Financial Networks and Cartography
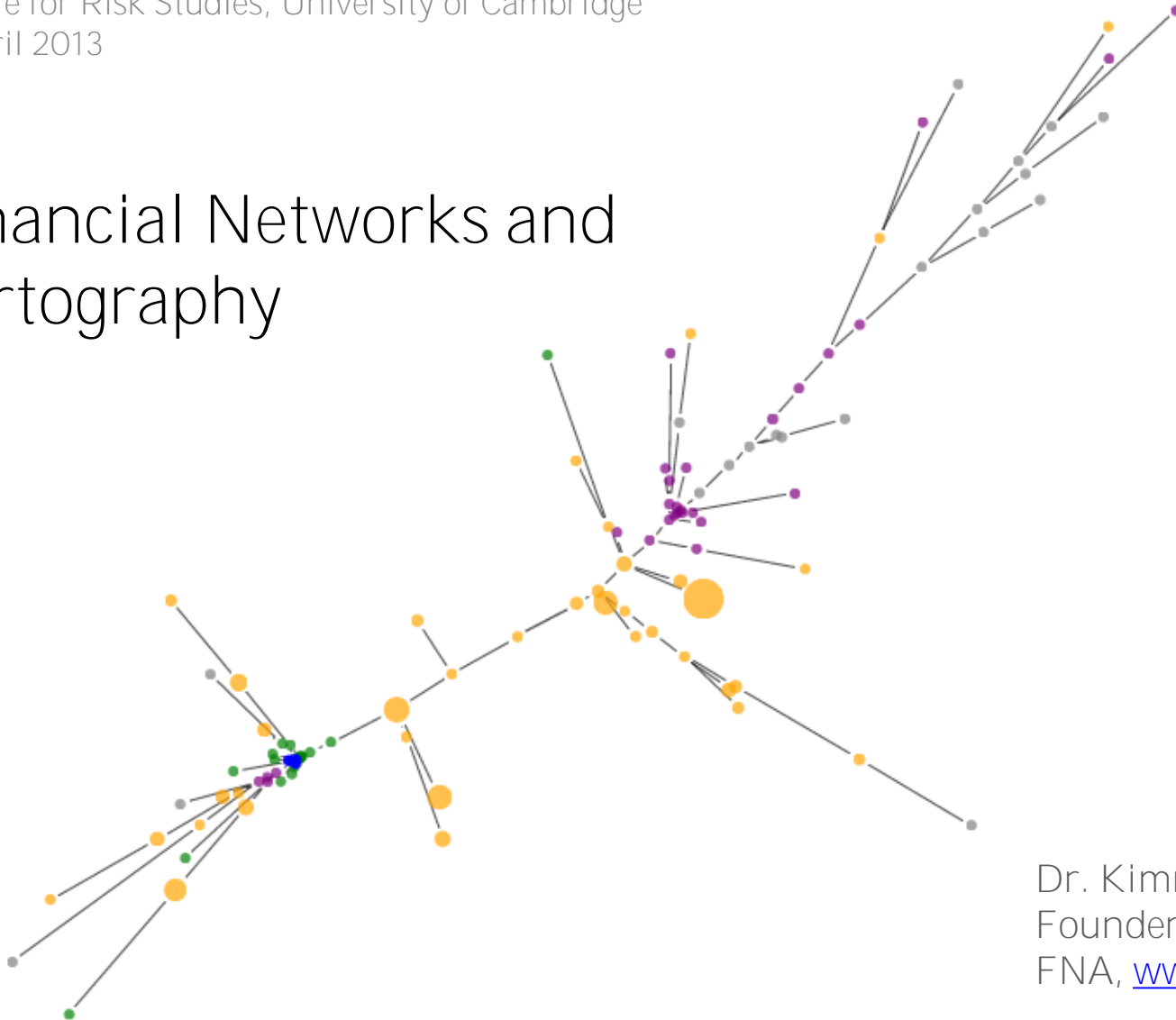
Dr. Kimmo Soramäki
Founder and CEO
FNA, www.fna.fi

Map of 1854 Broad Street cholera outbreak by John Snow

# Agenda

Networks "connect the dots". They operationalize the concept of financial interconnectedness that underpins systemic risk .

