



# Measuring financial integration: A network approach

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# What do we know about financial interconnections?

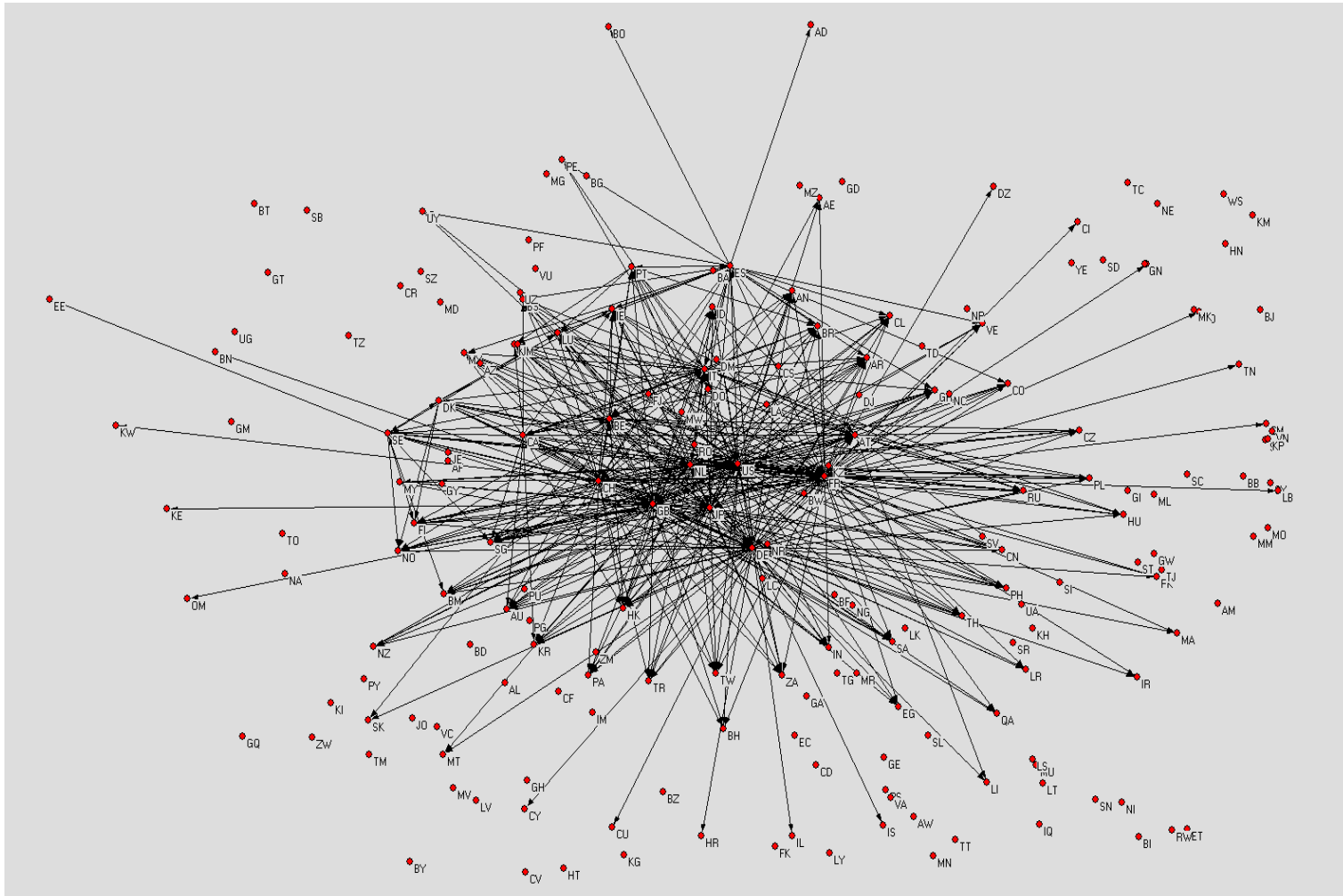
- We can map connections
- But can we comprehend the complexity of networks?
- Can we see the critical points?
- Think about what you know about financial connections in Asia:
- Where do financial flows go; who is connected with whom; are there central nodes; where are they?
- You are not alone in being unable to answer these questions.



