Illiquidity Component of Credit Risk

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NBER and NYU conference on Multiple Equilibria and
Financial Crises, February 2016

An Old Distinction

- Insolvency versus Iliquidity problems

Solvency View

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

Liquidity View

- Banks get in trouble when lenders withdraw / fail to rollover deposits / short term lending
- Focus on liability side of balance sheet
    - Problem is maturity mismatch, panic
- 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."

- ▶ Geitner, Bernanke and every central banker, finance minister and regulator in history?

Liquidity versus Solvency

- The Christopher Cox liquidity view is a little self-serving but more importantly a little simplistic...
- Bear Stearns - and other institutions facing liquidity risk - always (or almost always) have solvency problems
- Liquidity and solvency problems hard to disentangle in practice
  - Did the run hasten failure of an already insolvent bank?
  - Or, did the run scupper an otherwise sound bank?
- One policy response:
  - 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

- Yes, insolvency and illiquidity are tightly entwined in practise
- 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

Theoretical Decomposition of Credit Risk

Decomposition is counterfactual:

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?)

- Uncertainty about future insolvency drives illiquidity; but illiquidity risk has different comparative statics (policy response) from insolvency risk

- Liquidity Risk is higher when....
  - short term creditors have higher outside options
  - 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

Another Decomposition

Two kinds of illiquidity risk:

1. Run risk: probability of bank failure
2. Fire Sale risk: probability of failure because of impairment of balance sheet during a run despite (i) being solvent in the absence of a run; and (ii) surviving the run

Analysis:

1. Benchmark model assumes no balance sheet impairment and therefore focuses on run risk
2. Extension introducing long term costs of defending a run and therefore introduces fire sale risk

Liquidity View: Run Risk

- Banks get in trouble when lenders withdraw / fail to rollover deposits / short term lending *and the run causes bank failure*
- Focus on liability side of balance sheet
  - Problem is maturity mismatch, panic
- Classical Solutions:
  - Longer term funding / remove liquidity mismatch
  - Lender of Last Resort
  - Liquidity Regulation: *assets that have the highest possible liquidation value*

Liquidity View: Fire Sale Risk

▶ Banks get in trouble when lenders withdraw / fail to rollover deposits / short term lending *and the run impares the balance sheet*

▶ Focus on liability side of balance sheet
  ▶ Problem is maturity mismatch, panic

▶ Classical Solutions:
  ▶ Longer term funding / remove liquidity mismatch
  ▶ Lender of Last Resort
  ▶ Liquidity Regulation: *assets whose liquidation causes the least impairment of the balance sheet*

Two Kinds of Illiquidity Risk in the Financial Crisis

- ▶ 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

Implications of Fire Sale Risk

- Exists even without uncertainty about insolvency

Provisos

A couple of key things that are exogenous in our analysis:

1. Balance Sheet
2. Interest Rates

Literature

- Solvency versus Liquidity: Models of Solvency and Illiquidity often disconnected
- Illiquidity Risk pinned down as difference between unique equilibrium under incomplete information with best equilibrium under complete information
- "Global game" literature address how the two interact (Morris and Shin (2004), Rochet and Vives (2004), Goldstein and Pauzner (2005)) buries the distinction (because the focus is on other issues)
- will return to literature later....

Paper History

- First draft in March 2009
- This draft has ambitious objectives
    1. conceptual decomposition of credit risk
    2. policy tool
    3. crisis explanation
- Motive for resurrection
    - focus on (1) conceptual decomposition of credit risk
    - 25th percentile of my google scholar cites!

Benchmark Model

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

Benchmark Model

- Two periods
- Re-financing / liquidity problems arise at date 1
- Asset values realized at date 2

Balance Sheet

Assets	Liabilities
Cash M	Equity E
Bonds X	Short Debt S
Risky Asset Y	Long Debt L

Balance Sheet Assumptions

- Assets:
  - Cash is safe and fully liquid
  - Bonds are safe and can be sold but are (perhaps) subject cost to liquidation costs / fire sale prices
  - Risky assets cannot be sold
- Interest on safe assets and all liabilities normalized to zero
- Possibility of Runs:
$$S > M + X.$$

Risky Asset Returns

- Total return on the risky asset at date 2 is θ
- At date 1, θ is believed to be uniformly distribution on the interval $\left[\bar{\theta} - \frac{1}{2}\sigma, \bar{\theta} + \frac{1}{2}\sigma\right]$
- If nothing else happened before date 2, the equity of the bank would be
$$M + X + \theta Y - S - L.$$
- The bank is *solvent* at date 2 if this expression is positive, i.e., if
$$\theta \geq \theta^{**} = \frac{S + L - M - X}{Y}. \tag{1}$$
- Call θ^{**} the solvency point

