Network theory and systemic importance

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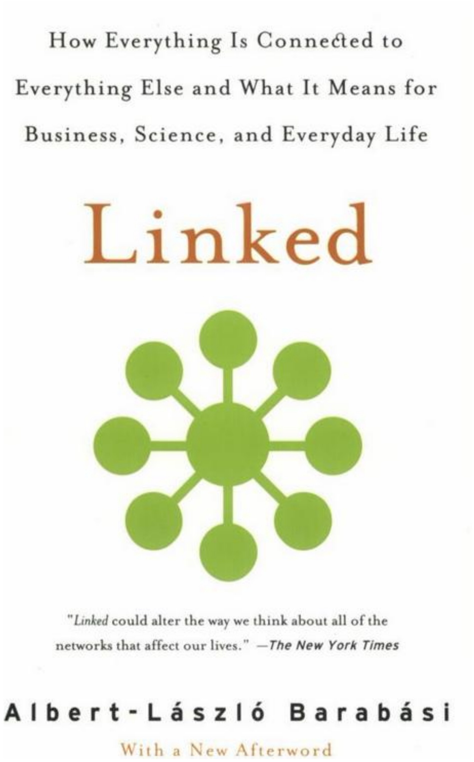
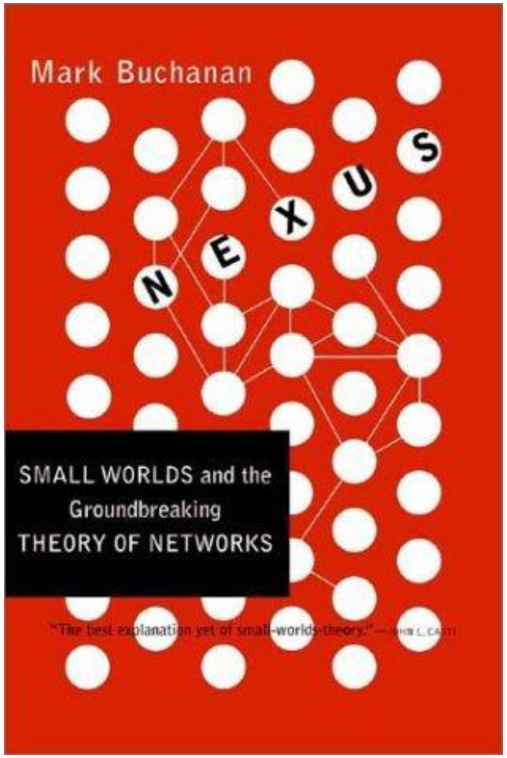
The views expressed in this presentation do not necessarily reflect those of the European Central Bank