# Recent focus

- Some recent work looking for the link between systemic importance and fragility comes from the central bank concerns.
- Simple mapping approaches for global system give some visual clues but hard to interpret.
- Most network studies are either purely theoretical or simulation based.
- But we need some way to interpret network characteristics – maps alone hard to read.

# Global network 1999

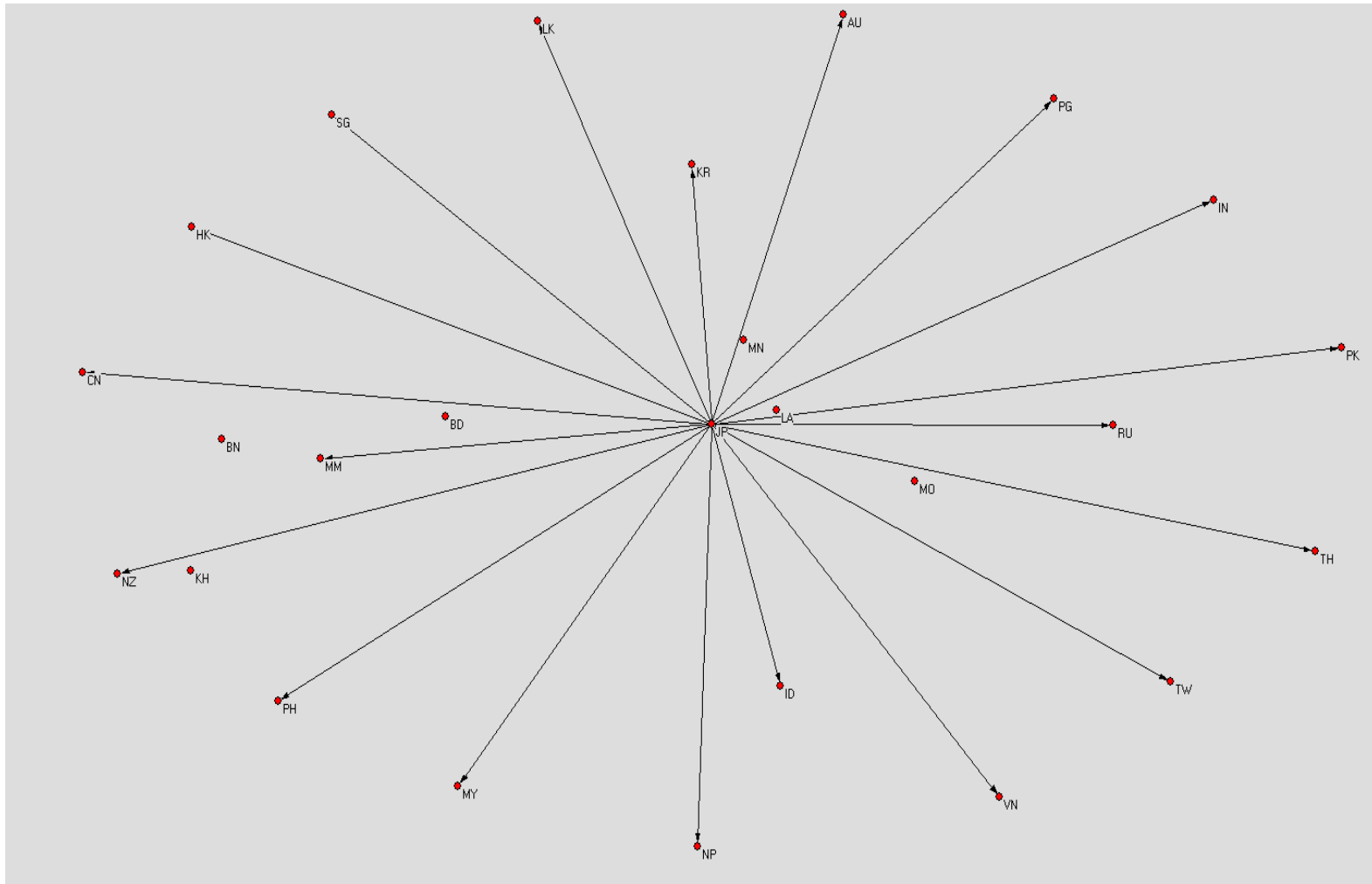


Note: data compiled from from BIS banking statistics; map drawn by the network software 'Pajek'.





# Asian network 1999



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# A way to capture network features

- Network methods can capture ***financial interconnectedness in a different way***
