The Multilayer Structure of the Financial System

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Austrian interbank network

What is a multilayer network?

Interconnected Networks:

Connectivity

Dependency

Adjacency matrix

Interconnected Networks:
Multilayer interbank networks


Mapping the financial system

Funding layer

Asset layer

Multilayer structure

<table>
<thead>
<tr>
<th>Layer</th>
<th>Node</th>
<th>Function</th>
<th>Primary regulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer</td>
<td>Agent</td>
<td>Core</td>
<td>Periphery</td>
</tr>
<tr>
<td>Asset</td>
<td>Hedge Funds</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Asset</td>
<td>CAsset Managers</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Asset</td>
<td>Bank/Dealer Market Makers</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Asset</td>
<td>Bank/Dealer Derivatives</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Asset</td>
<td>Exchanges and non-bank Market Makers</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>Hedge Funds</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>Cash providers (pension funds, insurance companies)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Funding</td>
<td>Bank/Dealer Finance Desk</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>Bank/Dealer Prime Brokerage</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Collateral</td>
<td>Cash providers (pension funds, insurance companies)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Collateral</td>
<td>Derivatives</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Collateral</td>
<td>Bank/Dealer Financial Desk</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Collateral</td>
<td>Central Counterparties (CCPs)</td>
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<td></td>
</tr>
<tr>
<td>Collateral</td>
<td>Tri-party Repo Agents</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s analysis
Percolation – a framework for stress testing networks

- Second Order Phase Transition
- In Random Networks (ER) - \( P_\infty = p(1 - e^{-kp_c}) \)
- Percolation Threshold – \( p_c \)
- Critical Exponents – \( P_\infty(x)_{x \rightarrow p_c} = A(x - p_c)^\beta \)

Source: Author’s analysis
Analytic solutions for dynamical process

At steady state:

\[
\begin{aligned}
\psi'_1 &= p_1 \\
\phi'_1 &= p_2 \left[1 - q_2 (1 - p_1 g_1 (\psi'_1))\right]
\psi'_2 &= p_1 \left[1 - q_1 (1 - p_2 g_2 (\phi'_1))\right]
\vdots
\psi'_t &= p_1 \left[1 - q_1 (1 - p_2 g_2 (\phi'_{t-1}))\right]
\phi'_t &= p_2 \left[1 - q_2 (1 - p_1 g_1 (\psi'_t))\right]
\end{aligned}
\]

\[
P_{\infty,i} = x_i g_i (x_i)
\]

Source: Parshani et al., PRL 105, 048701 (2010).
Cascading failures in multilayer networks

Source: Author’s analysis
Cascading failures in multilayer networks

Cascading failures in multilayer networks

Cascading failures in multilayer networks

Applications and Challenges

- Obtaining and tying together different data sources and using them to calibrate the interaction between nodes in different layers. Detailed counterparty position level transaction data is needed.

- Understanding the financial system as a multilayer network results in the need to modify contagion models for the financial system, considering the spread of shocks within and between the different layers. These new models should lead to the development of a new class of stress tests, and ultimately to a new class of intervention strategies for the management of financial crises.

- Rethinking how financial institutions are defined, according to their activity in the different layers. This will require rethinking regulation and monitoring policies, and provide new definitions into systemically important financial institutions.

- Providing quantitative evidence for the effect of integration versus segregation in the financial system. This is becoming increasingly important considering how financial institutions, are branching out into new financial activities.
Thank You.

Questions?