Using network analysis to assess the centrality of second-tier banks in CHAPS

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Motivation

• Tiering in CHAPS creates risks: credit, liquidity and operational
• Policy drive to have more direct members (Chris Salmon’s speeches)
• We know half of CHAPS values by 2\textsuperscript{nd}-tier banks
• But another aspect to being systemic/central: connectedness – network analysis gives insights
This paper

• Questions:
  – How central are 2\textsuperscript{nd}-tier banks?
  – How would the network change with more direct members? Trade-off between risk reduction and connectivity?

• Part of the descriptive literature network (topology), applied to relevant policy question

• Data analysis
  – One month (Jan’11) of data from BoE’s payments database, including 2\textsuperscript{nd}-tier banks
  – 50 largest banks, make up > 85% of CHAPS values
  – Fna network software
Methodology

1. Compare settlement bank, “flow” and “relationship” networks: connectedness and other characteristics

2. Compare the centrality of settlement banks and 2\textsuperscript{nd}-tier banks in groups of 5 using averages of individual centrality measures

3. Simulation of how the settlement bank network would change if 5, 10 and 15 2\textsuperscript{nd}-tier banks joined CHAPS
We build 3 different networks

1. **Settlement bank network**: made up of payments going across 16 settlement banks only

2. **“Relationship” network**: payments between ultimate sender and receiver, not including the leg between 2\(^{nd}\)-tier and their settlement banks
   - Ultimate links across banks. Could be seen as what the network would look like if the 50 banks became direct members

3. **“Flow” network**: all legs of payments, between 2\(^{nd}\)-tier banks and settlement banks and across settlement banks
   - Operational network, how payments travel. Could be seen as the real network in the current tiered system. Counts some payments twice
1. Comparing the networks:

settlement bank network

• Well connected, almost complete: connected networks more resilient to shocks but impact of a large node failing is larger
• Compact
• Subsets: core of three, then five, then others
1. Comparing the networks: relationship network

- Nodes and flows smaller: only own, not those of 2\textsuperscript{nd}-tier customer banks
- 2\textsuperscript{nd}-tier banks red, direct members blue
- Appears well-connected
- No differences in size of nodes and flows between many direct and 2\textsuperscript{nd}-tier banks
1. Comparing the networks: flow network

- Star-shaped, with a central hub
- Much less connected
- 2\textsuperscript{nd}-tier banks use several settlement banks
1. Comparing the networks: network statistics

<table>
<thead>
<tr>
<th>Network</th>
<th>Number of nodes</th>
<th>Number of links</th>
<th>Connectivity</th>
<th>Average degree</th>
<th>Average path length (min=1)</th>
<th>Clustering coefficient</th>
<th>Reciprocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Settlement bank</td>
<td>16</td>
<td>231</td>
<td>96%</td>
<td>14.4/15</td>
<td>1.04</td>
<td>97%</td>
<td>99%</td>
</tr>
<tr>
<td>Relationship</td>
<td>50</td>
<td>1,882</td>
<td>77%</td>
<td>37.7/49</td>
<td>1.23</td>
<td>87%</td>
<td>87%</td>
</tr>
<tr>
<td>Flow</td>
<td>50</td>
<td>677</td>
<td>27%</td>
<td>13.5/49</td>
<td>1.72</td>
<td>46%</td>
<td>78%</td>
</tr>
</tbody>
</table>
1. Comparing the networks

• SB and relationship networks highly connected, flow network sparse

• Some 2\textsuperscript{nd}-tier banks appear as “core” as settlement banks

• A large part of the network outside CHAPS right now – high degree of connectivity in the settlement bank network an illusion in “real” representation of flows is flow network
2. Centrality of settlement and 2nd-tier banks

• From now on we use the relationship network
  – Avoid double counting of flows
  – Ultimate links relevant to assess centrality

• Measures of individual centrality that are:
  – Intuitive and well-established, not very highly correlated with value and not very highly cross-correlated
  – Two measures:
    • Betweenness: the proportion of payments across banks that go through that bank
    • Eigenvector centrality: a bank is more central if connected to banks that are themselves central
2. Centrality of settlement and 2\textsuperscript{nd}-tier banks

- SB as a whole more central than 2\textsuperscript{nd}-tier banks
- But top 5 2\textsuperscript{nd}-tier banks
  - more central than bottom 7 SBs in betweenness
  - as central as middle SBs in eigenvector centrality.

