\xi \gg \sigma$, ex ante illiquidity risk will be $\frac{1}{\xi}$ times the area of the triangle

$$EAIR = \frac{\sigma}{2\xi} \left( \frac{\alpha}{\lambda} \right)^2$$
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Ex Ante Illiquidity Risk Comparative Statics

- No illiquidity risk without solvency uncertainty
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  - response of EALR to liquidity ratio \(\lambda\) \((\frac{d}{d\lambda} EILR)\), is decreasing in \(\lambda\)
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Suppose now that the bank can always come up with enough cash to pay off short term creditors....
Balance Sheet Impairment Perspective

- Suppose now that the bank can always come up with enough cash to pay off short term creditors....
- ...but the cost of doing so impairs the balance sheet
Suppose now that the bank can always come up with enough cash to pay off short term creditors....

...but the cost of doing so impairs the balance sheet

Define impairment function

$$\tilde{\delta} : \mathbb{R}_+ \rightarrow \mathbb{R}_+$$

where

$$\tilde{\delta}(Z)$$

is the cost to the balance sheet if proportion $Z$ of creditors withdraw.
If we let

$$\tilde{\delta}(Z) = \begin{cases} 
0, & \text{if } Z \leq M \\
\infty, & \text{if } Z > M
\end{cases}$$

then our results can be interpreted as balance sheet impairment with the bank turning into a zombie bank that is surely going to fail in period 2.
Balance Sheet Impairment Interpretation

Can consider less extreme assumptions on $\tilde{\delta}$:

1. $\tilde{\delta}(Z)$ is increasing and convex, with $\tilde{\delta}'(Z) \leq 1$. 

Case studied by Rochet and Vives (2004) and Vives (2013)
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2. Piecewise linear:

   $$\tilde{\delta}(Z) = \begin{cases} 
   0, & \text{if } Z \leq M_0 \\
   \delta(Z - M_0), & \text{if } M_0 \leq Z \leq M \\
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Another Decomposition

Two kinds of illiquidity risk:

1. Run risk:

\[ \delta(Z) = \infty \]

2. Fire Sale risk:

2.1 Being solvent in the absence of a run;

2.2 Surviving the "run" (\( \delta(Z) < \infty \))
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Liquidity View: Run Risk

- Banks get in trouble when lenders withdraw / fail to rollover deposits / short term lending and the run causes bank failure
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Two Kinds of Illiquidity Risk in the Financial Crisis

- Bear Sterns failed after a run (at least, according to Chris Cox)
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- Bear Sterns failed after a run (at least, according to Chris Cox)
- Many other banks had impaired balance sheets because of the drying up of short term funding and implied need for fire sales
Three Cases

There are now three possible scenarios corresponding to the proportion of short term creditors $\pi$ who do not rollover:

1. If $\pi S \leq M_0$, then withdrawals can be met out of cash, ex post equity remains unchanged and the bank will be solvent ex post if inequality (1) holds.

2. If $M_0 \leq \pi S$, then $\pi S$ must be sold and adjusted so the solvency point becomes:

$$\theta = \theta + \delta(\pi S)$$

3. If $M_0 > \pi S$, then the bank cannot meet its obligations, and goes into bankruptcy at the interim date.
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$$\theta \geq \theta_{\delta^*}^{**} (\pi)$$

$$= \frac{S + L + \delta (\pi S - M_0) - M}{Y}$$

$$= \theta^{**} + \frac{\delta (\pi S - M_0)}{Y}$$
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\theta \geq \theta^{**}_\delta (\pi) \\
= \frac{S + L + \delta (\pi S - M_0) - M}{Y} \\
= \theta^{**} + \frac{\delta (\pi S - M_0)}{Y}
\]

3. If $M < \pi S$, then the bank cannot meet its obligations, and goes into bankruptcy at the interim date.
Short Term Creditors

- Algebra gets messier...
Short Term Creditors

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- Write $\theta_0^*$ for the run point (when $\delta = 0$)
Short Term Creditors

- Algebra gets messier...
- Write $\theta_0^*$ for the run point (when $\delta = 0$)
- We have fire sale point

\[ \theta_1^* = \theta_0^* + \frac{\delta (M - M_0)^2}{2YM} \]

\[ = \theta^{**} + \sigma \left( \frac{\alpha S}{M} - \frac{1}{2} \right) + \frac{\delta (M - M_0)^2}{2YM} \]
Fire Sale Risk