- Network approaches provide a framework to illustrate interconnections in a system
  - They are descriptive, not theoretically-based, methods
  - but they do measure interconnectedness in a system
    - can take the system as a whole and capture all connections in it
    - could be developed to identify possible shock transmission channels

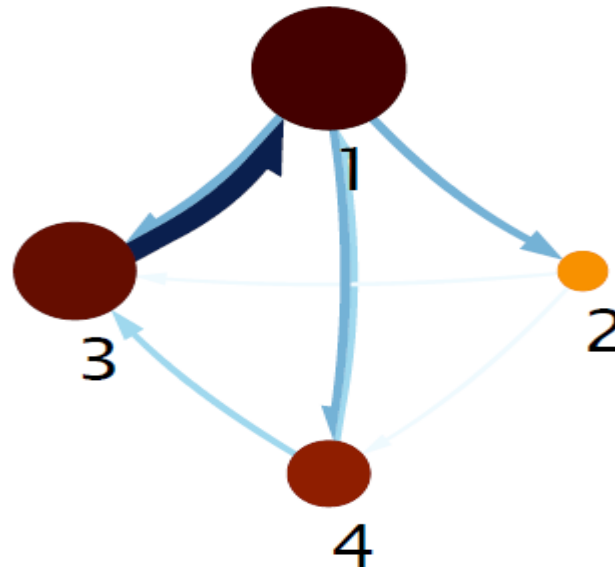




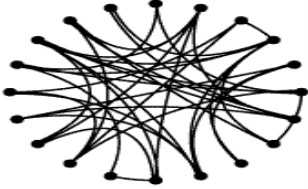
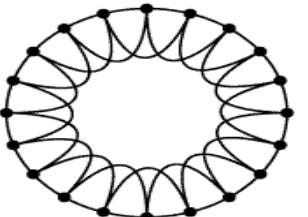
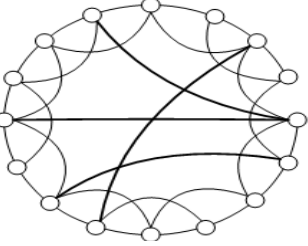
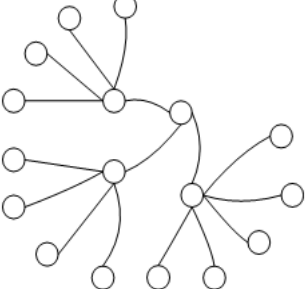
# Network methods

- The field draws on theories and methods including graph theory from **mathematics**, statistical mechanics from **physics**, data mining and information visualization from **computer science**, and social structure from **sociology**.

