Endogenous Systemic Liquidity Risk

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The myths of liquidity

Liquidity is the root of all evils.

- Financial markets: Notion of abundant liquidity;
  - "The Economist, A fluid concept" (Feb. 2007): "World’s financial markets are awash with liquidity"

- However: Fear that liquidity may dry out suddenly (risk of fire sales);
- Liquidity squeeze may force central banks to ease policy again;
- However: Does expectation of such central bank reaction encourage excessive risk taking?
  - Over-investment in risky activities creates systemic risk?

Liquidity: Key to understanding monetary policy and banking regulation.
And, the controversies...

- **Mervyn King**, September 12, 2007
  - “The provision of large liquidity facilities penalises those financial institutions that sat out the dance, encourages herd behaviour and increases the intensity of future crises.”

- **Lawrence Summers**, Financial Times, September 24, 2007
  - “Moral hazard fundamentalists misunderstand the insurance analogy”

Implication for banking regulation?

- **The Economist**, May 14, 2009
  - “There is no single big remedy for the banks’ flaws. But better rules — and more capital — could help...”
Research questions. Our approach.

- Research questions:
  - Back to origin: What is liquidity? How is liquidity provided?
  - Monetary policy for financial stability, implication for banking regulation.

- This paper: An integrated approach towards banking regulation
  - Endogenized systemic liquidity risk in a bank run model;
  - Nominal contract and monetary policy;
  - Monetary policy and banking regulation;
  - Quantitative policy analysis for varieties of regulatory regimes, e.g. liquidity regulation, equity requirement, etc.
Structure of the model

Baseline model: Risk-neutral agents and real contracts

<table>
<thead>
<tr>
<th>Investors</th>
<th>Entrepreneur $i$, $i = 1, 2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit endowment at $t = 0$, can be stored or invested in projects</td>
<td>$R_1 &gt; 1$: Safe project, realized early at $t = 1$</td>
</tr>
<tr>
<td>Investors want to consume at $t = 1$</td>
<td>$R_2 &gt; R_1$: Risky project, may be delayed until $t = 2$, with probability $1 - p$</td>
</tr>
</tbody>
</table>

**Competitive Bankers**

- **Technology**: Expertise to collect $0 < \gamma < 1$ from projects’ return
- **Fragile structure**: Banks offer deposit contracts as commitment device not to abuse their collection skills
- **Cost**: Risk of bank runs with inefficient liquidation $0 < c < 1$ before $t = 1$
**Information and timing**

- \( t = \frac{1}{2} \) is crucial: If investors anticipate to be paid less than \( d_0 \) at \( t = 1 \), they run already at \( t = \frac{1}{2} \) — first-come-first-serve rule — even early projects have to be liquidated.

<table>
<thead>
<tr>
<th>Investors</th>
<th>Run</th>
<th>Wait</th>
<th>Withdraw</th>
</tr>
</thead>
<tbody>
<tr>
<td>t = 0: ( p ) unknown</td>
<td>( \alpha )</td>
<td>( 1 - \alpha )</td>
<td>( t = 1 ) ( R_1 ) ( R_2 ) with prob. ( p ) ( 1 - p )</td>
</tr>
<tr>
<td>t = 0.5: ( p ) reveals</td>
<td>( R_2 ) with prob. ( 1 - p )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t = 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t = 2</td>
<td></td>
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</table>

Investors get deposit contract \( d_0 \).
Return maximization and liquidity trade

- Bertrand competition in deposit market — Bankers maximize investors’ return with all resources available at \( t = 1 \): Liquidity trade between bankers and entrepreneurs, market cleared at interest rate \( r \).

<table>
<thead>
<tr>
<th>Entrepreneurs</th>
<th>Safe Projects ( \rightarrow )</th>
<th>Risky Projects ( \rightarrow )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t = 0 )</td>
<td>( (1 - \gamma)R_1 )</td>
<td>( (1 - \gamma)pR_2 )</td>
</tr>
<tr>
<td>Banker</td>
<td>( \alpha )</td>
<td>( \gamma R_1 )</td>
</tr>
<tr>
<td></td>
<td>( 1 - \alpha )</td>
<td>( \gamma pR_2 )</td>
</tr>
<tr>
<td>( t = 0.5 )</td>
<td>( t = 1 )</td>
<td>( t = 2 )</td>
</tr>
</tbody>
</table>

- **Liquidity Trade**

\[
\pi_1 = (1 - \gamma)R_1, \quad \pi_2 = (1 - \gamma)pR_2
\]

- No free-riding

\[
\pi_3 = \gamma R_1, \quad \pi_4 = \gamma pR_2
\]

\[
\pi_5 = \gamma (1 - p)R_2
\]
Baseline results

Market outcome is in line with the solution of the planner’s problem when

- **Deterministic** $p$: Banker $i$ choose $\alpha_i$ to pay out $d_0$ to investors and refinance all late projects:

$$\alpha_i(p) = \frac{\gamma - p}{\gamma - p + (1 - \gamma) \frac{R_1}{R_2}} : p \uparrow \Rightarrow \alpha \downarrow$$

- **Idiosyncratic risk**: As long as there are just idiosyncratic shocks, banks are always solvent via trade on the liquidity market:

$$\alpha_i(p) = \frac{\gamma - E[p]}{\gamma - E[p] + (1 - \gamma) \frac{R_1}{R_2}}$$
Aggregate risk: A strategic trade-off

- $p$ takes two values: $0 \leq p_L < p_H \leq \gamma$ with probability $\pi$ for the lucky state with $p_H$.