Growing interest in networks



2003



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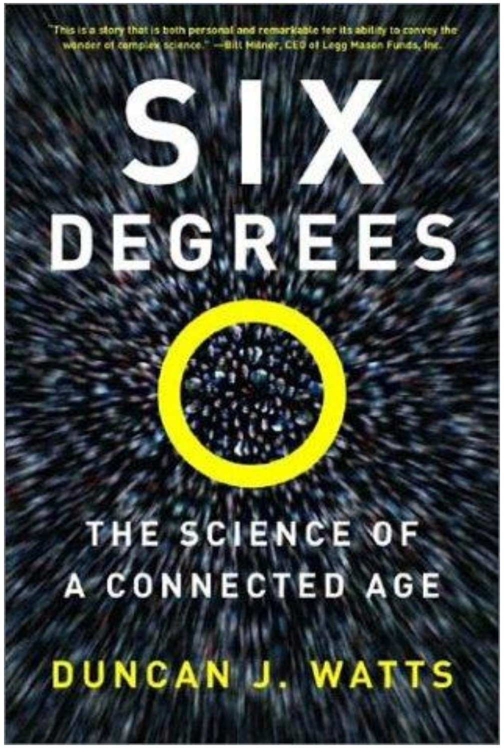
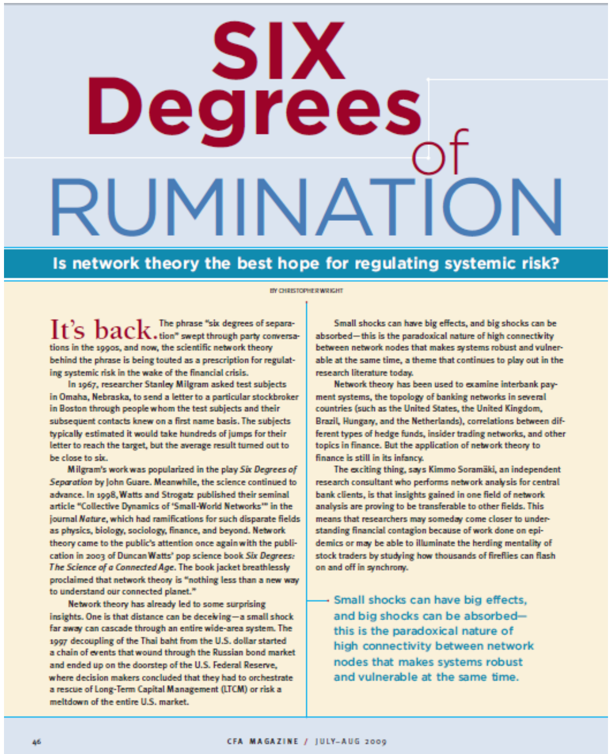
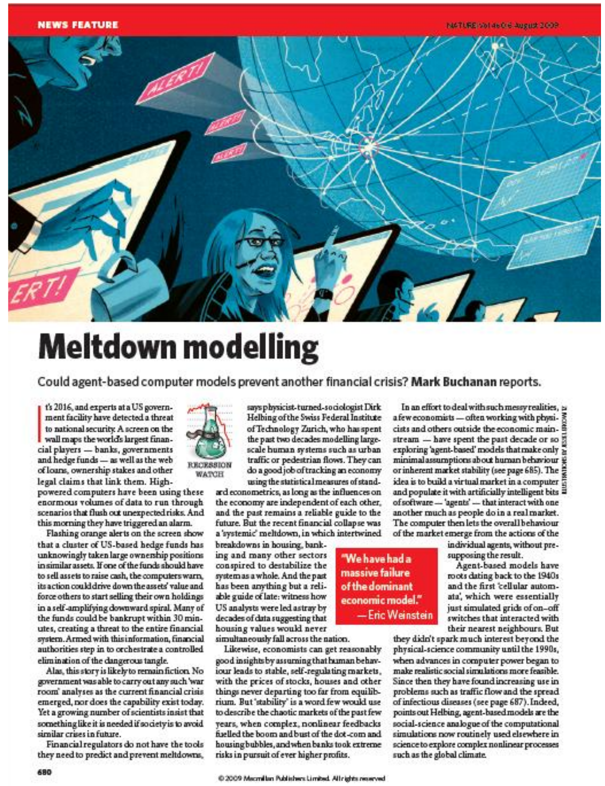


2004





"Is network theory the best hope for regulating systemic risk?"

"Meltdown modeling - Could agent-based computer models prevent another financial crisis?"

"... need for new and fundamental understanding of the structure and dynamics of economic networks."

CFA Magazine, July 2009

Nature, August 2009

Science, July 2009

It was the ultra-interconnectedness of the nation's financial institutions that posed the biggest risk of all [...] every firm was now dependent on the others – and many didn't even know it. If one fell, it could become a series of falling dominoes.

"Too Big to Fail", Andrew Ross Sorkin 2009

... given the fragile condition of the financial markets at the time, the prominent position of Bear Stearns in those markets, and the expected contagion that would result from the immediate failure of Bear Stearns, the best alternative available was to provide temporary emergency financing to Bear Stearns ...

Minutes of the Board of Governors of the Federal Reserve System, 14 March 2008

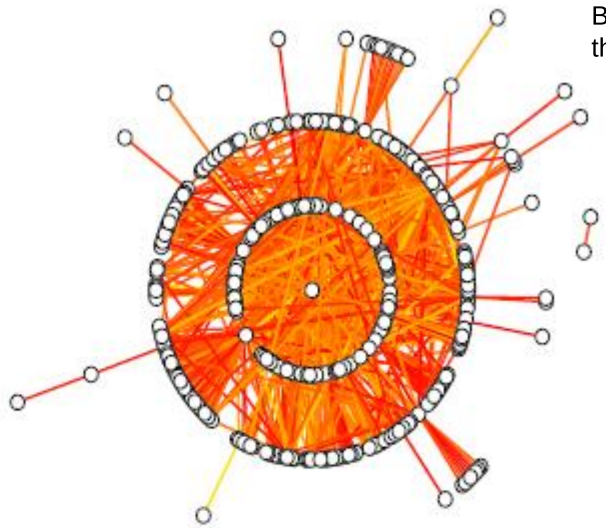
"Too big to fail"

