# Using network analysis to assess the centrality of 2nd-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 2nd-tier banks
- But another aspect to being systemic/central: connectedness – network analysis gives insights

# This paper

- Questions:
  - **How central are 2nd-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 2nd-tier banks
  - 50 largest banks, make up > 85% of CHAPS values
  - Fna network software

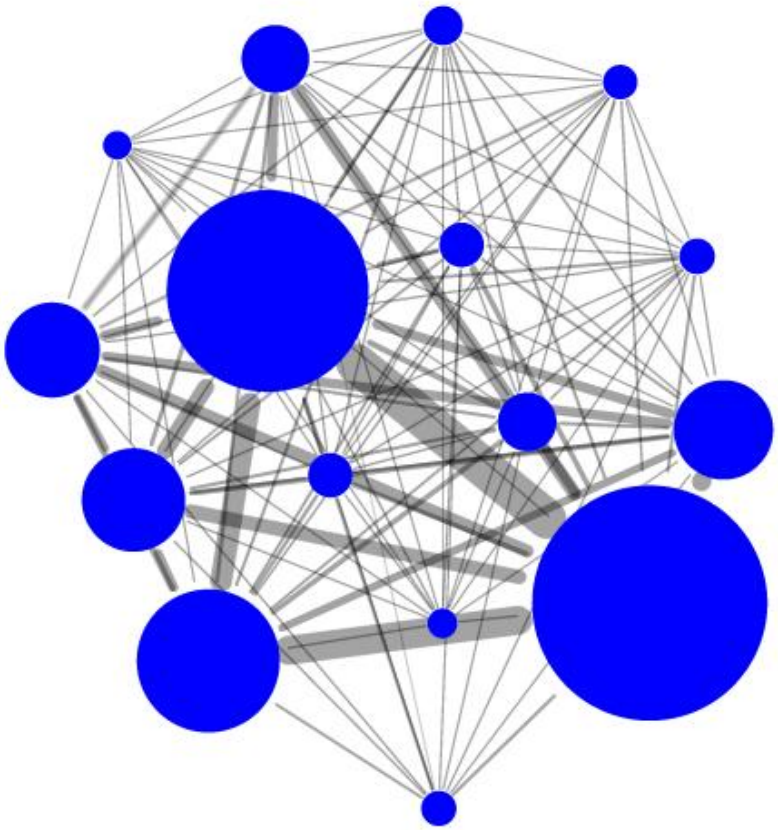
# Methodology

1. Compare settlement bank, “flow” and “relationship” networks: connectedness and other characteristics
2. Compare the centrality of settlement banks and 2nd-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 2nd-tier banks joined CHAPS

