

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

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monitoring indicators

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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<sup>nd</sup>-tier banks
- But another aspect to being systemic/central: connectedness – network analysis gives insights

# This paper

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

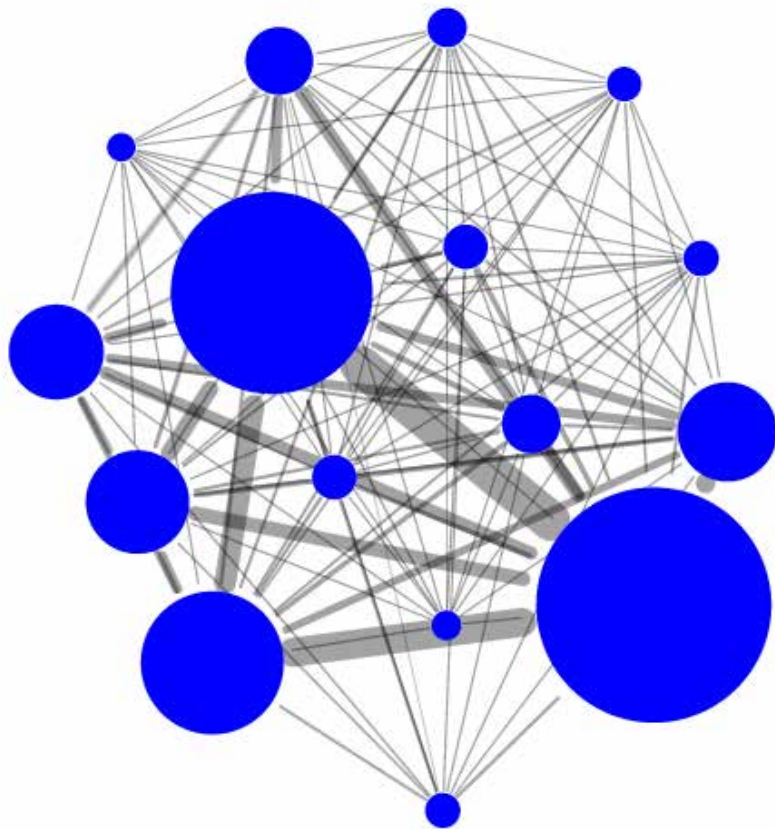
# Methodology

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

# We build 3 different networks

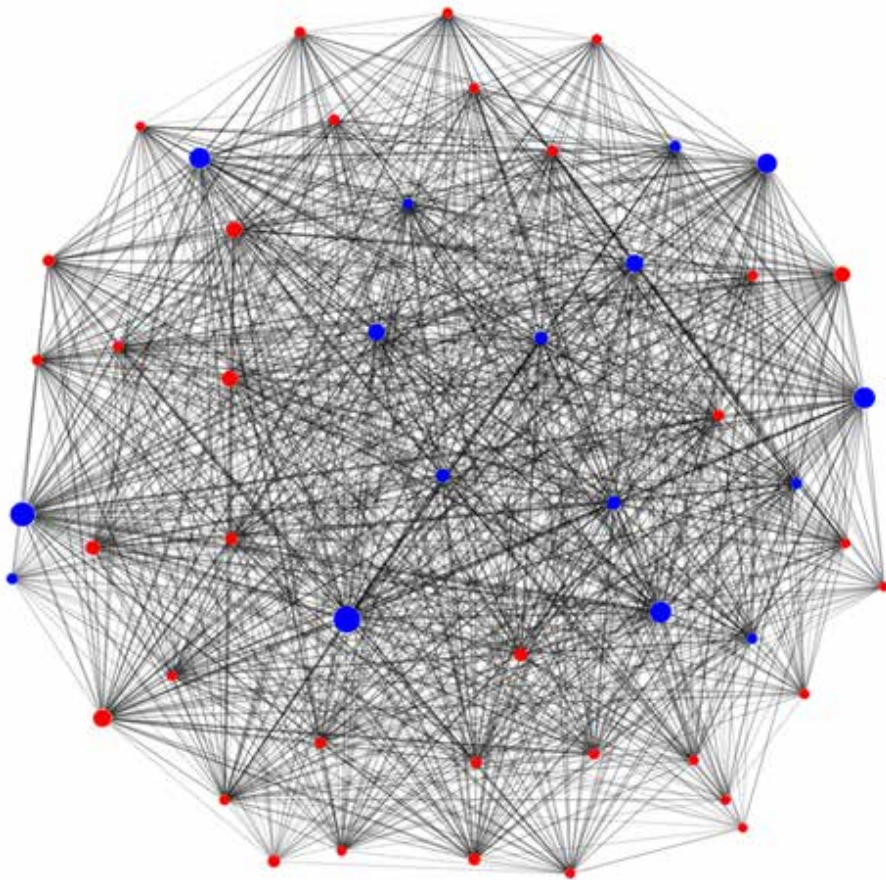
1. Settlement bank network: made up of payments going across 16 settlement banks only
2. "Relationship" network: payments between ultimate sender and receiver, not including the leg between 2<sup>nd</sup>-tier and their settlement banks
  - Ultimate links across banks. Could be seen as what the network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