The epidemiology of finance is the study of contagion. Contagion models are often based on network models. The goal is often to identify and contain "super-spreaders" or "systemically important banks"

Network visualizations allow us to "map the financial system". Maps are intelligence amplification, they aid in decision making and build intuition

Systemic risk ≠ system<u>a</u>tic risk
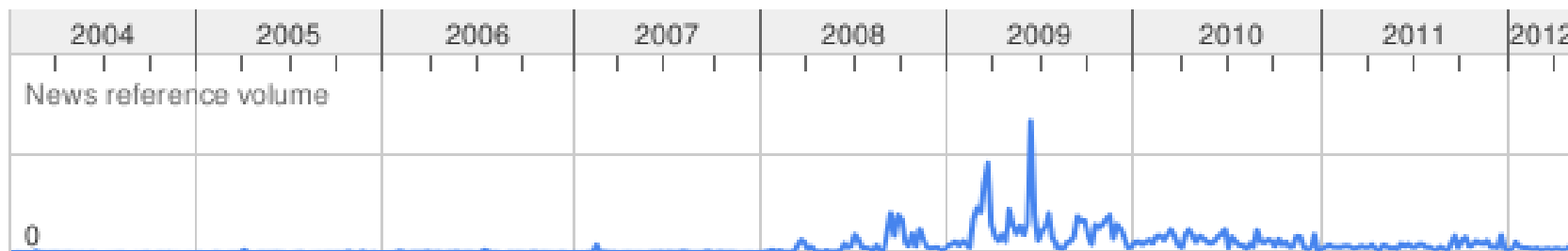
News articles mentioning "systemic risk", Source: trends.google.com

The risk that a system composed of many interacting parts fails (due to a shock to some of its parts).

In Finance, the risk that a disturbance in the financial system propagates and makes the system unable to perform its function – i.e. allocate capital efficiently.

Domino effects, cascading failures, financial interlinkages, ... -> i.e. a process in the financial network
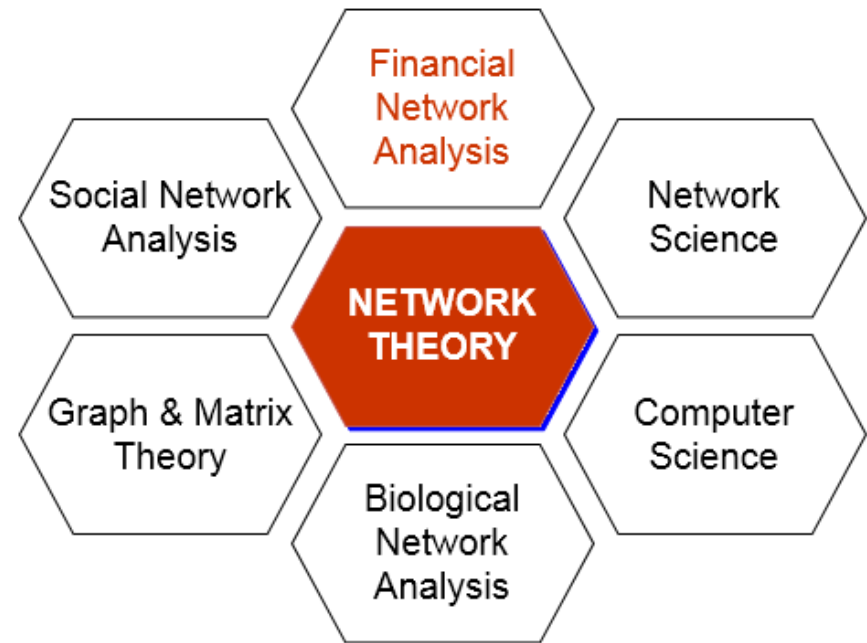

Not:

Network Theory is applied widely

Main premise of network theory:
Structure of links between nodes matters

Large empirical networks are generally very sparse

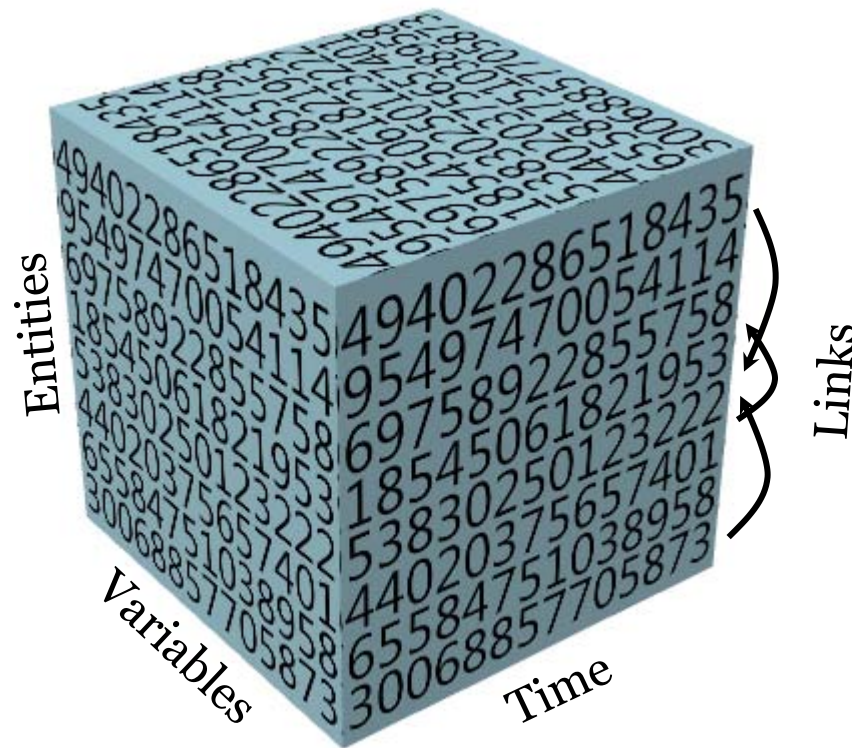Network analysis is not an alternative to other analysis methods