+

"Too interconnected to fail"

Visualizing financial networks

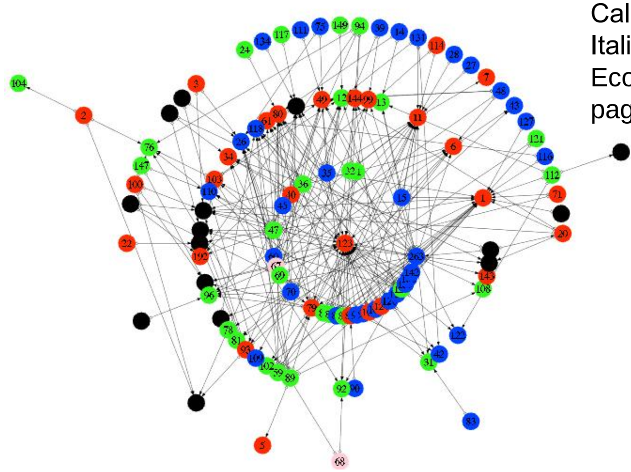
Federal funds



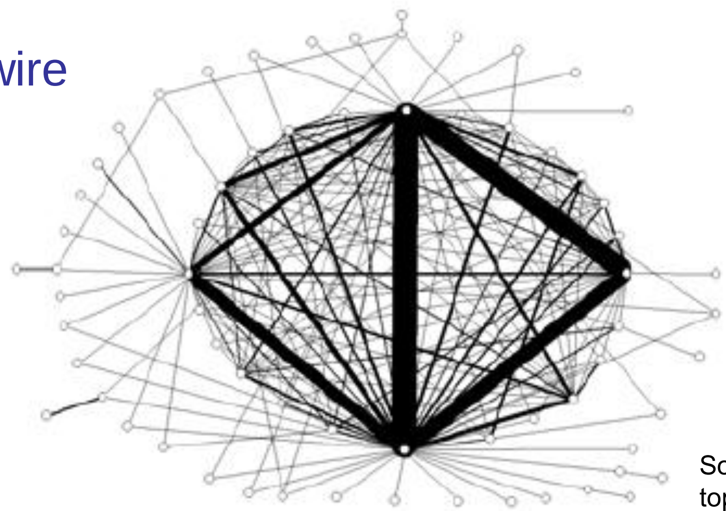
Bech, M.L. and Atalay, E. (2008), "The Topology of the Federal Funds Market". ECB Working Paper No. 986.

Italian money market

Iori G, G de Masi, O Precup, G Gabbi and G Caldarelli (2008): "A network analysis of the Italian overnight money market", Journal of Economic Dynamics and Control, vol. 32(1), pages 259-278