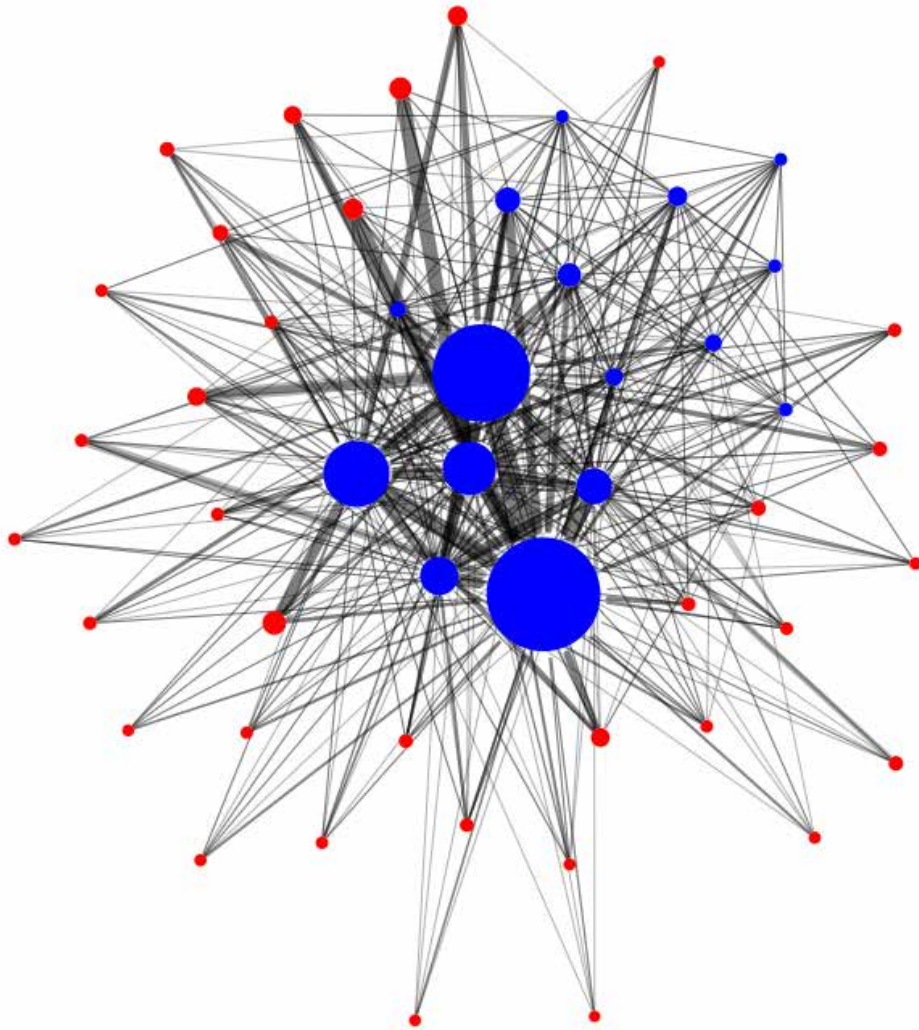
- Well connected, almost complete: connected networks more resilient to shocks but impact of a large node failing is larger
- Compact
- Subsets: core of three, then five, then others

# 1. Comparing the networks: relationship network



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

# 1. Comparing the networks: flow network



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



# 1. Comparing the networks: network statistics

<i>Network</i>	<i>Number of nodes</i>	<i>Number of links</i>	<i>Connectivity</i>	<i>Average degree</i>	<i>Average path length (min=1)</i>	<i>Clustering coefficient</i>	<i>Reciprocity</i>
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 2<sup>nd</sup>-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 2<sup>nd</sup>-tier banks