# We build 3 different networks

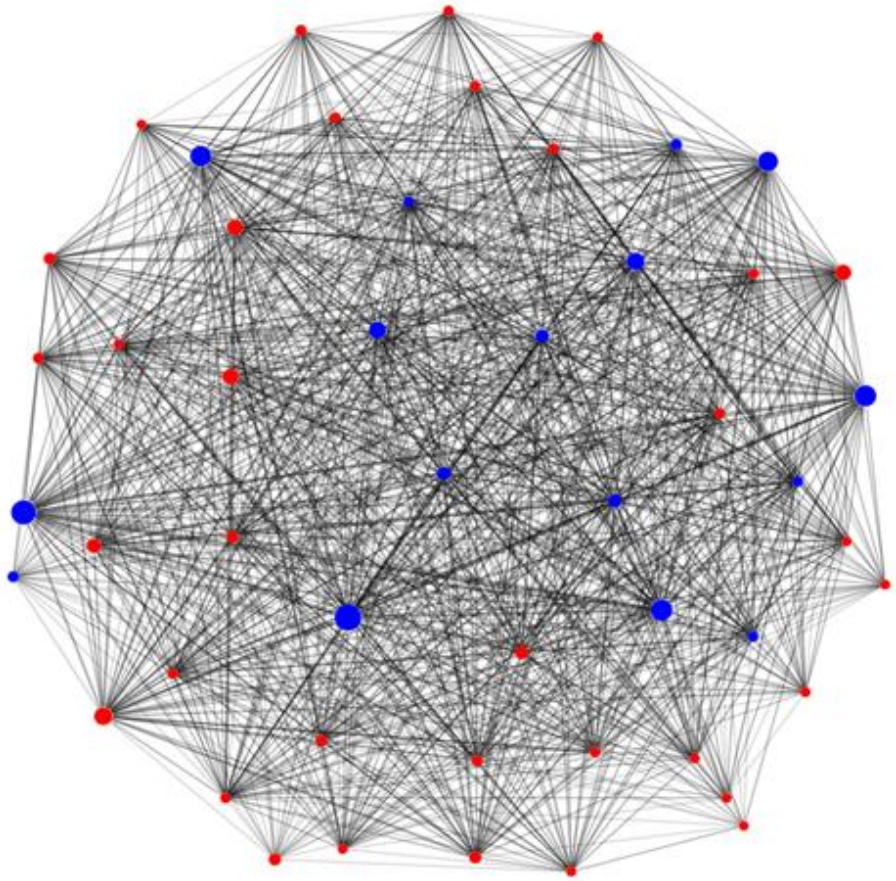
1. Settlement bank network: made up of payments going across 16 settlement banks only
2. "Relationship" network: payments between ultimate sender and receiver, not including the leg between 2nd-tier and their settlement banks
   - Ultimate links across banks. Could be seen as what the network would look like if the 50 banks became direct members
3. "Flow" network: all legs of payments, between 2nd-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



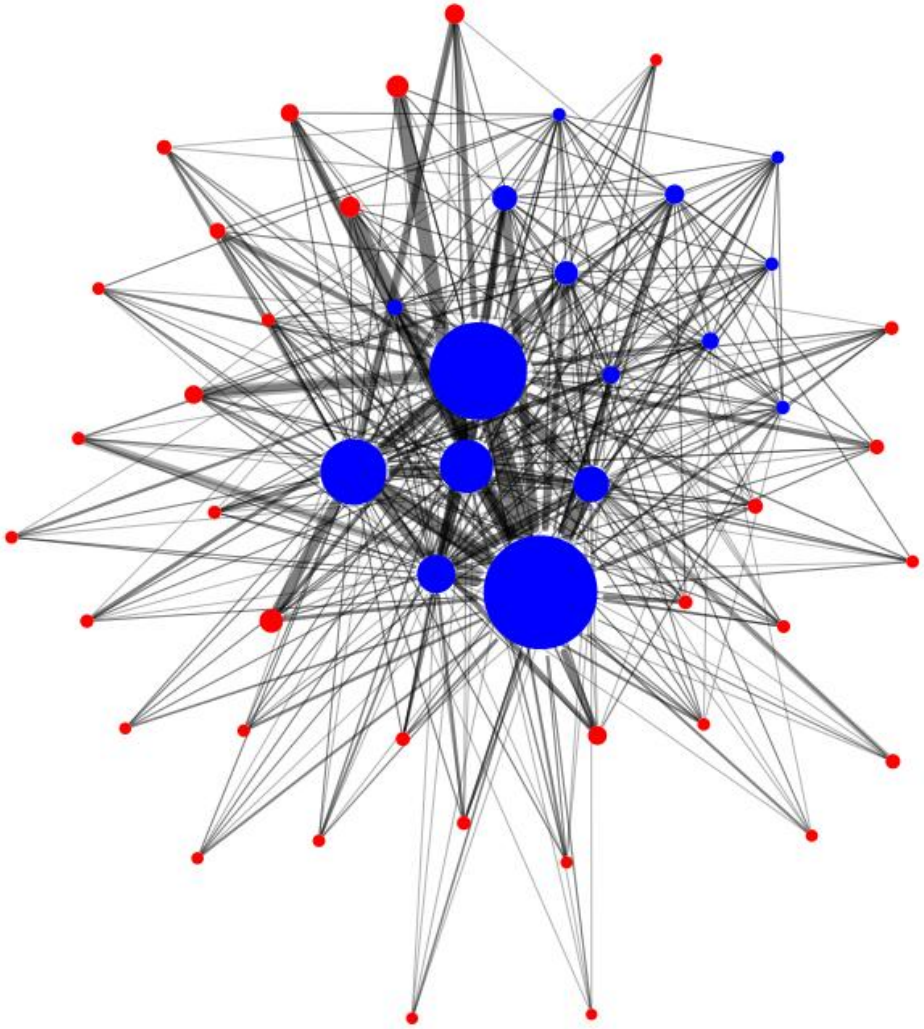
- Well connected, almost complete: connected networks more resilient to shocks but impact of a large node failing is larger
- Compact
- Subsets: core of three, then five, then others