Network aspect is an unexplored dimension of ANY data

Networks brings us beyond the Data Cube
" The Tesseract"

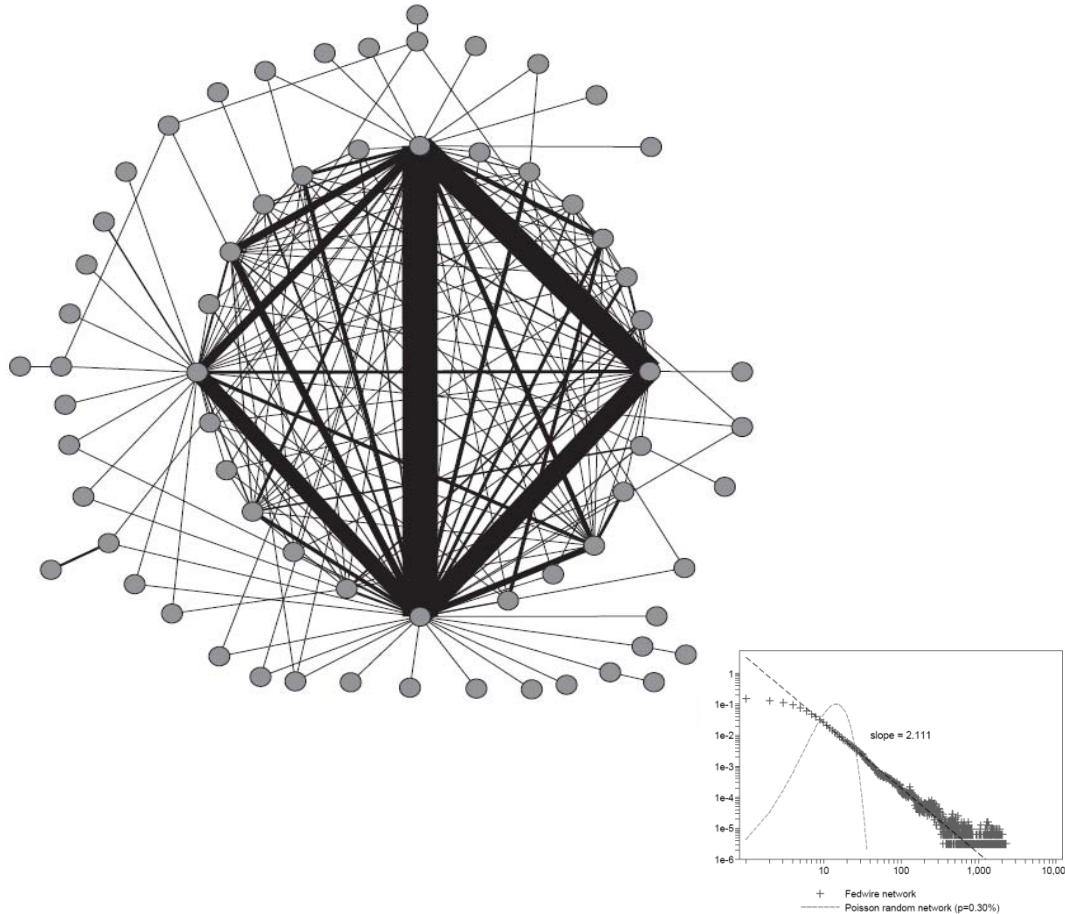**For example:**

Entities:
100 banks

Variables:
Balance sheet items

Time:
Quarterly data since 2011

Links:
Interbank exposures

Information on the links allows us to develop better models for banks' balance sheets in times of stress
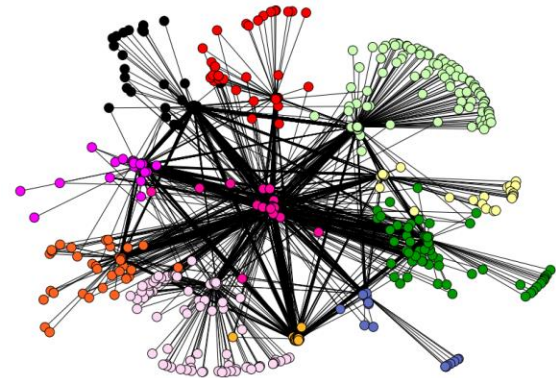
First empirics