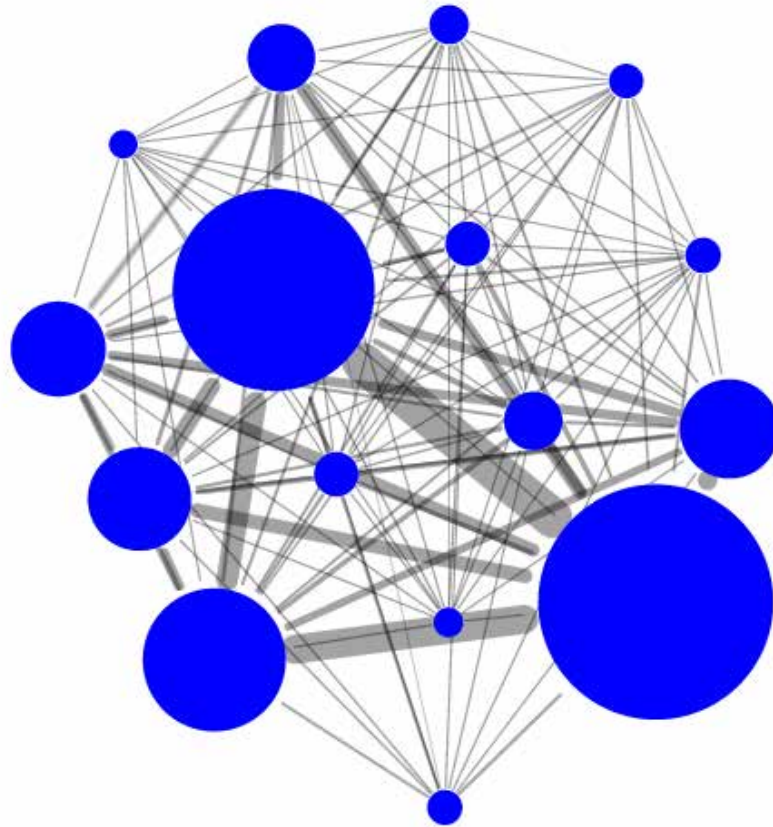
- From now on we use the relationship network
  - Avoid double counting of flows
  - Ultimate links relevant to assess centrality
- Measures of individual centrality that are:
  - Intuitive and well-established, not very highly correlated with value and not very highly cross-correlated
  - Two measures: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

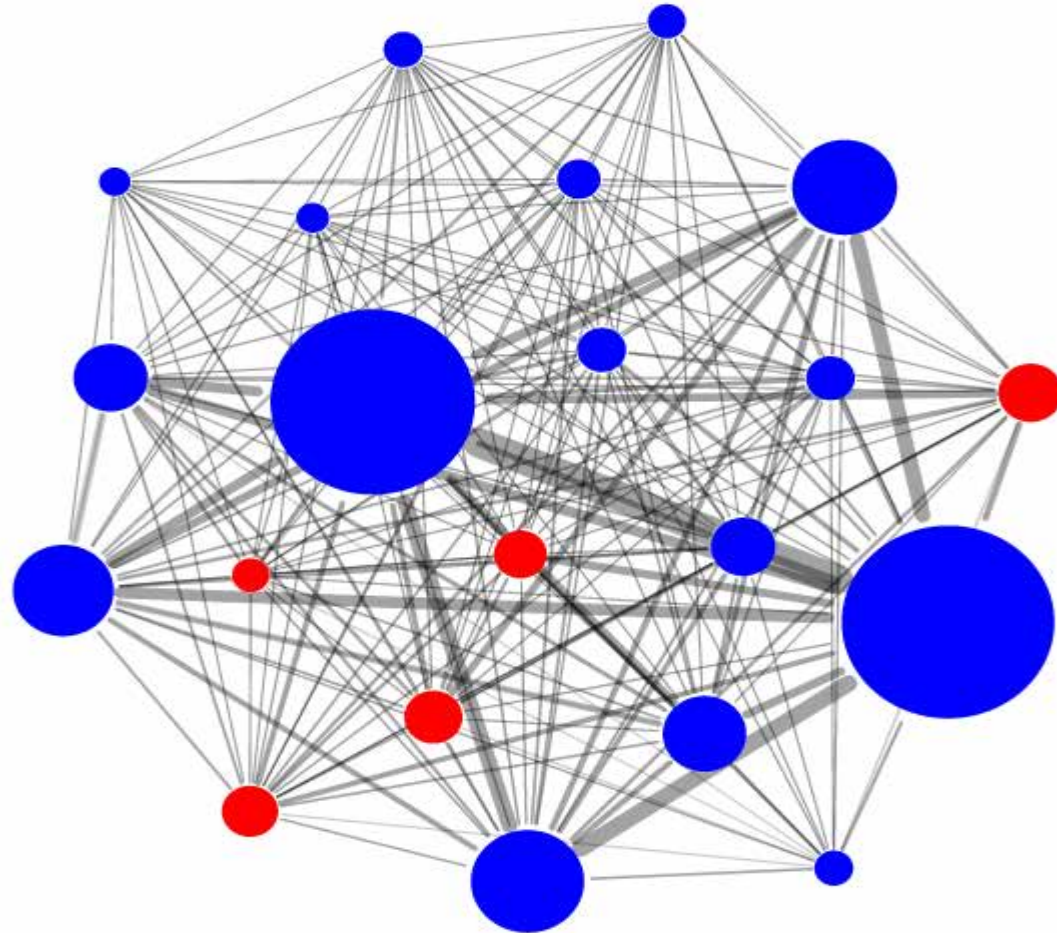
- SB as a whole more central than 2<sup>nd</sup>-tier banks
- But top 5 2<sup>nd</sup>-tier banks
  - more central than bottom 7 SBs in betweenness
  - as central as middle SBs in eigenvector centrality.