- A small network
  - 4 vertices/nodes
  - 8 directed links



# Network structures

	Characteristics	Graphs
Random network	A set of $n$ isolated nodes connected with successive links between them at random	
Regular network	In- and out-degrees of each node are equal to each other; nodes have the same number of links (homogenous network)	
Small-world network	Small average path length like a random network but highly clustered like a regular network; homogenous network	
Scale-free network	The majority of nodes have one or two links but a few nodes have a large number of links	



# Methodology

- **Financial interconnectedness (*integration*)** index of any country  $i$  at year  $t$ ,  $x_{it}$ , is the weighted sum of the interconnectedness of all other countries  $j$  ( $j = 1..J$ ),  $x_{jt}$ , that link to it through bank claims  $a_{ijt}$

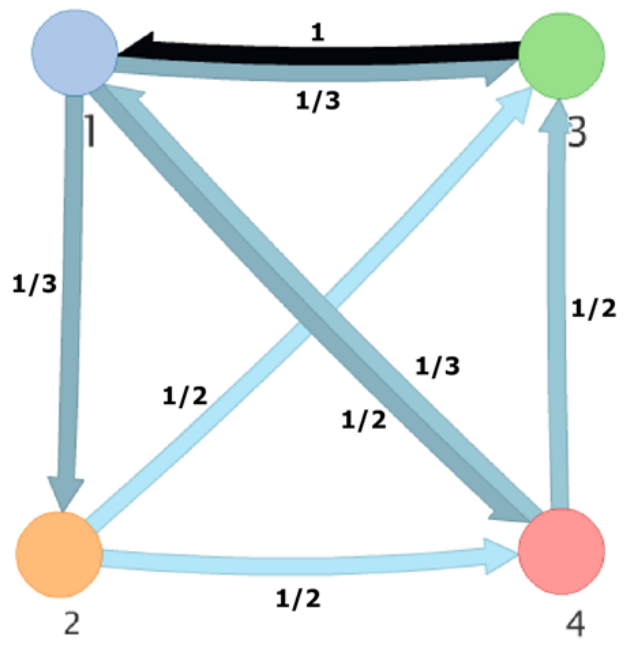
$$x_{it} = \sum_{j=1}^N \frac{a_{i \leftarrow jt}}{\sum_{i=1}^N a_{i \leftarrow jt}} x_{jt}$$

- The weight for a link  $j \rightarrow i$  is share of the bank claims from  $j$  to  $i$  in country  $j$ 's total foreign claims at year  $t$
- The weight represents the strength of a link



# Example

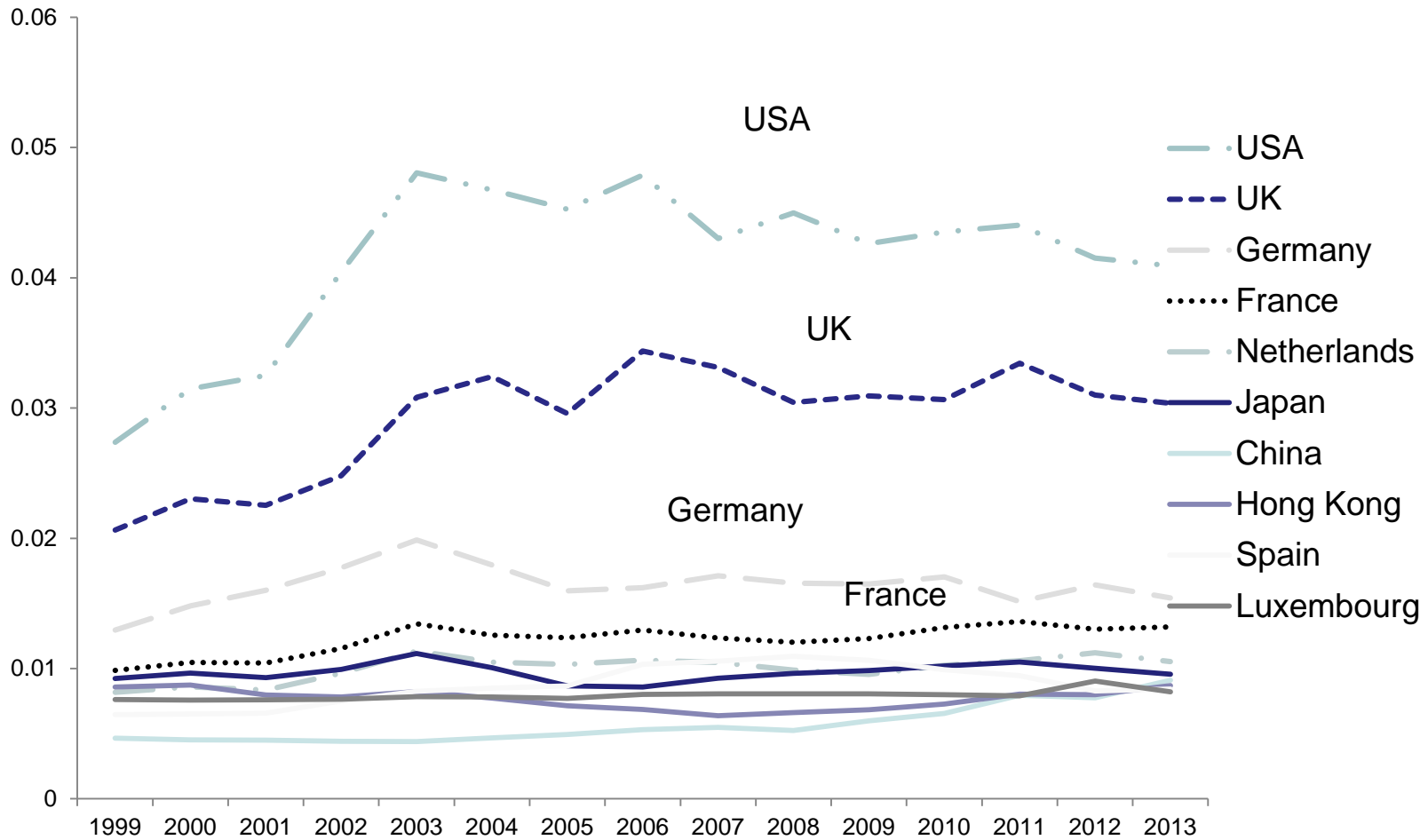
- A small international banking network of 4 countries and connections among them and its transition matrix