Fedwire Interbank Payment Network, Fall 2001

Around 8000 banks, 66 banks comprise 75% of value,25 banks completely connected

Similar to other socio-technological networks

slope = 2.111

+ Fedwire network
---- Poisson random network (p=0.30%)

Soramäki, Bech, Beyeler, Glass and Arnold (2007), Physica A, Vol. 379, pp 317-333.
See: www.fna.fi/papers/physa2007sbagb.pdf

M. Boss, H. Elsinger, M. Summer, S. Thurner, The network topology of the interbank market, Santa Fe Institute Working Paper 03-10-054, 2003.
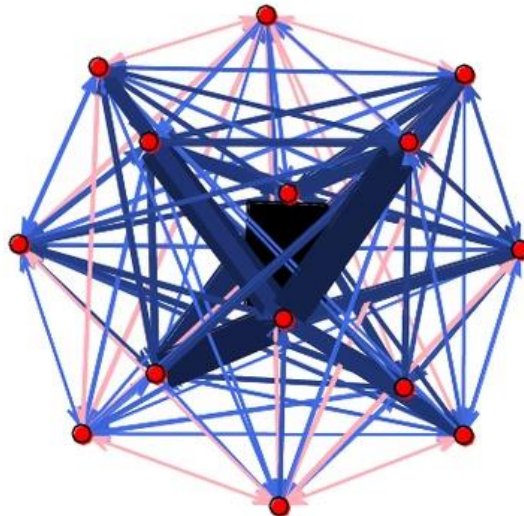
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Most central banks have now mapped their interbank payment systems
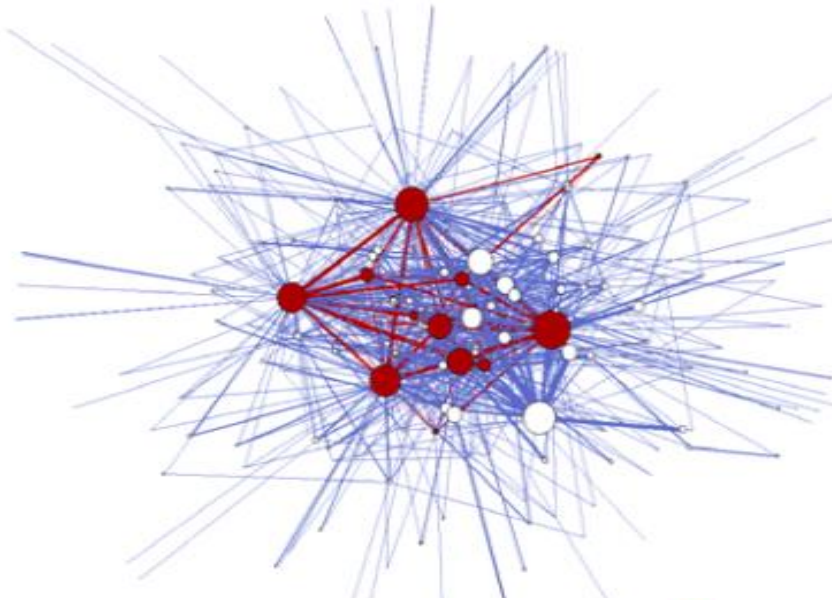
Becher, Millard and Soramäki (2008).
The network topology of CHAPS
Sterling. BoE Working Paper No. 355.
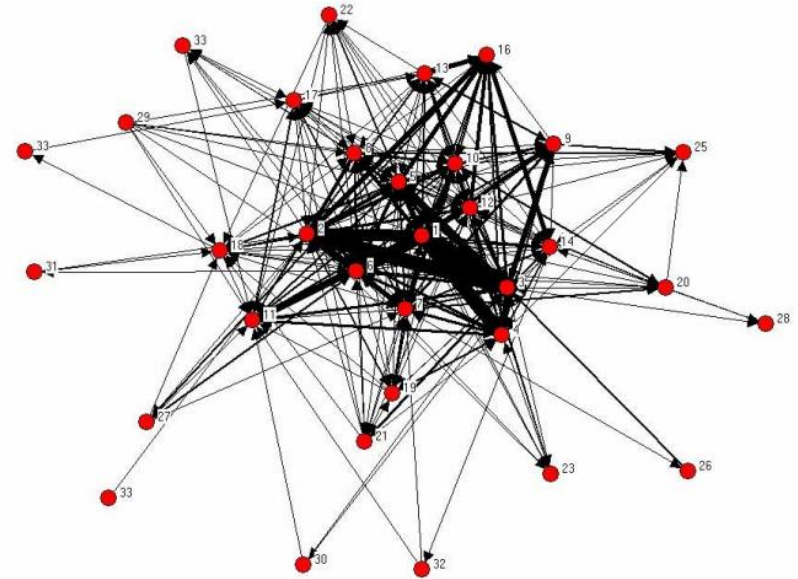
Agnes Lubloy (2006). Topology of the Hungarian
large-value transfer system. Magyar Nemzeti Bank
Occasional Papers