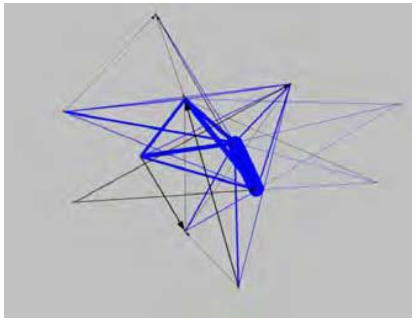


Fedwire



Unsecured sterling money market

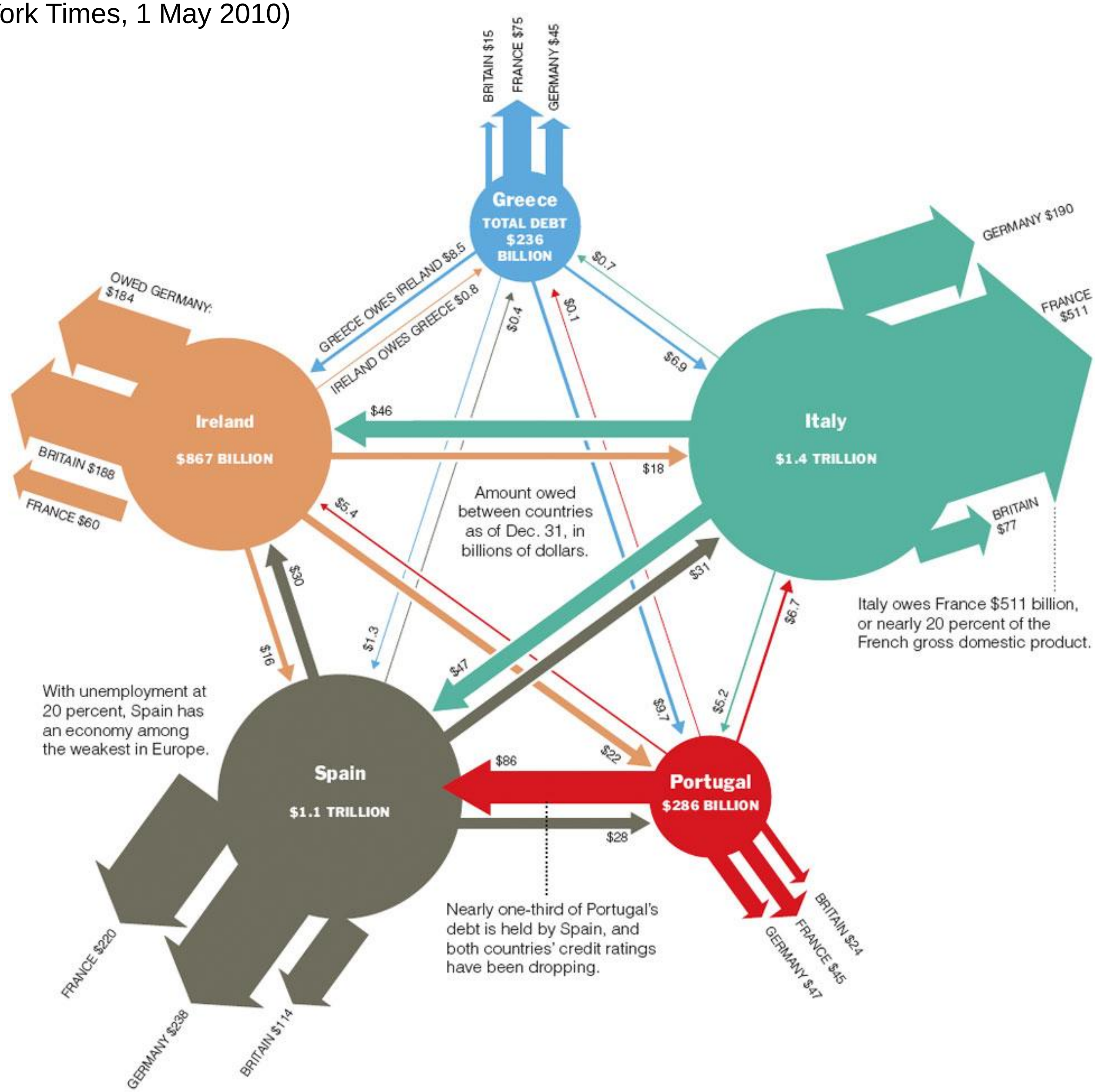
Wetherilt, A. P. Zimmerman, and K. Soramäki (2008), "The sterling unsecured loan market during 2006–2008: insights from network topology", in Leinonen (ed), BoF Scientific monographs, E 42