# 1. Comparing the networks: relationship network



- Nodes and flows smaller: only own, not those of 2nd-tier customer banks
- 2nd-tier banks red, direct members blue
- Appears well-connected
- No differences in size of nodes and flows between many direct and 2nd-tier banks

# 1. Comparing the networks: flow network



- Star-shaped, with a central hub
- Much less connected
- 2nd-tier banks use several settlement banks

# 1. Comparing the networks: network statistics

| *Network* | *Number of nodes* | *Number of links* | *Connectivity* | *Average degree* | *Average path length (min=1)* | *Clustering coefficient* | *Reciprocity* |
|---|---|---|---|---|---|---|---|
| **Settlement bank** | **16** | **231** | **96%** | **14.4/15** | **1.04** | **97%** | **99%** |
| **Relationship** | **50** | **1,882** | **77%** | **37.7/49** | **1.23** | **87%** | **87%** |
| **Flow** | **50** | **677** | **27%** | **13.5/49** | **1.72** | **46%** | **78%** |

# 1. Comparing the networks

- SB and relationship networks highly connected, flow network  sparse
- Some 2nd-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

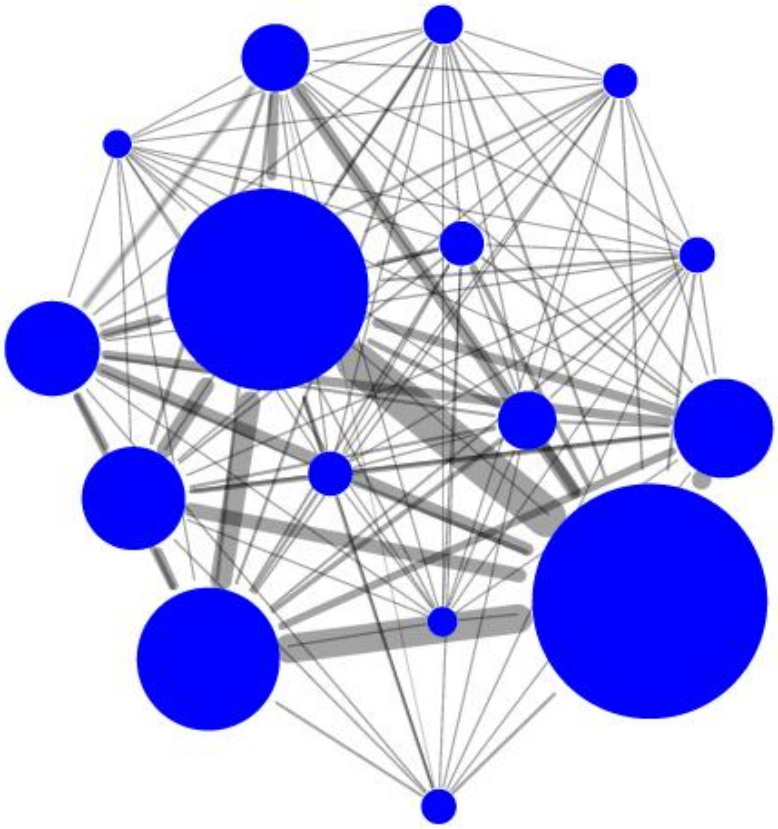
- From now on we use the relationship network
  - Avoid double counting of flows
  - Ultimate links relevant to assess centrality
- Measures of individual centrality that are:
  - Intuitive and well-established, not very highly correlated with value and not very highly cross-correlated
  - Two measures:
    - **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 2nd-tier banks