Embree and Roberts (2009). Network
Analysis and Canada's Large Value Transfer
SystemBoC Discussion Paper 2009-13

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Centrality Measures for Financial Systems

Metrics developed in other fields and with other network processes in mind:

- Degree, Closeness, Betweenness, PageRank, etc.

Recently developed financial system specific metrics:

- Core-Periphery
  - Craig and von Peter 2010, Optimal classification that matches theoritical core-periphery model
- DebtRank
  - Battiston et al, Science Reports 2012, Cascading failures -model
- SinkRank
 - Soramäki and Cook, Kiel Economics DP, 2012, Absorbing Markov chain
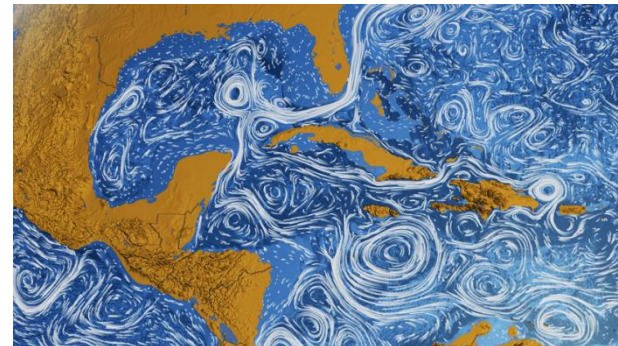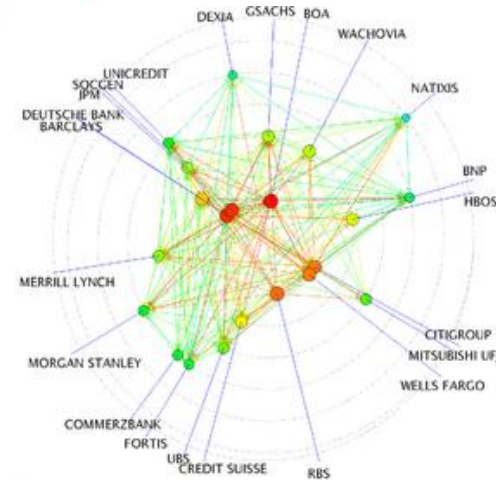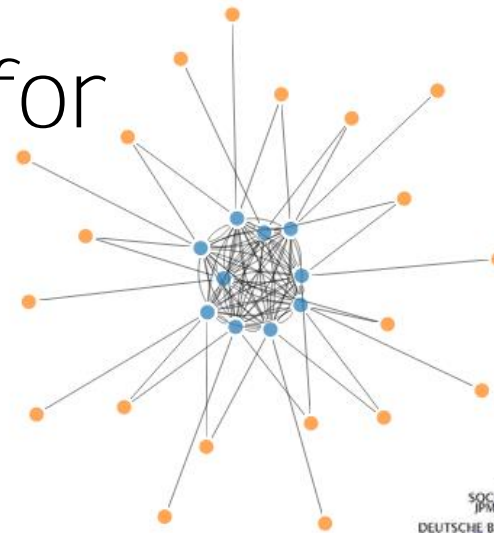
World's Ocean Currents
NASA Scientific Visualization Studio

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Types of financial networks

- **Observing Networks**
  - Flow: payment, trade, collateral
  - Stock: exposure, co-exposure,
  - Bipartite: trader-asset, bank-risk, …

- **Inferring networks**
  - Model: correlation, partial correlation, tail dependence, similarity, Granger causality
  - Data: Asset returns, Balance sheet change, …