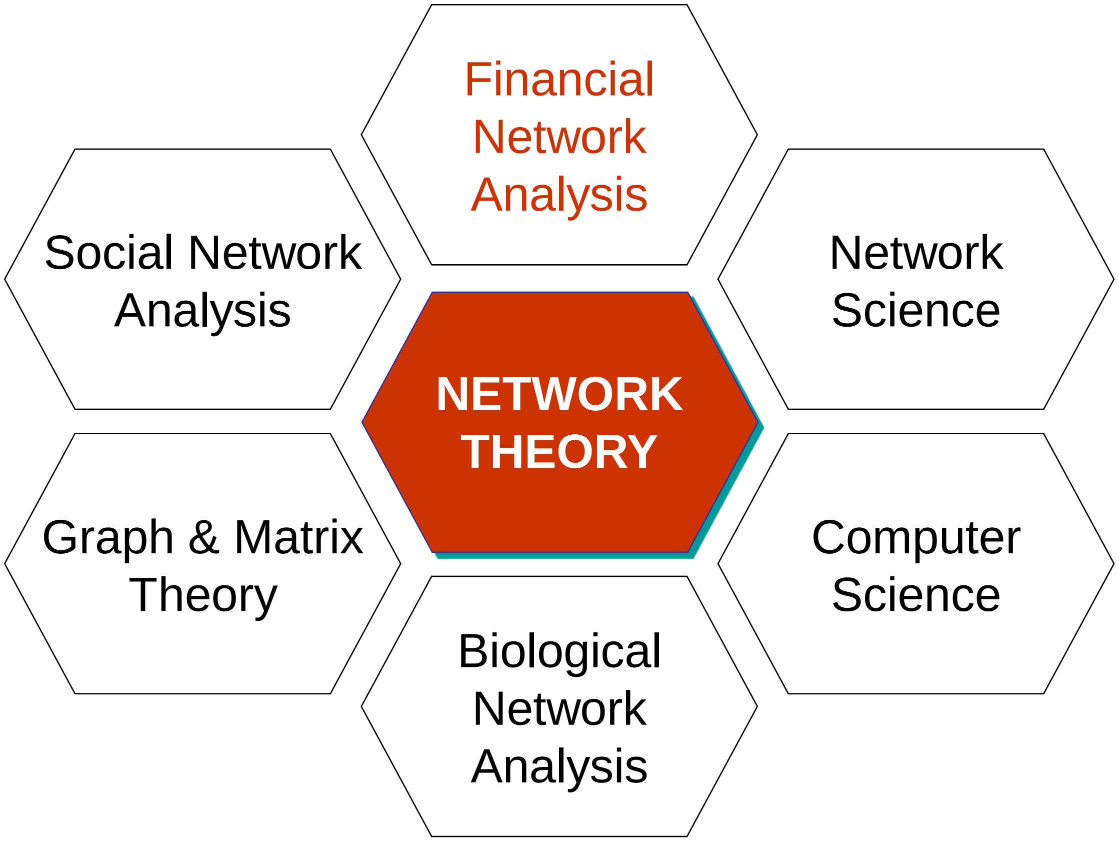
Soramaki, K, M.L. Bech, J. Arnold, R.J. Glass and W.E. Beyeler (2007), "The topology of interbank payment flows", Physica A, Vol. 379, pp 317-333, 2007.

Europe's Web of Debt

(Bill Marsh / The New York Times, 1 May 2010)



Network theory and related fields



Main premise of network analysis:
the structure of the links between nodes matters

The properties and behaviour of a node cannot be analysed on the basis its own properties and behaviour alone.

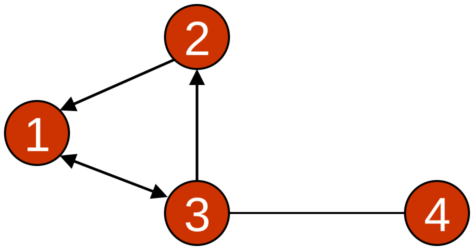
To understand the behaviour of one node, one must analyse the behaviour of nodes that may be several links apart in the network.

Bottom up approach. Generalize and describe.

Financial context: network of interconnected balance sheets

Network basics

- Terminology
  - node/vertex -> Bank/banking group
  - link/tie/edge/arc -> Financial interlinkages, bilateral positions, exposures
  - directed vs undirected
  - weighed vs unweighted
  - graph + properties = network



- Algorithms/measures
  - Centrality -> Systemical importantance
  - Flow -> Liquidity
  - Community/pattern identification
  - Distance, shortest paths
  - Connectivity, clustering
  - Cascades, epidemic spreading -> Contagion

Systemic importance

A risk-adjusted rate could be designed to address the contribution to systemic risk. Ideally, the rate would vary according to the size of the systemic risk externality, e.g. based on a network model which would take into account all possible channels of contagion.

IMF report for the Meeting of G-20 Ministers, April 2010

Centrality in network theory

The relative importance of a vertex within the graph

Depends on network process:

Trajectory: geodesic paths, paths, trails or walks

Transmission: parallel/serial duplication or transfer

Table 1
Typology of flow processes

	Parallel duplication	Serial duplication	Transfer
Geodesics	<No process>	Mitotic reproduction	Package delivery
Paths	Internet name-server	Viral infection	Mooch
Trails	E-mail broadcast	Gossip	Used goods
Walks	Attitude influencing	Emotional support	Money exchange

