

Cambridge Judge Business School

Centre for Risk Studies 7th Risk Summit Research Showcase

Financial Risk and Network Analysis

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20 June 2016
Cambridge, UK

Centre for
Risk Studies



UNIVERSITY OF
CAMBRIDGE
Judge Business School

Agenda

- Contagion and systemic risk
- Network models to analyse financial stability
- CRS work on Cambridge Banking Model
 - Distress propagation
 - Network reconstruction
 - Stress test scenarios
- Future Work
 - Multi-layer networks

Financial Crisis

ECONOMY

TRENDING

[Brexit](#) | [Junk Science Week](#) | [Apple WWDC](#) | [FP500](#) | [Oil](#) | [Loonie](#) | [Housing](#) | [Valeant](#)

There will be another financial crisis. The only question is when?



BEN WRIGHT, VIEWPOINT, THE TELEGRAPH | February 18, 2016 12:45 PM ET
[More from The Telegraph](#)



Another major quake in the global financial system is imminent, according to the former governor of the Bank of England Sir Mervyn King



Financial crises tend to occur every two to three years on average — and the last one ended more than three years ago. Associated Press

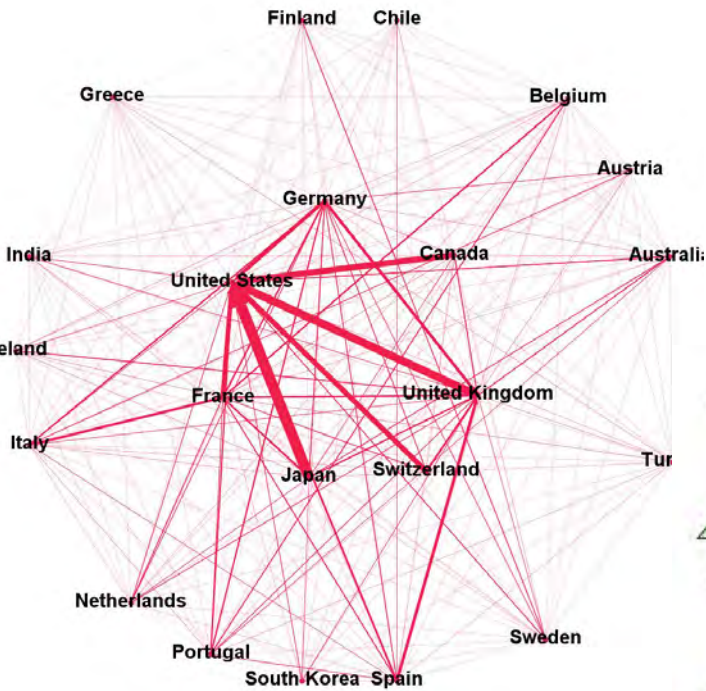
We Need a Better Understanding of Contagion

- The 2007 financial crisis has shown that economists have been behind the curve in regard to **mapping, modelling** and **monitoring** the highly **interconnected** and global financial system
- The failure of financial institutions has led to fears of system failure from **domino effects** of one failed entity bringing down others. This has given rise to concepts such as financial contagion and ***“too interconnected to fail”***.

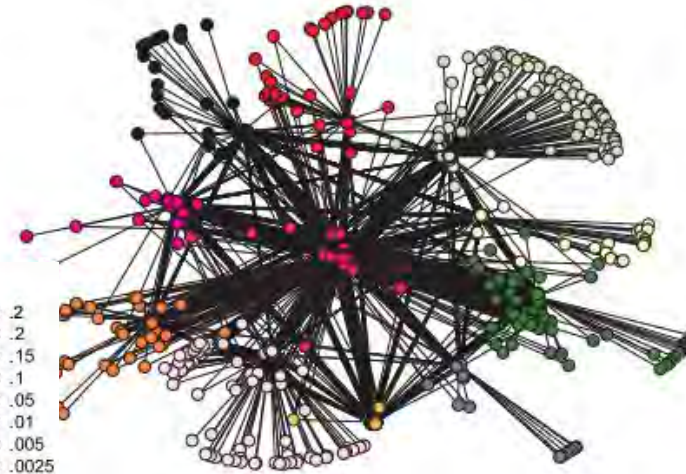
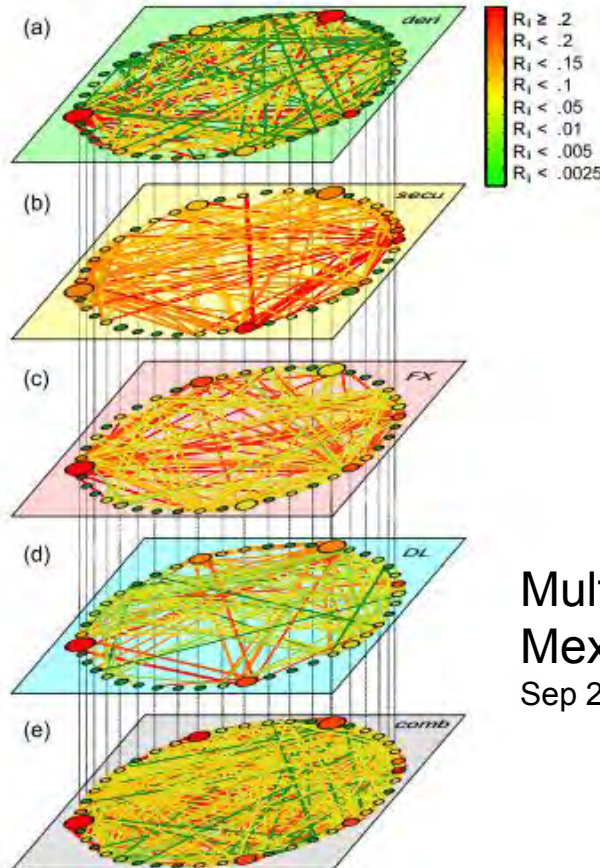
Systemic Risk and Interconnectedness