- Planner’s problem: Trade-off for the bankers
  - $\alpha(p_H)$ maximizes banks’ return at $p_H$ but banks will be unable to pay out high return at $p_L$ so banks will be run at $t = \frac{1}{2}$ and can just pay return $c$;
  - $\alpha(p_L)$ maximizes banks’ return at $p_L$ but misses high profitability in the good state $p_H$.

\[
\pi = 0 \quad \alpha(p_L) \quad \alpha??? \quad \alpha(p_H)
\]

- However: Market outcome deviates for intermediate $\pi$. 
Free-riding, equilibrium of mixed strategies

- Opportunity for free-riding liquidity provision at mid- $\pi$
  - In state $p_H$, early entrepreneurs provide excess liquidity supply;
  - Profitable free-riding: Setting $\alpha = 0$ and trade liquidity at $t = 1$ by its high return from late projects;
  - Though run in state $p_L$.

  - More free-riding banks become free-riders with $\alpha = 0$, interest rate $r_H$ bid higher;
  - The prudent banks reduce $\alpha_s < \alpha(p_L)$, to cut down the opportunity cost of investing in safe projects;
  - Ex ante probability $\theta$ of being free-rider: Determined by aggregate market clearing conditions in both states.
Free-riding and inferior solution

Investors’ expected return

\[ E[R(\alpha(p_i))] \]

\[ E[R(\alpha(p_H), c)] \]

\[ E[R(\alpha(p_L))] \]

No free-riding

Free-riding
Nominal contracts and cash-in-market pricing

- What can central bank do? How does central bank intervention affect the outcome?
  - Inefficiencies:
    - Inferior mixed strategy equilibrium, and
    - Costly bank run.
  - Nominal deposits – allow central bank to implement state contingent payoffs as a public good: Injection of additional liquidity
    - To prevent bank runs;
    - To eliminate free-riding.

- Cash-in-the-market principle (Allen & Gale, 2004): Price level determined by the ratio of market liquidity (sum of money and real goods) to real goods.
Liquidity requirement & conditional bail out

- Via open market operation, central bank injects paper money to the banks whose $\alpha \geq \alpha$, filling in liquidity shortage.

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<tr>
<td>deposit contract $d_0$</td>
<td>$t = 0$: $p$ unknown</td>
<td>$t = 0.5$: $p$ reveals</td>
<td>$t = 1$</td>
</tr>
<tr>
<td>Banker decides $\alpha$</td>
<td>$1 - \alpha$</td>
<td></td>
<td></td>
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</tbody>
</table>

Central Bank: $\text{Money injection at } p_L$

- $R_1$ with prob. $p$
- $R_2$ with prob. $1 - p$

Get repaid
Risk-taking and welfare improvement

Investors’ expected return

\[
E[R(\alpha(p_i))] \\
E[R(\alpha(p_L))] \\
E[R(\alpha(p_H), k)] \\
E[R(\alpha(p_H), c)]
\]
Dynamic inconsistency problem

In a systemic crisis, conditional liquidity support (the commitment not to provide liquidity to free-riders) is not credible! — Dynamic inconsistency problem.

- Illiquidity problem: Free-riding banks have sufficient ”good collaterals” ; so
- Always ex post optimal to bail out free-riders.
- Prudent banks driven out whenever there is unconditional liquidity supply! — Bagehot Rule not sufficient!
- Surprising result: Moral hazard arises even in an economy with pure illiquidity risk.
Equity requirement: Introducing equity

- Equity requirement: Banks required to hold some equity level $k$ in their assets.
  - Introducing equity: Banks issue a mixture of deposit contract and equity for the investors in $T = 0$;
  - Equity holders can only get a share of $\zeta = \frac{1}{2}$ from the surplus

$$\rightarrow k = \frac{\frac{\gamma E[R_s,i] - d_{0,i}}{2}}{\gamma E[R_s,i] - d_{0,i} + d_{0,i}} \Rightarrow d_{0,i} = \frac{1 - k}{1 + k} \gamma E[R_s,i].$$

- Optimal level of $k$? Intuition: Holding equity is costly for the banks, therefore $k$ should make banks just stay solvent in the bad state ("narrow banking")

$$\frac{1 - k}{1 + k} \gamma E[R_H] = \alpha (p_H) R_1 + (1 - \alpha (p_H)) p_L R_2.$$

\[\text{deposit contract} \quad \text{real resource in bad state}\]
Does capital requirement help?

- **Outcome:** Equity requirement versus laissez-faire.

Does equity requirement help? (cont’d)

- Equity requirement dominated by *credible* monetary policy. Still: Equity holding is costly.
Conclusion

Key findings:
- Endogenized liquidity risk: Free-riding incentive and coordinative failure;
- Inefficiencies of banking: Inferior mixed strategy equilibrium and costly bank run;
- Nominal contract and its impact on the equilibrium: Central bank improves allocation by targeted liquidity injection. But: Dynamic inconsistency problem!
- Equity requirements: Stability gain at a cost; dominated by credible bail out policy;
- Stricter regulation and supervisory reform.

Future research: