Systemic Liquidity Shortages and Interbank Network Structures

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* This presentation represents the author’s personal opinions and does not necessarily reflect the view of the Bank of Korea.
Following the LEH bankruptcy, short-term wholesale funding markets suddenly dried up, which caused system-wide liquidity shortages (IMF 2010).

Interbank markets play a role as propagation channels of liquidity shocks, the entire banking system become exposed to the knock-on effects of liquidity shocks.

Previous studies focus on default contagion, while I emphasize the systemic nature of funding liquidity risk.

In this paper, we propose a method for calculating the systemic liquidity shortages and investigate the effect of interbank network structures on the systemic liquidity shortages.
Main Findings

- A greater imbalance in liquidity positions across banks tends to aggravate the liquidity shortage of a deficit bank.

- A deficit bank may suffer from liquidity shortages even without a direct deposit withdrawal.

- A core-periphery network with a deficit money center bank is most vulnerable to systemic liquidity shortages.

- A banking system becomes more vulnerable to liquidity shocks as its interbank network is more ill-matched.
Existing Literature on Network Analysis

- Graph theory-based network models

- Balance sheet-based network models
  - Furfine (2003), Upper and Worm (2004), Elsinger et al. (2006), Aikman et al. (2009)

- Most previous studies focus on interbank credit losses and default contagion among banks.
  - No consideration for liquidity shortages and liquidity contagion, such as sudden drying up of liquidity in interbank markets.
The knock-on process of liquidity shocks differs from a default shocks in two ways.

1. Default losses: debtors $\rightarrow$ lenders

   Liquidity needs: lenders $\rightarrow$ debtors.

2. Default contagion stops if no additional banks fail.

   Liquidity contagion continues until the initial liquidity needs are met by liquidating external assets.
A stylized bank’s balance sheet.

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sum_{j \in \mathcal{N}} b_{ji}$</td>
<td>$\sum_{j \in \mathcal{N}} b_{ij}$</td>
</tr>
<tr>
<td>$q_i$</td>
<td></td>
</tr>
<tr>
<td>$z_i$</td>
<td>$d_i$</td>
</tr>
<tr>
<td></td>
<td>$e_i$</td>
</tr>
</tbody>
</table>

Balance sheet identity

$$\sum_{j \in \mathcal{N}} b_{ji} + q_i + z_i = \sum_{j \in \mathcal{N}} b_{ij} + d_i + e_i.$$
Matrix representation of banking system

<table>
<thead>
<tr>
<th>Interbank assets</th>
<th>Interbank liabilities</th>
<th>Nonbank liabilities</th>
<th>capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 ... $b_{1j}$ ... $b_{1n}$</td>
<td>$d_1$</td>
<td>$e_1$</td>
</tr>
<tr>
<td>:</td>
<td>: ... : ... :</td>
<td>:</td>
<td>:</td>
</tr>
<tr>
<td>$i$</td>
<td>$b_{i1}$ ... 0 ... $b_{in}$</td>
<td>$d_i$</td>
<td>$e_i$</td>
</tr>
<tr>
<td>:</td>
<td>: ... : ... :</td>
<td>:</td>
<td>:</td>
</tr>
<tr>
<td>$n$</td>
<td>$b_{n1}$ ... $b_{nj}$ ... 0</td>
<td>$d_n$</td>
<td>$e_n$</td>
</tr>
<tr>
<td>Nonbank assets</td>
<td>Liquid</td>
<td>$q_1$ ... $q_j$ ... $q_n$</td>
<td></td>
</tr>
<tr>
<td>Iliquid</td>
<td>$z_1$ ... $z_j$ ... $z_n$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A bank is said to face a liquidity shortage if its total liquidity needs $l_i^n$ exceed its total liquid assets $l_i$.

\[ l_i^s \equiv \max(0, l_i^n - l_i) \]

where

\[ l_i^n = \sum_{j \in \mathcal{N}} \phi_{ij} \Delta l_j + \Delta d_i \]

and

\[ \Delta l_i = \min \left[ l_i, \sum_{j \in \mathcal{N}} \phi_{ij} \Delta l_j + \Delta d_i \right] \]
A simple banking system \((n = 2)\)

\[
\begin{array}{c|cc|c|c}
0 & \beta & \delta & e_1 \\
\alpha + \beta & 0 & 1 - \delta & e_2 \\
\gamma \delta & \gamma (1 - \delta) & & \\
z_1 & z_2 & & \\
\end{array}
\]

where \(\alpha (= 0.1)\): the excess funds of a surplus bank, \(\beta (= 0.05)\): cross holdings, \(\delta (= 0.5)\): the deposit share of a surplus bank, \(\gamma (= 0.1)\): the reserve ratio, \(\omega (= 0.1)\): the liquidity shock.
Liquidity shocks and liquidity shortages

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Aggregate shocks

Idiosyncratic shocks to a surplus bank

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Parameter values and liquidity shortages

Reserve ratio

Deposit share

Net surplus funds

Cross holdings

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Six Types of Interbank Network Structures

- Type I. A complete network

![Diagram of a complete network with nodes 1, 2, 3, and 4 interconnected]
Six Types of Interbank Network Structures

- **Type I. A complete network**

- **Type II. A disconnected network**
Type III. A circular well-matched network
Six Types of Interbank Network Structures

- **Type III. A circular well-matched network**

- **Type IV. A circular ill-matched network**
Six Types of Interbank Network Structures

- Type V. A core-periphery network with a surplus money center bank

![Diagram of Type V network]

3

1

2

4
Six Types of Interbank Network Structures

- **Type V.** A core-periphery network with a surplus money center bank

- **Type VI.** A core-periphery network with a deficit money center bank
Properties of Network Structures

<table>
<thead>
<tr>
<th>Network properties</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Type 3</th>
<th>Type 4</th>
<th>Type 5</th>
<th>Type 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completeness</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Interconnectedness</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Matchedness</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Centeredness</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Type 1: complete, Type 2: disconnected,
Type 3: circular well-matched, Type 4: circular ill-matched,
Type 5: surplus bank-centered, Type 6: deficit bank-centered.
Network Structures and Liquidity Shortages

Type 1: complete, Type 2: disconnected, Type 3: circular well-matched, Type 4: circular ill-matched, Type 5: surplus bank-centered, Type 6: deficit bank-centered.
Liquidity risk might be, therefore, underestimated if it is assessed only by individual institution’s liquidity positions.

- A greater imbalance in liquidity positions across banks tends to aggravate the liquidity shortage of a deficit bank.
- A core-periphery network with a deficit money center gives rise to the highest level of systemic liquidity shortages.
- A banking system becomes more vulnerable to liquidity shocks as its interbank network is more ill-matched.

The role of systemic liquidity shortages on default contagion is left as a subject for future research.