The Interdependence of Bank Capital and Liquidity

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Liquidity played a central role in the recent financial crises (e.g., Bernanke, 2008).

As a result, liquidity regulation (e.g., LCR, NSFR) was introduced to complement capital regulation.

Capital and liquidity requirements are meant to serve different purposes.

- The former deals with solvency issues, the latter with liquidity ones.

(In)solvency and (il)liquidity are closely intertwined concepts in triggering financial crises.

In light of these considerations, do capital and liquidity interact in affecting bank stability? If so, how?
What we do in the paper

- We present a model to analyze the interdependent effect of capital and liquidity on financial stability

- Need a model where
  - **Solvency** (spurred by bad fundamentals) and **liquidity** crises (due to coordination failure) can be told apart
  - Crisis probabilities are **endogenously** pinned down and depend on bank’s balance sheet choice (leverage and asset liquidity)
  - (Rich) debt holders’ **payoffs** depend on bank’s balance sheet
  - Existing models (e.g., Diamond and Kashyap, 2016; Vives, 2014; Kashyap et al., 2017) do not have **all** these ingredients

- We develop a global-games framework à la Goldstein and Pauzner (2005) and derive
  - New results on the effects of capital and liquidity on bank stability
  - Some implications for capital and liquidity regulation
Banks raise short term debt and equity, and choose portfolio with liquidity/return trade-off.

Debt holders receive imperfect information about the long term portfolio value, and decide whether to roll over or run.

Both solvency and liquidity crises occur, with probability uniquely determined as a function of bank balance sheet composition.

Two inefficiencies:
- Runs lead to inefficient liquidation of bank portfolios.
- Liquidation may entail losses due to fire sales.
Results in a nutshell

- Capital and liquidity have ambiguous effects on the likelihood of crises, depending on
  - Nature of crises, i.e., solvency or liquidity
  - Initial bank balance sheet composition

- In particular,
  - Capital is detrimental only for banks with little capital/liquidity
  - Liquidity is beneficial only for banks with intermediate levels of capital/portfolio liquidity

- Regulation should consider both sides of bank balance sheet
  - Regulation can restore efficiency, only with small cost of capital and liquidity and good market funding conditions
The baseline model: Banks and investors

- Three dates ($t = 0, 1, 2$) economy with a continuum $[0, 1]$ of banks and (risk-neutral) investors.
- At date 0, banks raise a fraction $k$ as capital and $1 - k$ as short-term debt, and invests in a risky portfolio.
  - Capital entails a per unit cost $\rho > 1$.
  - Debt holders are promised $r_1$ at date 1 and $r_2$ at date 2 in case of rollover, with $r_2 \geq r_1 \geq 1$, and obtain 1 in expectation.
- Portfolio returns $\ell \chi \in [0, 1]$ at date 1 and $R(\theta)(1 - \alpha\ell)$ at date 2, where:
  - $\ell$ is a choice variable capturing bank portfolio liquidity → liquidity/return trade-off.
  - $\chi \in (0, 1]$ represents market funding conditions.
  - $\theta \sim U[0, 1]$, $R'(\theta) > 0$ and $0 < \alpha \leq \bar{\alpha}$ is cost of liquidity.
The baseline model: debt holders’ information

- At the beginning of date 1, each debt holder receives a private signal \( s_i \) on the fundamental of the economy of the form

\[
s_i = \theta + \epsilon_i
\]

with \( \epsilon_i \sim U[-\varepsilon, +\varepsilon] \) being i.i.d across agent and \( \epsilon \to 0 \)

- Based on the signal, debt holders decide whether to withdraw (run) at date 1 or roll over their debt
  - They update their beliefs about \( \theta \) and the others’ actions

- The bank satisfies early redemptions by liquidating its portfolio

- Debt holders receive a pro-rata share, whenever bank proceeds are not enough to repay \( r_1 \) or \( r_2 \)
Debt holders’ rollover decision and crises

<table>
<thead>
<tr>
<th>Solvency crises</th>
<th>Liquidity crises</th>
<th>No crises</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>θ</td>
<td>1</td>
</tr>
<tr>
<td>debt holders</td>
<td>debt holders</td>
<td>no debt holders</td>
</tr>
<tr>
<td>withdraw</td>
<td>withdraw</td>
<td>withdraw</td>
</tr>
<tr>
<td>as low θ</td>
<td>because of θ and n</td>
<td></td>
</tr>
</tbody>
</table>

where θ is the solution to

\[ R(\theta) (1 - \alpha \ell) = (1 - k) r_1 \]

and θ* to

\[ \int_{n=0}^{\hat{n}(\theta)} r_2 + \int_{n=\hat{n}(\theta)}^{\bar{n}} \frac{R(\theta) (1 - \alpha \ell) \left[ 1 - \frac{(1-k)nr_1}{\ell \chi} \right]}{(1-k)(1-n)} = \int_{n=0}^{\bar{n}} r_1 + \int_{n=\bar{n}}^{1} \frac{\ell \chi}{(1-k)n} \]
When \((1 - k)r_1 = \ell \chi\) (i.e., for \(k = k^{\text{max}}(\ell)\)), there are no strategic complementarities and \(\theta^* \to \theta\).
Capital and bank fragility