Insolvency Risk

- Insolvency risk at date 1 is the probability that the bank fails under this scenario. Insolvency risk is then given by

$$
\mathcal{S}\left(\overline{\theta}\right) = \Pr\left(\theta \geq \theta^{**}\right) = \left\{ \begin{array}{l} 1, \text{ if } \overline{\theta} \leq \theta^{**} - \frac{1}{2}\sigma \\ \frac{1}{2} + \frac{\overline{\theta} - \theta^{**}}{\sigma}, \text{ if } \theta^{**} - \frac{1}{2}\sigma \leq \overline{\theta} \leq \theta^{**} + \frac{1}{2}\sigma \\ 0, \text{ if } \theta^{**} + \frac{1}{2}\sigma \leq \theta_1 \end{array} \right.
$$

- This is plotted on the next slide

Insolvency Risk

figure 1

Illiquidity Risk: Short Term Creditors' Decisions

- Outside option α with $0 < \alpha < 1$ for creditors who do not rollover ($\alpha < \frac{M+X}{S}$)
- Assume for now that cash and bonds are perfect substitutes...
    - interpretation: if you sell bonds, you can buy them back at the same price; if you repo bonds, no haircut...
    - pure "run risk", no "fire sale" risk
- If proportion π of creditors do not rollover, then the bank will survive if

$$\pi S \leq M + X.$$

- 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 on shortly)
- The probability of the bank surviving a run will be

$$\frac{M + X}{S}$$

Short Term Creditors' Decisions

- 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.,

$$\frac{M + X}{S} \left(1 - \mathcal{S}\left(\bar{\theta}\right)\right)$$

- Write θ_R^* for the "run point", i.e., unique value of θ solving

$$\frac{M + X}{S} \left(1 - \mathcal{S}\left(\bar{\theta}\right)\right) = \alpha$$

- Can show

$$\theta^* = \theta^{**} + \sigma \left(\frac{\alpha S}{M + X} - \frac{1}{2}\right).$$

"Global Game" Foundations for "Laplacian" Beliefs

- Suppose each creditor observed mean $\overline{\theta}$ with a small amount of noise $\varepsilon \sim f\left(\cdot\right)$, so $x_i = \overline{\theta} + \tau\varepsilon$.
- Smooth prior $g\left(\cdot\right)$ on $\overline{\theta}$
- Statistical Question: What belief does creditor i observing x_i have about the proportion of creditors π with higher signals?
- If $g\left(\cdot\right)$ is uniform, or if τ is small, the creditor has uniform beliefs on π 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 insufficient reason
    - If $g\left(\cdot\right)$ is uniform, or if τ is small, creditor's signal conveys little information about rank of creditor's signal
- Now at run point $x^* \approx \theta^*$, 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"
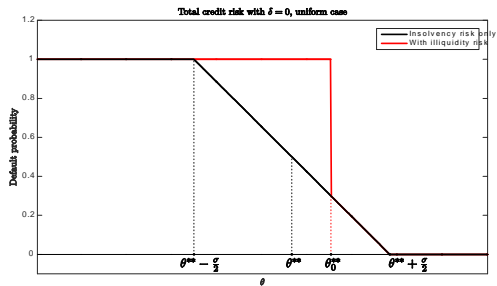
Illiquidity Risk

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

$$\mathcal{R}\left(\overline{\theta}\right) = \begin{cases} 0, \text{ if } \overline{\theta} \le \theta^{**} - \frac{1}{2}\sigma \\ \frac{1}{2} - \frac{1}{\sigma}\left(\theta^{**} - \overline{\theta}\right), \text{ if } \theta^{**} - \frac{1}{2}\sigma \le \overline{\theta} \le \theta^{**} + \sigma\left(\frac{\alpha S}{M+X} - \frac{1}{2}\right) \\ 0, \text{ if } \overline{\theta} > \theta^{**} + \sigma\left(\frac{\alpha S}{M+X} - \frac{1}{2}\right) \end{cases}$$

Run Risk

figure 2.

Ex Ante Illiquidity Risk

- To evaluate policy, we would like to identify risk before $\overline{\theta}$
- Suppose that at prior time 0, $\overline{\theta}$ is distributed with uniformly on $\left[\theta_0 - \frac{1}{2}\xi, \theta_0 + \frac{1}{2}\xi\right]$
- Assume that $\xi \gg \sigma$, ex ante illiquidity risk will be $\frac{1}{\xi}$ times the area of the triangle

$$\frac{\sigma}{2\xi}\left(\frac{\alpha S}{M + X}\right)^2$$

Ex Ante Illiquidity Risk Comparative Statics

- Illiquidity risk is decreasing in...
    - solvency precision ($\frac{1}{\sigma}$)
    - excess return of short run debt ($\frac{1}{\alpha}$)
    - liquidity ratio ($\lambda = \frac{M+X}{S}$)
- Decreasing returns to liquidity

Fire Sale Risk

- Now assume that bond sales of Z generate a cost δZ to the balance sheet. Interpretations are:
  - we have normalized the return on bonds to zero, but there is actually a positive return which is lost if bonds are turned into cash
  - cost of selling into fire sale market
- If $\delta = 0$, analysis as before...