<table>
<thead>
<tr>
<th></th>
<th>betweenness</th>
<th>eigenvector</th>
</tr>
</thead>
<tbody>
<tr>
<td>top 5 sb</td>
<td>38.9</td>
<td>0.08</td>
</tr>
<tr>
<td>next 5 sb</td>
<td>19.5</td>
<td>0.03</td>
</tr>
<tr>
<td>next 6 sb</td>
<td>11.6</td>
<td>0.01</td>
</tr>
<tr>
<td>top 5 2nd-tier</td>
<td>11.7</td>
<td>0.03</td>
</tr>
<tr>
<td>next 5 2nd-tier</td>
<td>5.1</td>
<td>0.01</td>
</tr>
<tr>
<td>next 5 2nd-tier</td>
<td>5.1</td>
<td>0.01</td>
</tr>
</tbody>
</table>
3. Impact of 2\textsuperscript{nd}-tier banks joining
3. Impact of 5 2\textsuperscript{nd}-tier banks joining
3. Impact of 10 2\textsuperscript{nd}-tier banks joining
3. Impact of 15 2\textsuperscript{nd}-tier banks joining
### 3. Impact of 2\textsuperscript{nd}-tier banks joining

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<td>1.03</td>
<td>97%</td>
<td>99%</td>
</tr>
<tr>
<td>Plus five</td>
<td>21</td>
<td>403</td>
<td>96%</td>
<td>19.2/20</td>
<td>1.04</td>
<td>97%</td>
<td>98%</td>
</tr>
<tr>
<td>Plus ten</td>
<td>26</td>
<td>623</td>
<td>96%</td>
<td>24.0/25</td>
<td>1.04</td>
<td>97%</td>
<td>97%</td>
</tr>
<tr>
<td>Plus fifteen</td>
<td>31</td>
<td>861</td>
<td>93%</td>
<td>27.8/30</td>
<td>1.07</td>
<td>95%</td>
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</tr>
</tbody>
</table>
3. Impact of 2\textsuperscript{nd}-tier banks joining

- Peak and average flows decrease substantially with more direct members

**Strength of links (=flows value, bidirectional), £ bn**

<table>
<thead>
<tr>
<th>Network</th>
<th>Maximum</th>
<th>Average</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 settlement banks</td>
<td>16</td>
<td>1</td>
<td>0.14</td>
</tr>
<tr>
<td>Plus five</td>
<td>12</td>
<td>0.5</td>
<td>0.10</td>
</tr>
<tr>
<td>Plus ten</td>
<td>9</td>
<td>0.4</td>
<td>0.06</td>
</tr>
<tr>
<td>Plus fifteen</td>
<td>8</td>
<td>0.3</td>
<td>0.04</td>
</tr>
</tbody>
</table>
3. Impact of 2\textsuperscript{nd}-tier banks joining

- Connectivity only goes down when more than 10 join
- So top 10 2\textsuperscript{nd}-tier banks are just as connected as the average of settlement banks
- No significant trade-off between reduction or risks and drop in connectivity for 5 or 10 joining, small and insignificant for 15
Conclusion: our initial questions

• **How central are 2\textsuperscript{nd}-tier banks in CHAPS?**
  – The largest ones as central or more than mid-size or smaller settlement banks

• **How would the CHAPS network change with more direct members?**
  – Up to 10 more, not significantly less connected: there would appear to be risk reduction without loss of connectivity
  – Interconnected networks are more robust up to a tipping point, when they spread risk faster