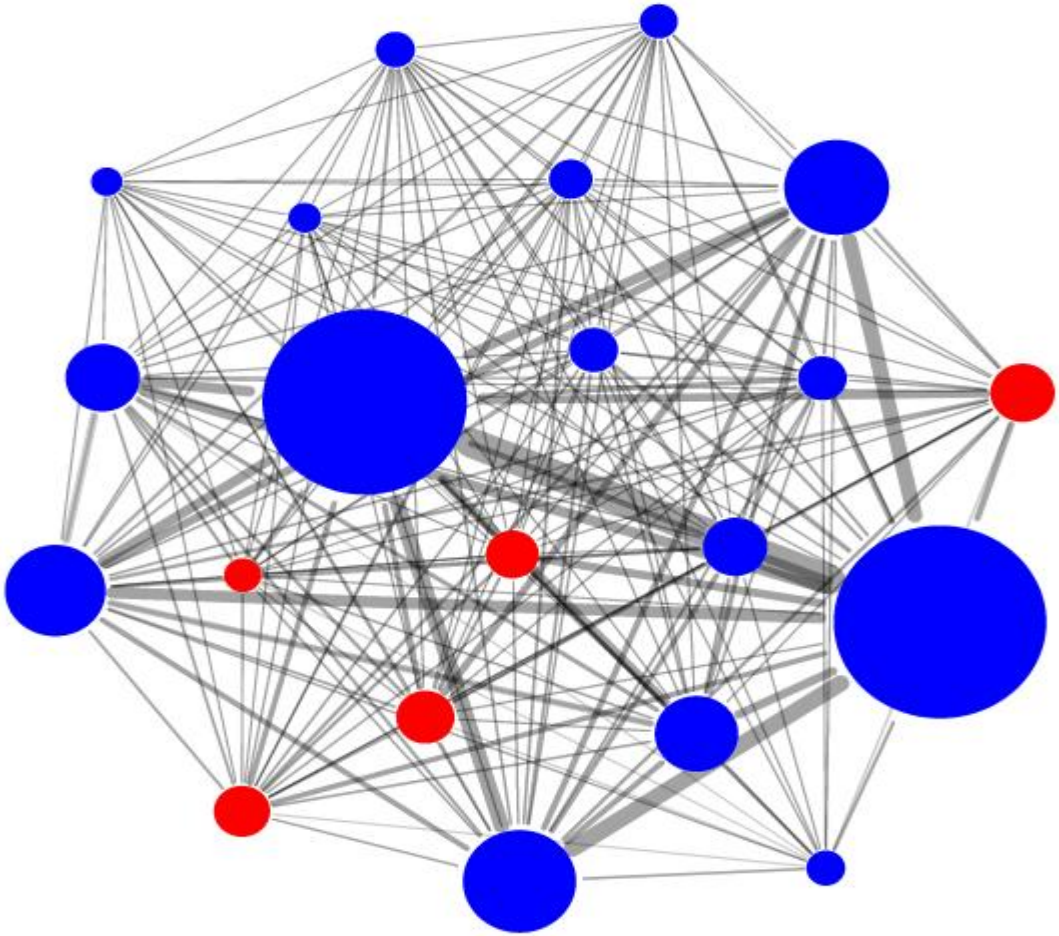
- SB as a whole more central than 2nd-tier banks
- But top 5 2nd-tier banks
  - more central than bottom 7 SBs in betweenness
  - as central as middle SBs in eigenvector centrality.

| | betweenness | eigenvector |
|---|---|---|
| **top 5 sb** | 38.9 | 0.08 |
| **next 5 sb** | 19.5 | 0.03 |
| **next 6 sb** | 11.6 | 0.01 |
| | | |
| **top 5 2nd-tier** | 11.7 | 0.03 |
| **next 5 2nd-tier** | 5.1 | 0.01 |
| **next 5 2nd-tier** | 5.1 | 0.01 |