$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 1/2 \\ 1/3 & 0 & 0 & 0 \\ 1/3 & 1/2 & 0 & 1/2 \\ 1/3 & 1/2 & 0 & 0 \end{bmatrix}$$



# FI indexes: Top 10 in the global network

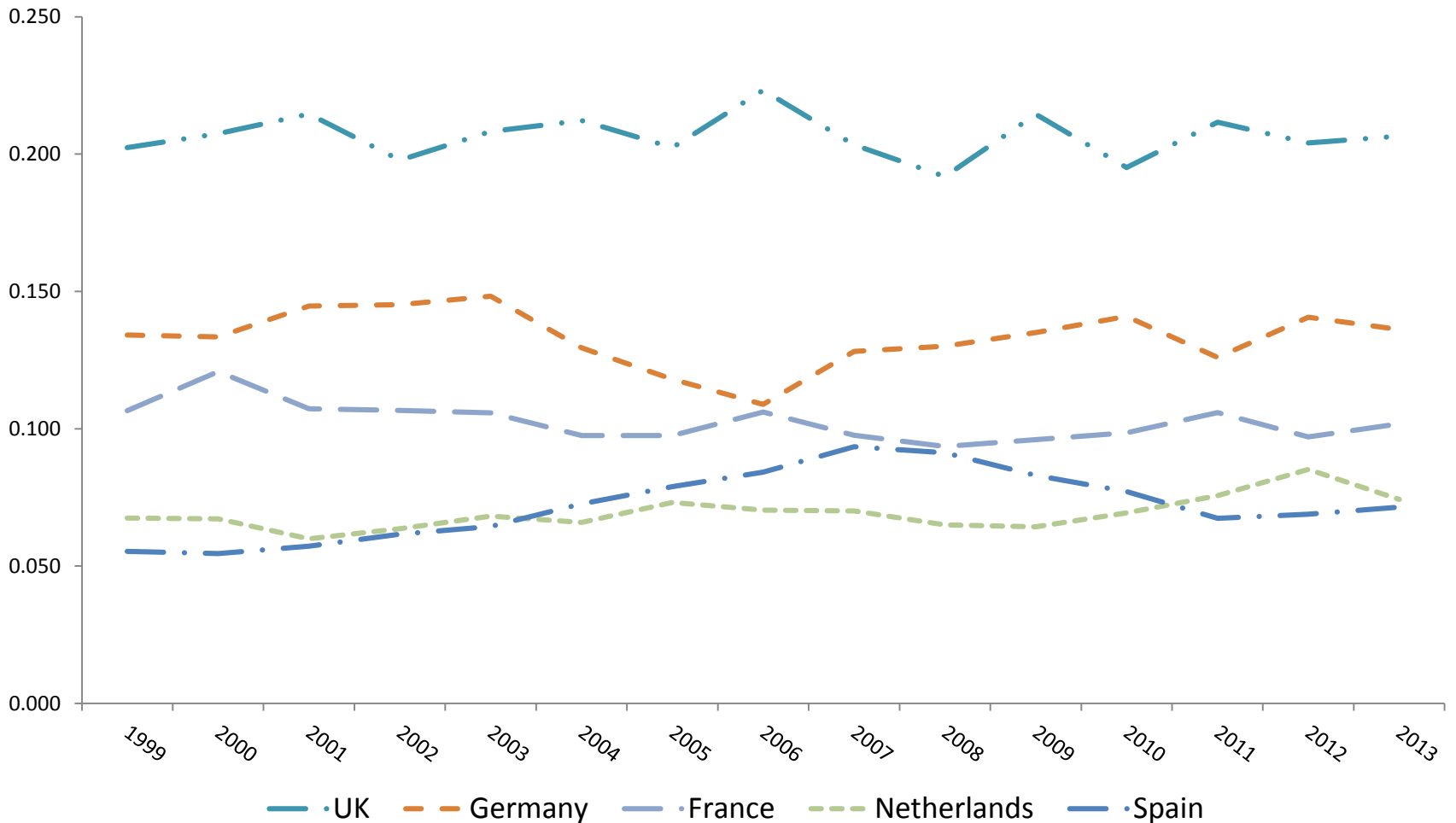




# Results for the global network

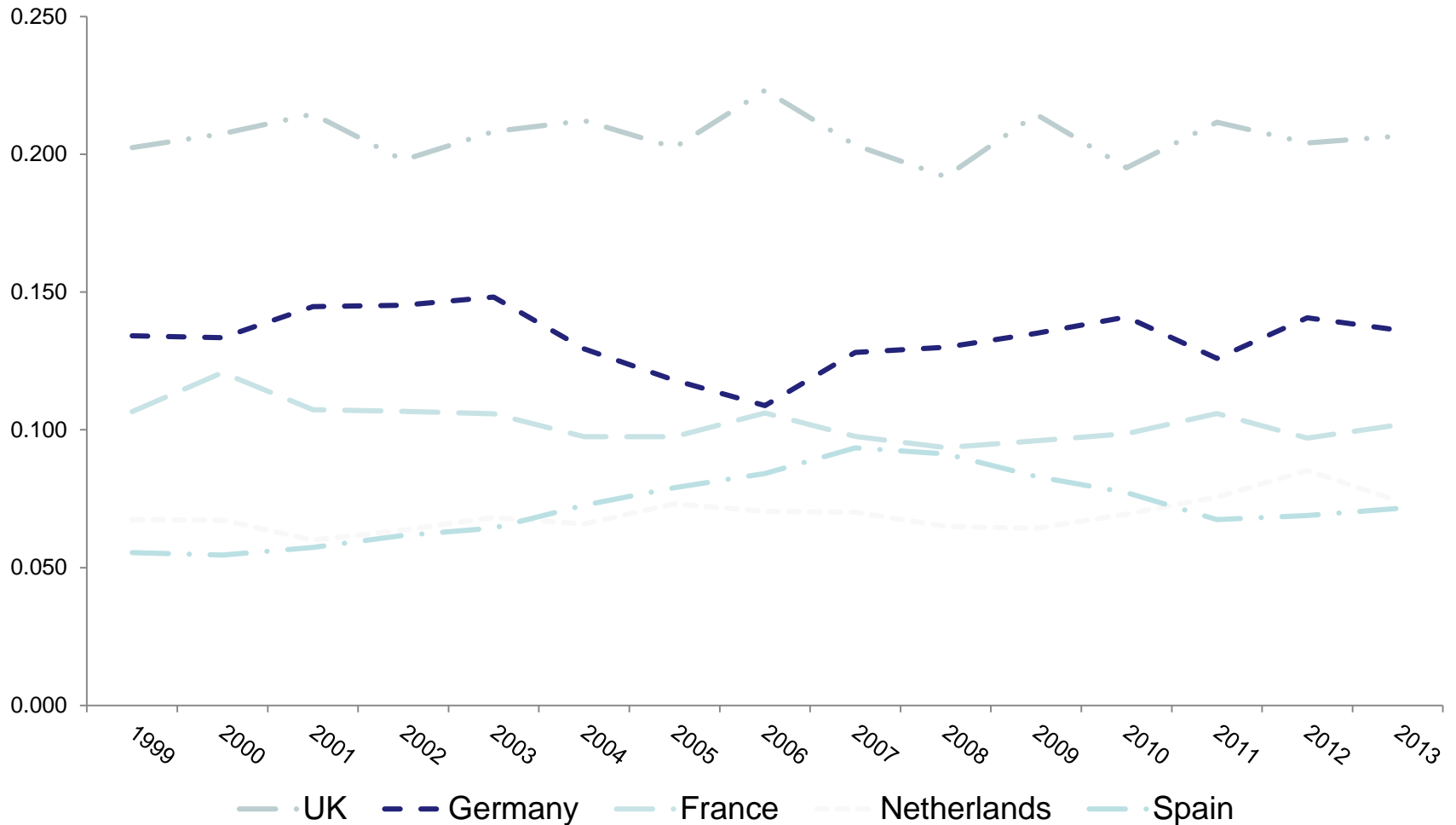
- ***USA, UK, Germany, and France*** are the most financially interconnected countries
- By contrast, most countries have low and similar level of connectedness.
- Consistent with the existing studies
  - Distribution of connectivity measured by the FI index follows a power law, typical of scale-free networks, only in a more extreme form (comparing Figure A and B)
  - Such a network is robust to random shocks but vulnerable to targeted attacks