- **Dimensions**
  - Time: intraday, overnight, long-term
  - Risk: operational, liquidity, solvency
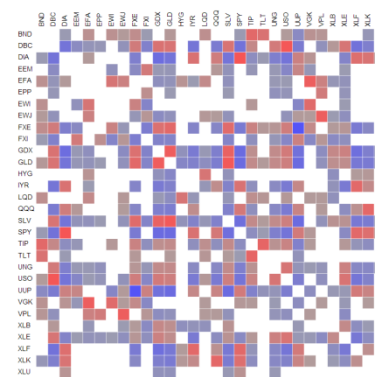
Inferring Networks
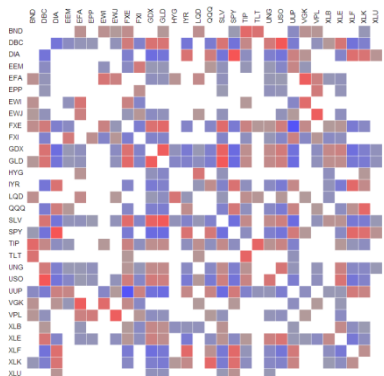
Calculate pairwise correlations
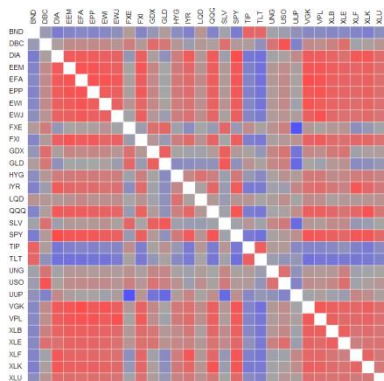
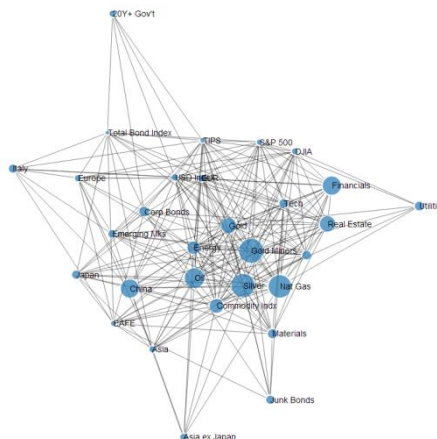Control for common factors (e.g. market)
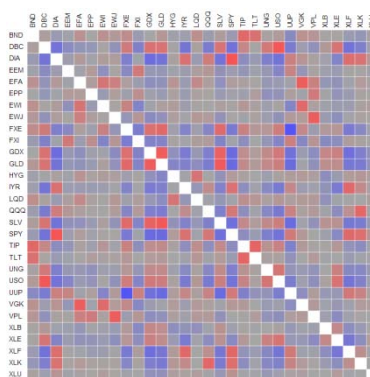
Keep statistically significant correlations
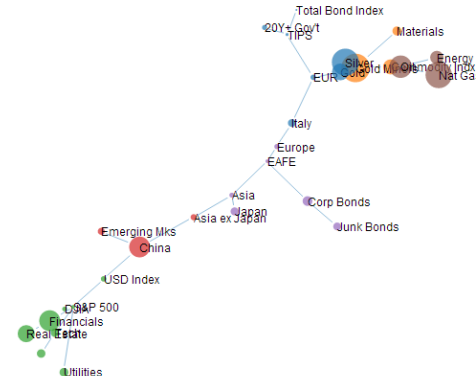

Correct for multiple comparisons

Convert to network

Visualize as tree

Map on cross asset correlations and volatilities

Nodes (circles) represent assets and links (lines) represent correlations between the linked assets
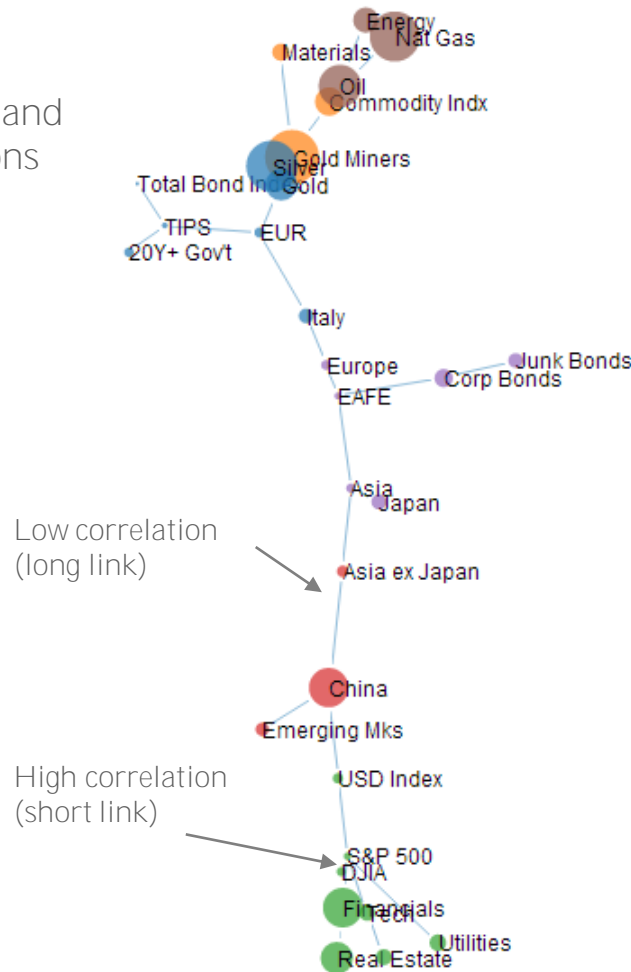
Node sizes scale with the variance of the return: assets with larger nodes have more variable returns

Shorter links indicate higher correlations.