	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

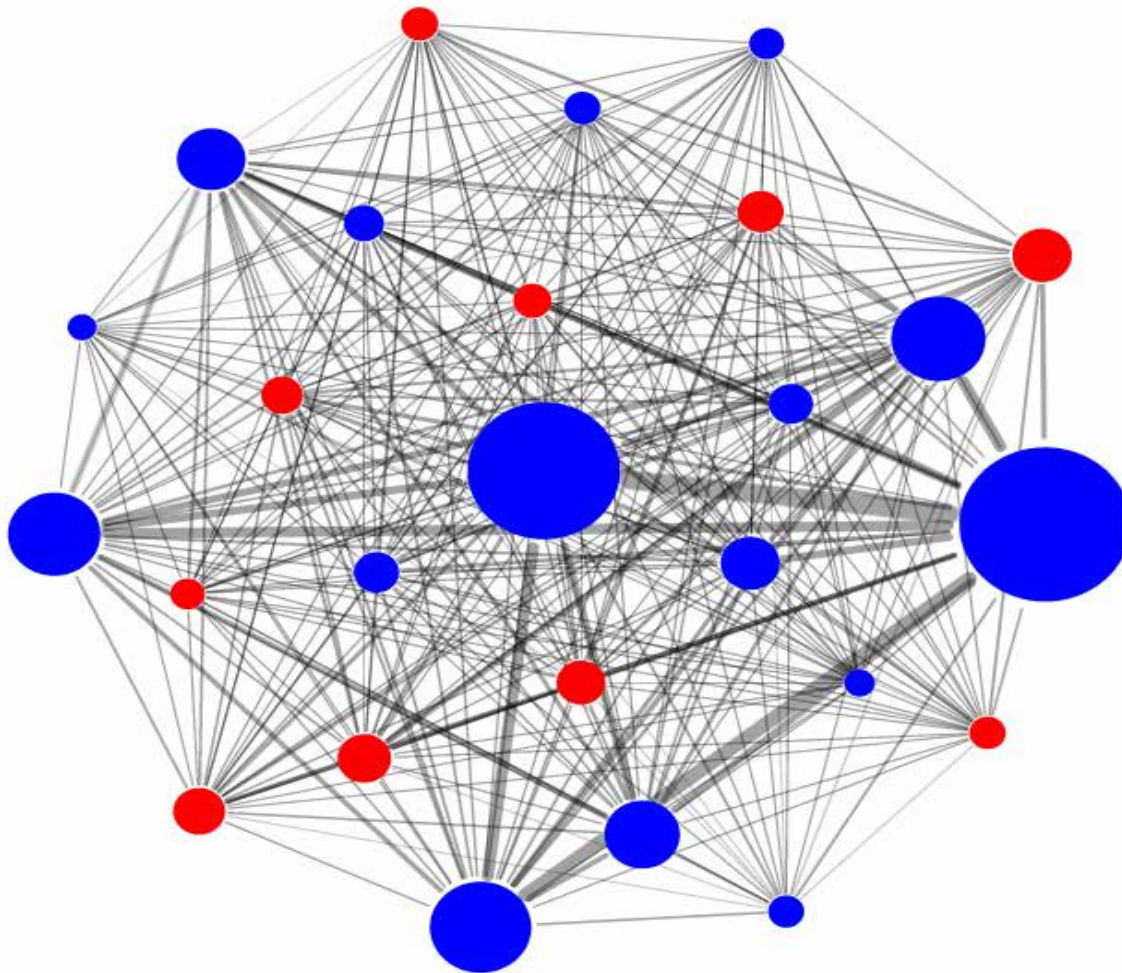
### 3. Impact of 2<sup>nd</sup>-tier banks joining