# FI indexes: Top 5 in the European network





# FI indexes: Top 5 in the European network



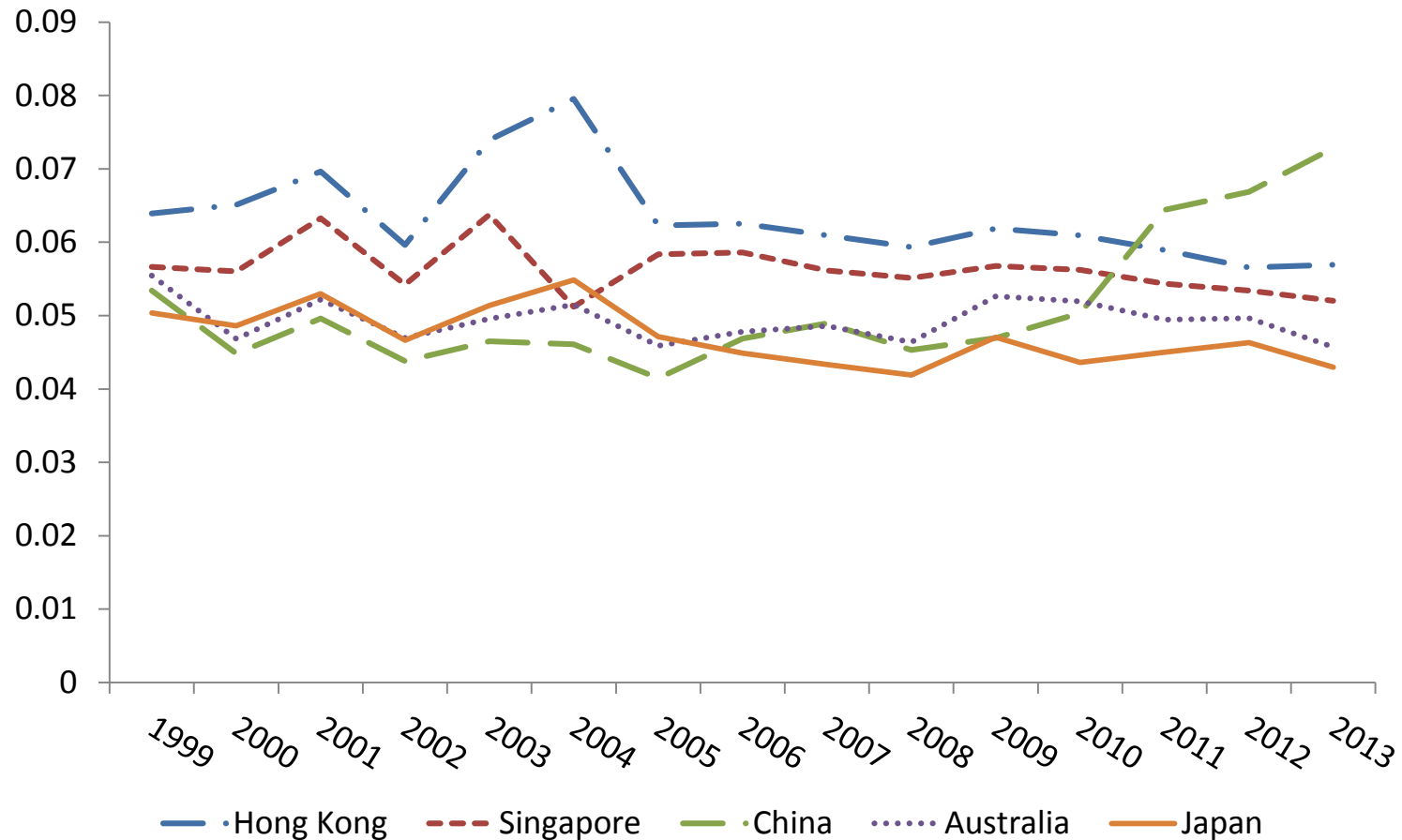




## Results for the European network

- The European network resembles the global network only at a smaller scale (**UK** in the core and most of the other European countries in the periphery)
- Distribution of FI shows a scale-free network
  - The European network is vulnerable to targeted attacks on the UK banking system

# FI indexes: the Asia network



# Tentative Results for the Asian network

- Regional integration:
  - **HK** historically very well integrated in the region
  - **China** is rapidly integrated with the regional partners
  - In spite of being highly integrated with the global financial market, **Japan** is not fully integrated with the regional counterparts
- The distribution also shows a scale-free network
  - **China** started to form the 'core' of the Asian network
- Caution due to data issue:
  - Only Japan and Australia have complete data, other countries have inflow data only. We are seeking more complete data.



# Conclusion

- Propose a new measure of financial integration highlighting interconnectedness in the system
- Use the new measure to show
  - **US** and **UK** and other industrial countries remain the most interconnected countries in the world in spite of the GFC
  - **Japan** is highly integrated with the world financial market but less integrated with the Asian counterparties
  - **China** is rapidly integrated with the world as well as the Asian financial market since the GFC

- The global and regional banking networks all display scale-free, long-tail structures, indicating the vulnerability to targeted attacks on countries in the 'core' of the networks
- Future work:
  - More data from BIS to address the data issue
  - Other dimensions of financial linkages among countries (e.g. cross-border portfolio positions)

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