Centrality measures in network theory

degree: number of links

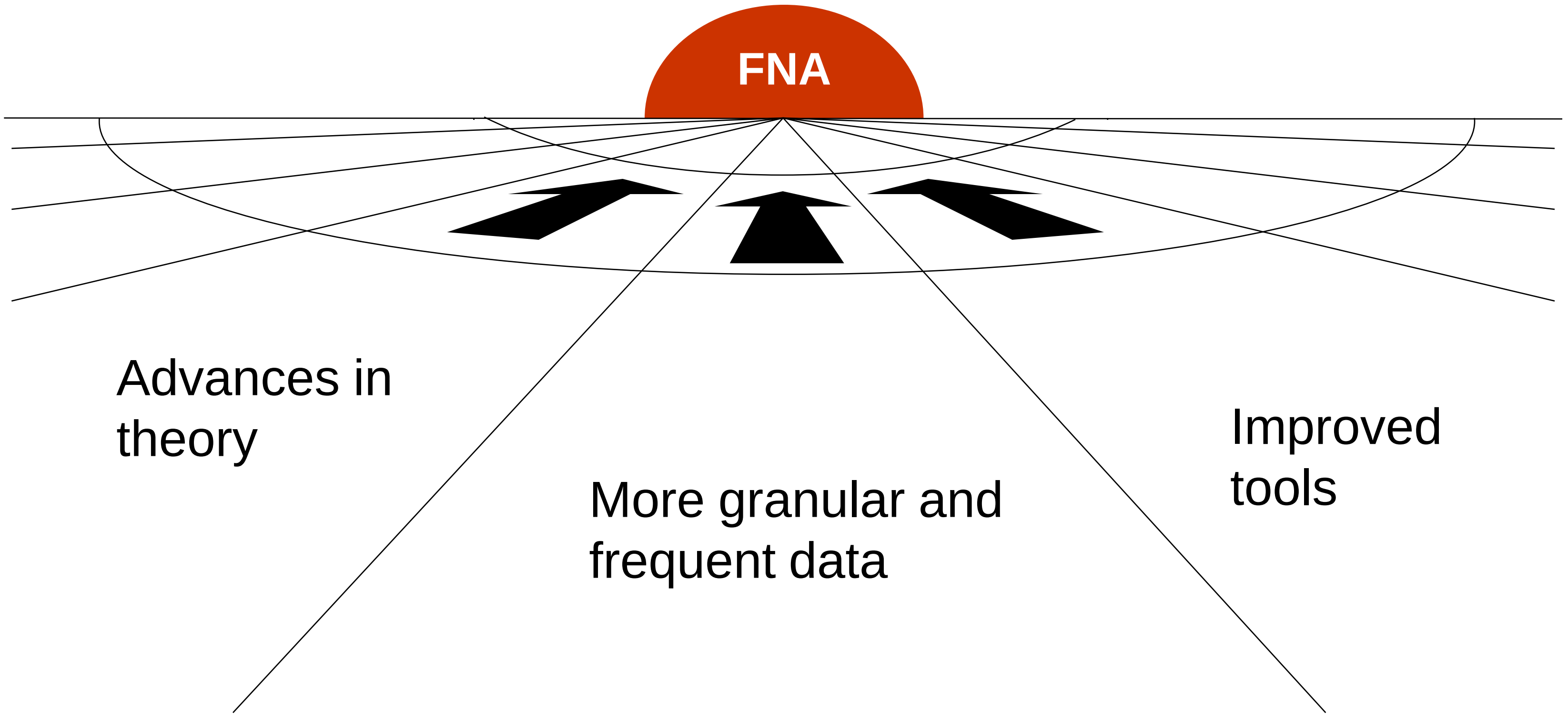
closeness: distance to other nodes via shortest paths

betweenness: number of shortest paths going through the node

eigenvector: nodes that are linked by/to other important nodes are more central (parallel duplication via walks)

markov: probability that a random process is at a node (transfer via walks)

Road ahead


FNA
Advances in theory
More granular and frequent data
Improved tools

Advances in theory

- able to identify the contagion channels in different parts of the financial system
- explain the formation and information content of links between financial institutions and their behaviour under normal and stress situations.
- models of systemic risk could make sense of real economic interactions among market

More granular and frequent data

- a key prerequisite for financial network analysis as a surveillance tool
- more granular and frequent, long enough time series for a statistical analysis of different market conditions
- regulators and overseers should continue to develop ways to systematically collect, share and analyse the data from both market sources and financial infrastructures.

Improved tools

- Tools for network analysis/data mining have developed substantially over the last few years.
- Ongoing work: “Financial Network Analyzer” (www.financialnetworkanalysis.com/fna)

Thank you

More information:

June Risk Magazine article

June ECB Financial Stability Review

My blog: www.financialnetworkanalysis.com

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