### 3. Impact of 5 2<sup>nd</sup>-tier banks joining

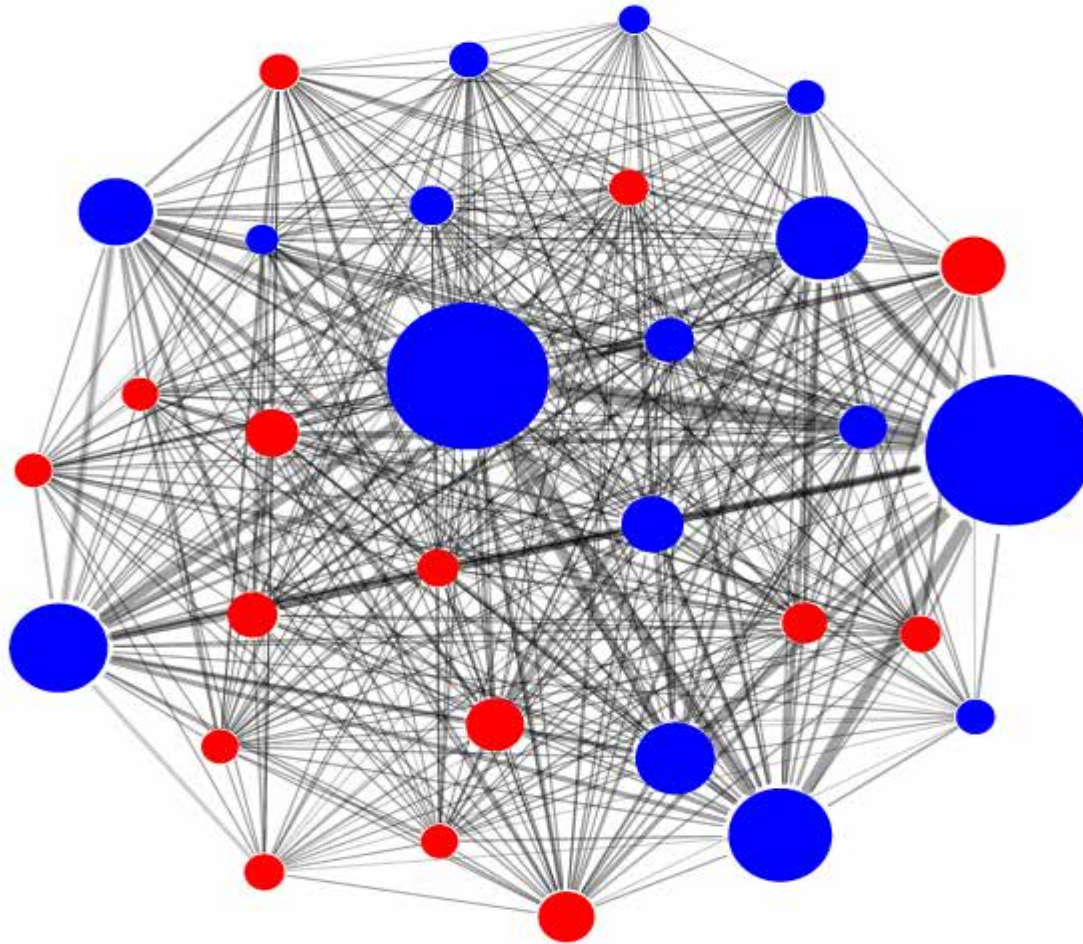


### 3. Impact of 10 2<sup>nd</sup>-tier banks joining





### 3. Impact of 15 2<sup>nd</sup>-tier banks joining





# 3. Impact of 2<sup>nd</sup>-tier banks joining

<i>Network</i>	<i>Number of nodes</i>	<i>Number of links</i>	<i>Connectivity</i>	<i>Average degree</i>	<i>Average path length</i>	<i>Clustering coefficient</i>	<i>Reciprocity</i>
<b>16 settlement banks</b>	16	231	96%	14.4/15	1.03	97%	99%
<b>Plus five</b>	21	403	96%	19.2/20	1.04	97%	98%
<b>Plus ten</b>	26	623	96%	24.0/25	1.04	97%	97%
<b>Plus fifteen</b>	31	861	93%	27.8/30	1.07	95%	95%

# 3. Impact of 2<sup>nd</sup>-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 2<sup>nd</sup>-tier banks joining

- Connectivity only goes down when more than 10 join
- So top 10 2<sup>nd</sup>-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<sup>nd</sup>-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