Node color indicates identified community

Mapping multiple dimensions of the same data set on a single map allows visual inference of connections.

One can focus on details - while maintaining an overview.

Interactive version at www.fna.fi/demos/crc/viz/asset-tree.html

Priorities for research agenda

1. Measuring and mapping interconnectedness (network structure), modelling contagion (network process) and understanding their interplay

Example: Bank-Asset graphs and projections

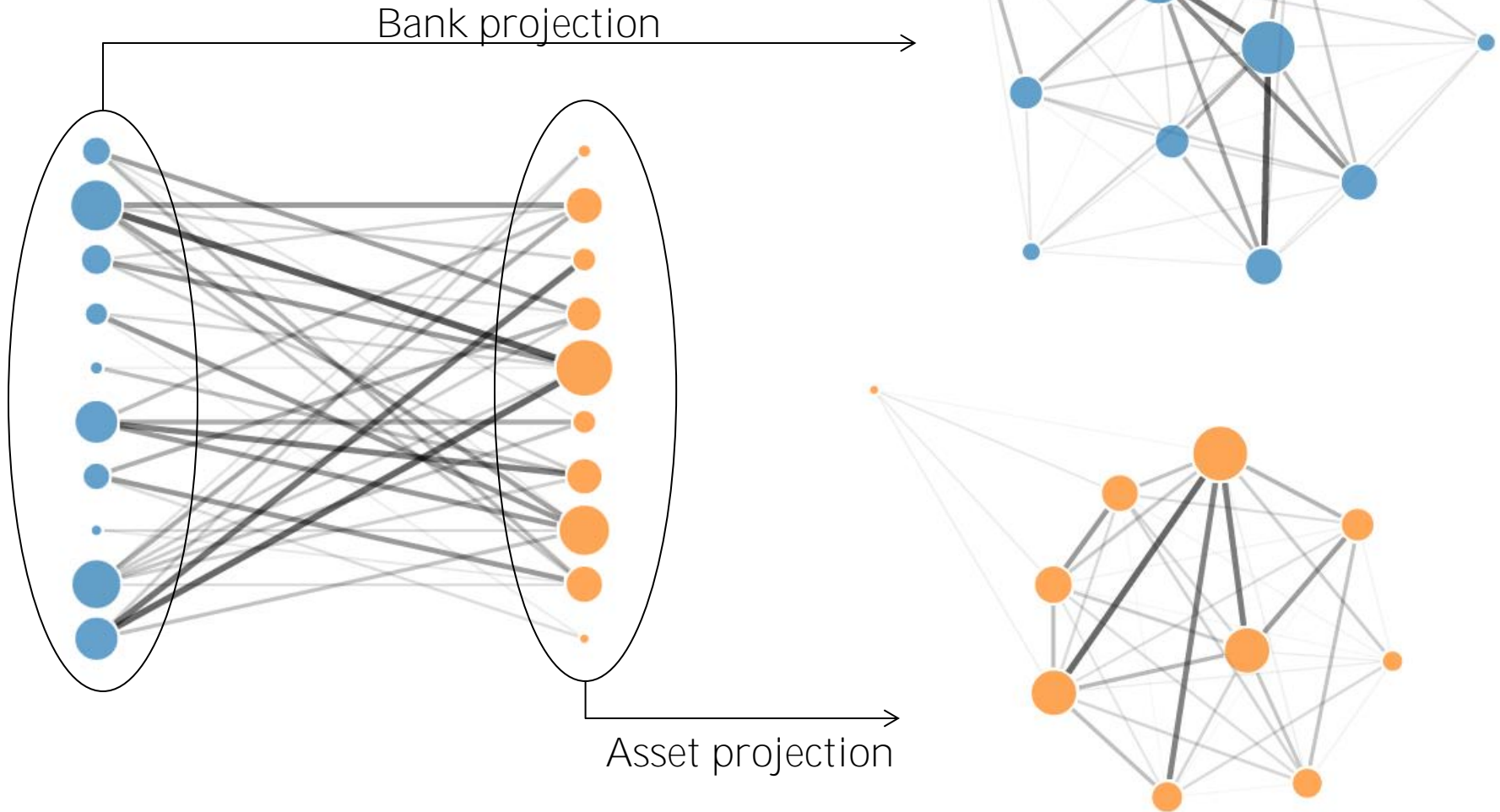Bank projection

Asset projection

Priorities for research agenda

1. Measuring and mapping interconnectedness (network structure), modelling contagion (network process) and understanding their interplay