Three Cases

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

1. If $\pi S \leq M$, 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 $M \leq \pi S \leq M + X$, then $\pi S - M$ must sold and adjusted solvency point becomes:

$$\begin{aligned} \theta &\geq \widetilde{\theta}^{**}(\pi) \\ &= \frac{S + L + \delta(\pi S - M) - M - X}{Y} \\ &= \theta^{**} + \frac{\delta(\pi S - M)}{Y} \end{aligned}$$

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

Short Term Creditors

- Algebra gets messier...
- We have fire sale point

$$\theta_F^* = \theta_R^* + \frac{\delta X^2}{2Y(M+X)}$$

$$= \theta^{**} + \sigma\left(\frac{\alpha S}{M+X} - \frac{1}{2}\right) + \frac{\delta X^2}{2Y(M+X)}$$

Fire Sale Risk

figure 3

Fire Sale Risk

- Increasing in δ, returns to previous case if $\delta = 0$
- Still higher marginal benefit when ex ante liquidity risk is high
- (Roughly) Linear in Bonds
- Shifting resourses from cash to bonds drives fire sale risk

Two Related Questions

- What happens with more general distributions?
- What happens as uncertainty about solvency becomes small?
- Related becomes uniform analysis depended on δ small relative to σ

General Distributions

- Can solve for general distributions, just not in closed form....
- Following pictures illustrate what happens as σ becomes small when asset return is normally distributed normally

Pictures

figures 4-12:

fix δ, three values of σ, same scales:

1. σ big relative to δ, fire sale risk small compared to run risk
2. intermediate σ, with comparable run risk and fire sale risk
3. $\sigma \approx 0$, run risk almost disappeared, fire sale risk remains

three kinds of risk

Small Noise Limit

As $\sigma \to 0$,

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

- fire sale risk does not disappear:
$$\theta_F^* \to \theta^{**} + \delta \left(\frac{\alpha S - M}{Y} \right)$$

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)....
- But there will be a fire sale point $\theta_F^* > \theta^{**}$
- Fire Sale Point is associated with a critical proportion of creditors π_F^* that would degrade the balance sheet into insolvency
- Laplacian beliefs then imply fire sale run point

Fire Sale Noise Limit Algebra

- Repayment will occur if π satisfies

$$\theta^{**} + \frac{\delta\left(\pi S - M\right)}{Y} \geq \theta_F^*$$

- Making π the subject

$$\pi_F^* \geq \frac{1}{S}\left(\frac{\left(\theta_F^* - \theta^{**}\right)Y}{\delta} + M\right)$$

- Creditor indifference implies

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

- and so

$$\theta_F^* = \theta^{**} + \delta\left(\frac{\alpha S - M}{Y}\right)$$

Literature

1. Multiple Equilibria, e.g., Diamond-Dybvig (1983)
   - Solvency Risk $\approx$ Unique (Bad) Equilibrium
   - Illiquidity Risk $\approx$ Selection of Bad Equilibrium

2. "Informational Selection": Compare informationally selected unique equilibrium with best complete information equilibrium
   - Postlewaite and Vives (1987)
   - "Global Games"

Global Games Literature: Some Early Papers 1

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

1. Decomposition of Credit Risk:
   - Absent (pure liquidity risk?)
2. Modelling Comments: Bare Bones "Regime Change Game"
3. Focus: Public Signals

Goldstein-Pauzner (2005): "Coordination Risk and Price of Debt"

1. Decomposition of Credit Risk:
   - Continuous Payoff, no solvency
   - Could treat continuous payoff as proxy for insolvency risk
   - Illiquidity risk would go away as noise went to zero

2. Modelling Comments: real bank run payoffs

3. Focus:comparative statics of withdrawal penalty

► 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
- ▶ Eisenbach et al (2014), FRBNY Economic Policy Review, richer balance sheet, more reduced form modelling, similar pictures

Conclusion

- We have developed model based distinction between insolvency and illiquidity risk
- Funding of financial institutions by ultra short term credit and lack of liquid assets on balance sheet have played role in crises
- Liquidity issues should be addressed; but we need to understand interaction between illiquidity and insolvency to do this
- Offers guidance on when re-liquification may be as important as re-capitalization (and when it won't)