![Graph showing insolvency risk in a uniform case]

- $\theta^*$
- $\theta_0$
- $\theta^*$
- $\theta^* + \frac{\sigma}{2}$
Fire Sale Risk

- Exists even without solvency uncertainty
Fire Sale Risk

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- Still linear in $\sigma$

(Roughly) Linear in $M$
Fire Sale Risk

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- (Roughly) Linear in $M - M_0$
- Reducing $M_0$ drives fire sale risk
Normal Insolvency Risk

Total credit risk for $\sigma = 0.25$, $\alpha = 0.5$
Normal (Run) Illiquidity Risk

Total credit risk for $\sigma = 0.25$, $\alpha = 0.5$
Normal Fire Sale Risk

Total credit risk for $\sigma = 0.25$, $\alpha = 0.5$
Total credit risk for $\sigma = 0.5$, $\alpha = 0.5$
Decreasing Solvency Uncertainty

Total credit risk for $\sigma = 0.05, \alpha = 0.5$
Decreasing Solvency Uncertainty Further

Total credit risk for $\sigma = 0.01$, $\alpha = 0.5$
Small Noise Limit

As $\sigma \to 0$,

- "run risk" disappears:

  $\theta_0^* \to \theta^{**}$
As $\sigma \to 0$,

- "run risk" disappears:
  $$\theta_0^* \to \theta^{**}$$

- fire sale risk does not disappear:
  $$\theta_\delta^* \to \theta^{**} + \delta \left( \frac{\alpha S - M_0}{Y} \right)$$
If $\sigma \to 0$ and $\theta > \theta^{**}$, short term creditors believe that the bank is solvent (in the counterfactual sense) and there will not be a run (in the counterfactual sense)....
Fire Sale Noise Limit

- If $\sigma \to 0$ and $\theta > \theta^{**}$, short term creditors believe that the bank is solvent (in the counterfactual sense) and there will not be a run (in the counterfactual sense)....

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- Fire Sale Point is associated with a critical proportion of creditors $\pi_d^*$ such that if that proportion ran, the balance sheet would be degraded enough to make the bank insolvent
- Laplacian beliefs then imply fire sale run point
Fire Sale Noise Limit Algebra

- Repayment will occur if $\pi$ satisfies

$$\theta^{**} + \frac{\delta (\pi S - M_0)}{Y} \geq \theta^*$$
Fire Sale Noise Limit Algebra

- Repayment will occur if $\pi$ satisfies

$$\theta^{**} + \frac{\delta (\pi S - M_0)}{Y} \geq \theta^*_\delta$$

- Making $\pi$ the subject

$$\pi^*_\delta \geq \frac{1}{S} \left( \frac{(\theta^*_\delta - \theta^{**}) Y}{\delta} + M_0 \right)$$
Fire Sale Noise Limit Algebra

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  \]

- Creditor indifference implies
  \[
  \frac{1}{S} \left( \frac{(\theta^*_\delta - \theta^{**})}{\delta} Y + M_0 \right) = \alpha
  \]
Fire Sale Noise Limit Algebra

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- Creditor indifference implies

$$\frac{1}{S} \left( \frac{(\theta^*_\delta - \theta^{**}) Y}{\delta} + M_0 \right) = \alpha$$

- and so

$$\theta^*_\delta = \theta^{**} + \delta \left( \frac{\alpha S - M_0}{Y} \right)$$
More Robustness

- Can add in richer balance sheet (arbitrary combinations of riskiness and liquidity of assets)
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- Could endogenize interest rates (with signalling ruling out arbitrary interest rates on short run debt)
Literature

1. Multiple Equilibria, e.g., Diamond-Dybvig (1983)
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   - Solvency Risk $\approx$ Unique (Bad) Equilibrium
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2. "Informational Selection": Compare informationally selected unique equilibrium with best complete information equilibrium
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   - "Global Games"
Global Games Literature: Some Early Papers 1

Morris-Shin (2004): "Coordination Risk and Price of Debt"

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Rochet and Vives (2004):

1. Decomposition of Credit Risk:
   - focus on fire sale rather than illiquidity risk

2. Modelling Comments:
   - balance sheet modelling
   - restricted normal/normal framework

3. Focus:
   - Modelling lender of last resort policy
Some "Recent" Papers

[this means since the first version of this one!]

- Vives (2014): does a decomposition of credit risk and comparative statics in normal normal framework otherwise like this one
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