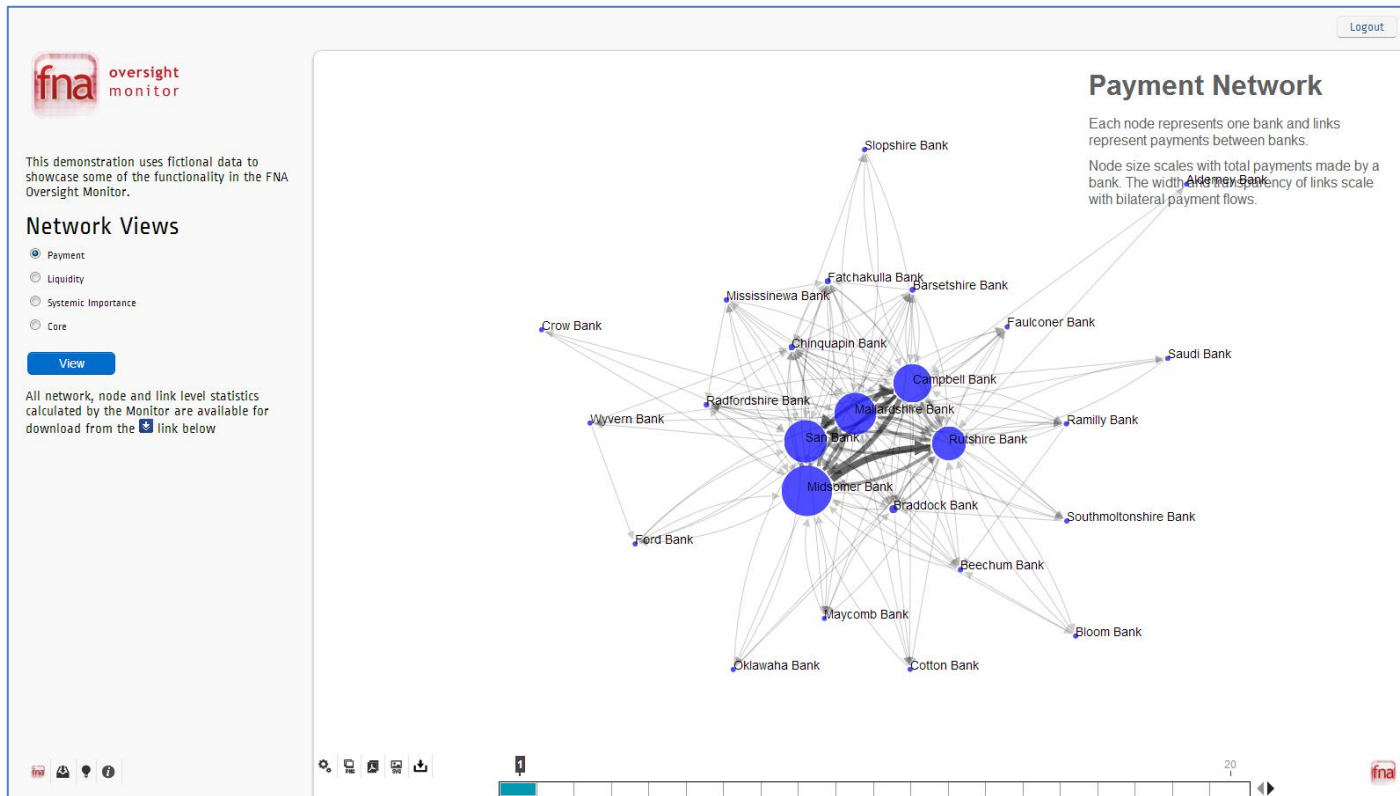
2. Developing early warning indicators and visual analytics systems for continuous monitoring of the financial system

Example: Oversight Monitor

(network is fictional)

The monitor will allow the identification of systemically important banks and evaluation of the impact of bank failures on the system

http://www.fna.fi/solutions/oversight-monitor

Priorities for research agenda

1. Measuring and mapping interconnectedness (network structure), modelling contagion (network process) and understanding their interplay

2. Developing early warning indicators and visual analytics systems for continuous monitoring of the financial system

3. Taking into account the 'social psychology' aspect of the financial system