- Capital is always **beneficial** for **solvency** crises
  - More capital $\rightarrow$ more resources to pay debt holders at $t = 2$
- **But** it is **ambiguous** for **liquidity** crises due to two opposing effects

\[
- \int_{\hat{n}(\theta)}^{\bar{n}} \frac{R(\theta)}{(1-k)(1-n)} \, dn + \int_{\bar{n}}^{1} \frac{\ell \chi}{(1-k)n} \, dn
\]

Higher repayment at date 2 \hspace{1cm} \text{Higher repayment at date 1}

- Initial balance sheet composition (i.e., $k$ and $\ell$) determines which effect dominates
Effect of capital on crisis probabilities

Capital reduces the likelihood of solvency crises
\[ \left( \frac{\partial \theta}{\partial k} < 0 \right) \]

Capital increases the likelihood of liquidity crises
\[ \left( \frac{\partial \theta^*}{\partial k} > 0 \right) \]

Capital reduces the likelihood of liquidity crises
\[ \left( \frac{\partial \theta^*}{\partial k} < 0 \right) \]
Liquidity and bank stability

- Liquidity is always **detrimental** for **solvency** crises
  - More liquidity → lower portfolio profitability at date 2

- **But** it is **ambiguous** for **liquidity** crises due to three different effects

\[
- \int_{\hat{n}(\theta)}^{\bar{n}} \frac{R(\theta) nr_1}{\ell^2 \chi (1-n)} dn + \int_{\hat{n}(\theta)}^{\bar{n}} \frac{\alpha R(\theta)}{(1-k)(1-n)} dn + \int_{\bar{n}}^{1} \frac{\chi}{(1-k)n} dn
\]

  Higher repayment at date 2 due to less liquidation at date 1
  Lower repayment at date 2 due to lower profitability
  Higher repayment at date 1

- Again, initial balance sheet composition (i.e., \(k\) and \(\ell\)) determines which effect dominates
Effect of liquidity on crisis probabilities

Liquidity increases the likelihood of solvency crises
\[ \left( \frac{\partial \theta}{\partial \ell} > 0 \right) \]

Liquidity increases the likelihood of liquidity crises
\[ \left( \frac{\partial \theta^*}{\partial \ell} > 0 \right) \]

Liquidity reduces the likelihood of liquidity crises
\[ \left( \frac{\partial \theta^*}{\partial \ell} < 0 \right) \]
The market equilibrium: The bank’s choice

- Given debt holders’ rollover decisions, at date 0 each bank chooses \( k, \ell, r_1 \) and \( r_2 \) to maximize

\[
\Pi^B = \int_{\theta^*}^{1} [R(\theta)(1 - \alpha \ell) - (1 - k)r_2] \, d\theta - k \rho
\]

subject to

\[
\int_{0}^{\theta^*} \frac{\ell \chi}{(1 - k)} \, d\theta + \int_{\theta^*}^{1} r_2 \, d\theta \geq 1 \text{ and } \Pi^B \geq 0
\]

- The solution entails two inefficiencies
  - Liquidity crises occur in equilibrium since \((1 - k^B)r_1^B > \ell^B \chi\) holds
  - Banks sell assets to outside investors with finite wealth \( w \)
  - Liquidation can be inefficient and entail losses due to fire sales (i.e., \( \chi(\ell, k, w) < 1 \)) if market conditions are tight (i.e., \( w \) small)
Regulatory intervention

- Regulator sets capital and liquidity requirements \( \{k^R, \ell^R\} \) to maximize

\[
\int_{0}^{\theta^*} \ell \chi(Q) \, d\theta + \int_{\theta^*}^{1} R(\theta) (1 - \alpha \ell) \, d\theta
\]

subject to

\[
r_1^B, r_2^B = \arg \max \Pi^B
\]

\[\Pi^B \geq 0\]

- Eliminating both inefficiencies may not be feasible for given \( \alpha, \rho \) and \( w \)
  - Limited investors’ wealth \( w \) associated with severe fire sales
  - Binding constraint \( \Pi^B = 0 \) when \( \alpha \) and \( \rho \) are large
Conclusions

- Capital and liquidity present complicated intertemporal trade-offs, which affect solvency and liquidity crises differently.
- Understanding all of them requires endogenizing crises probability and bank behavior, and distinguish between crises of different nature.
- Higher capital and liquidity are not always beneficial, in particular for banks that are highly leveraged and hold illiquid portfolios.
- Regulation should be based on both side of balance sheet.
  - Joint capital and liquidity regulation can correct market inefficiencies, but this may not be feasible if market funding conditions are tight.