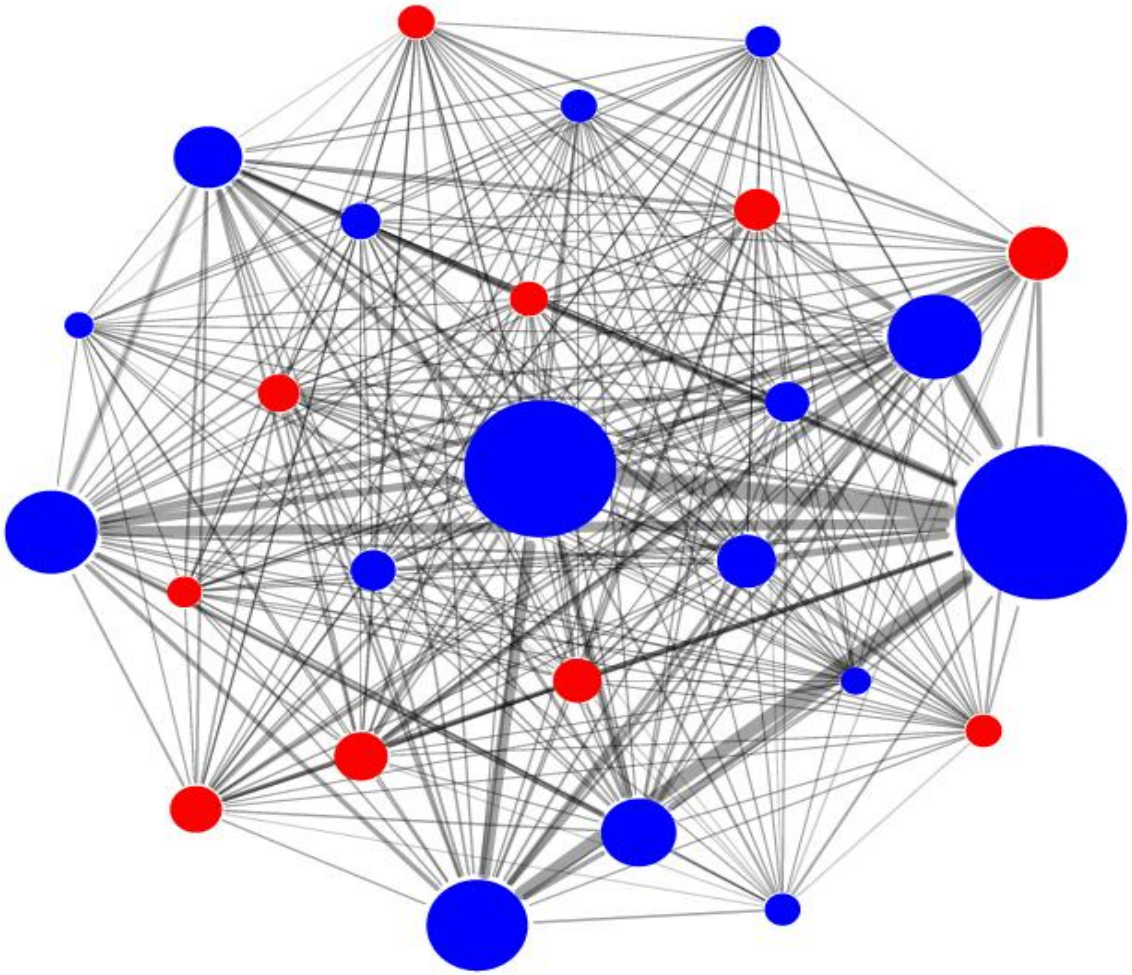
# 3. Impact of 2nd-tier banks joining



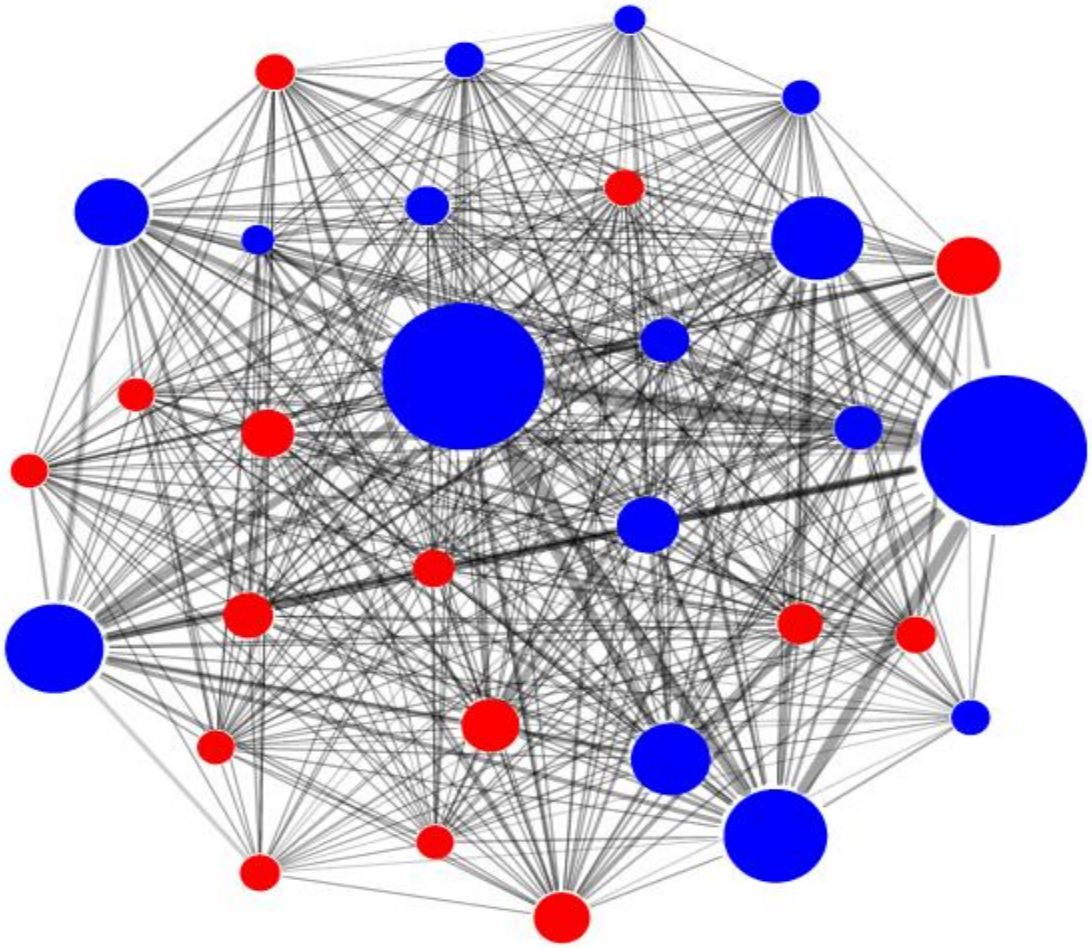
# 3. Impact of 5 2nd-tier banks joining



# 3. Impact of 10 2nd-tier banks joining



# 3. Impact of 15 2nd-tier banks joining



# 3. Impact of 2nd-tier banks joining

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|---|---|---|---|---|---|---|---|
| **16 settlement banks** | 16 | 231 | 96% | 14.4/15 | 1.03 | 97% | 99% |
| **Plus five** | 21 | 403 | 96% | 19.2/20 | 1.04 | 97% | 98% |
| **Plus ten** | 26 | 623 | 96% | 24.0/25 | 1.04 | 97% | 97% |
| **Plus fifteen** | 31 | 861 | 93% | 27.8/30 | 1.07 | 95% | 95% |

# 3. Impact of 2nd-tier banks joining

- Peak and average flows decrease substantially with more direct members

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

| Network | Maximum | Average | Median |
|---|---|---|---|
| 16 settlement banks | 16 | 1 | 0.14 |
| Plus five | 12 | 0.5 | 0.10 |
| Plus ten | 9 | 0.4 | 0.06 |
| Plus fifteen | 8 | 0.3 | 0.04 |

# 3. Impact of 2nd-tier banks joining

- Connectivity only goes down when more than 10 join
- So top 10 2nd-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 2nd-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