- **Systemic Risk** : Risk associated with the failure of the entire financial system
- **Channels of Contagion**
 - Interbank lending, Security settlement, FX settlement, Derivative exposures, Equity cross-holdings, Asset prices
 - **Interaction** between these contagion mechanisms is more important than a single mechanism on its own
- **Why does interconnectedness matter for financial stability?**
 - Structure of links between nodes matters
- Two methodological problems of financial contagion and systemic risk:
 - **Paradox of Volatility** and the pitfalls of market price data based systemic risk measures hence **structural bilateral data based networks modeling needed**
 - non-trivial **Negative Externalities problem** → the need for holistic visualization

Mapping the Financial Network



Cross Border Exposure
2014, BIS data, CRS Research

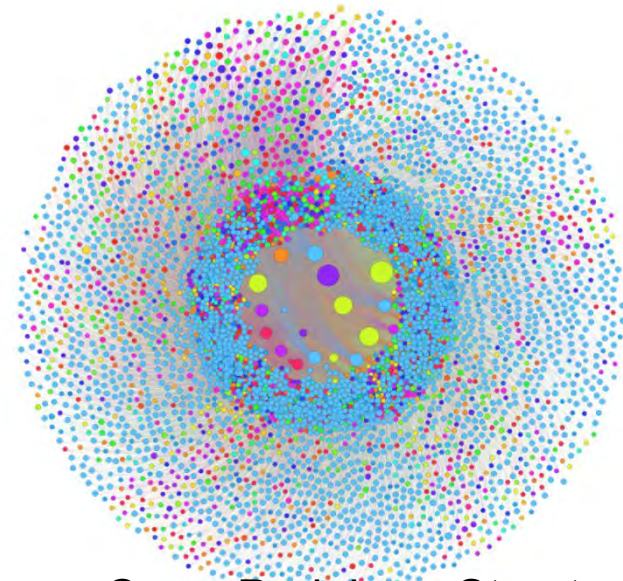


Austrian Interbank Market
Boss et.al 2003

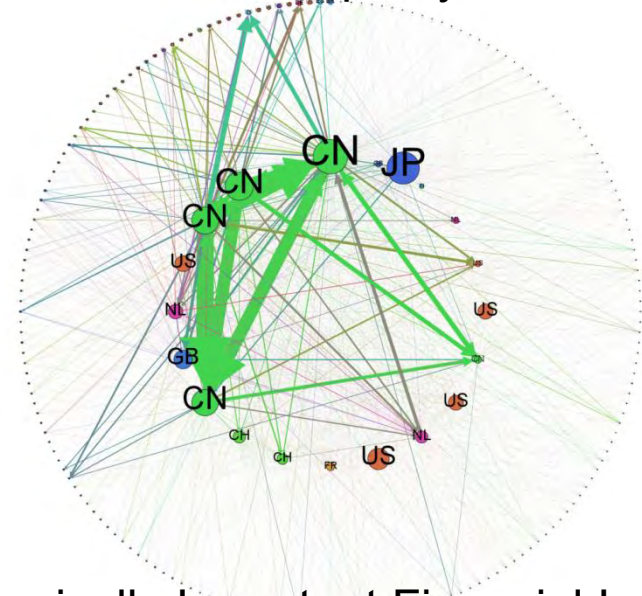
Multi-layer Structure of
Mexican Banking Network
Sep 2013 Poledna et.al 2015

Cambridge Global Interbank Network Model

- Balance sheet data on Financial Institutions
 - Iteration 1: 18,516 Banks
Total market value of \$214 Trillion
Total equity value of \$17.4 Trillion
 - Iteration 2: 5134 Banks
 - Bank Scope global bank balance sheet data
 - Bank of International Settlement Cross-border exposure data
- Network reconstruction → bilateral exposures; interbank lending



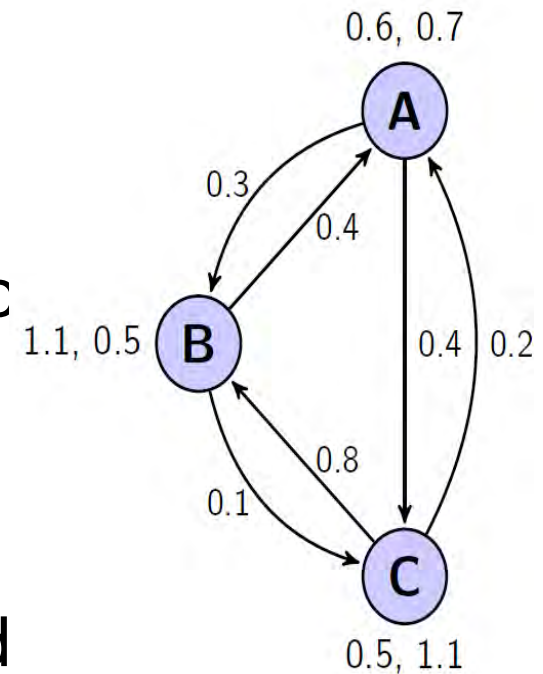
Core- Periphery Structure



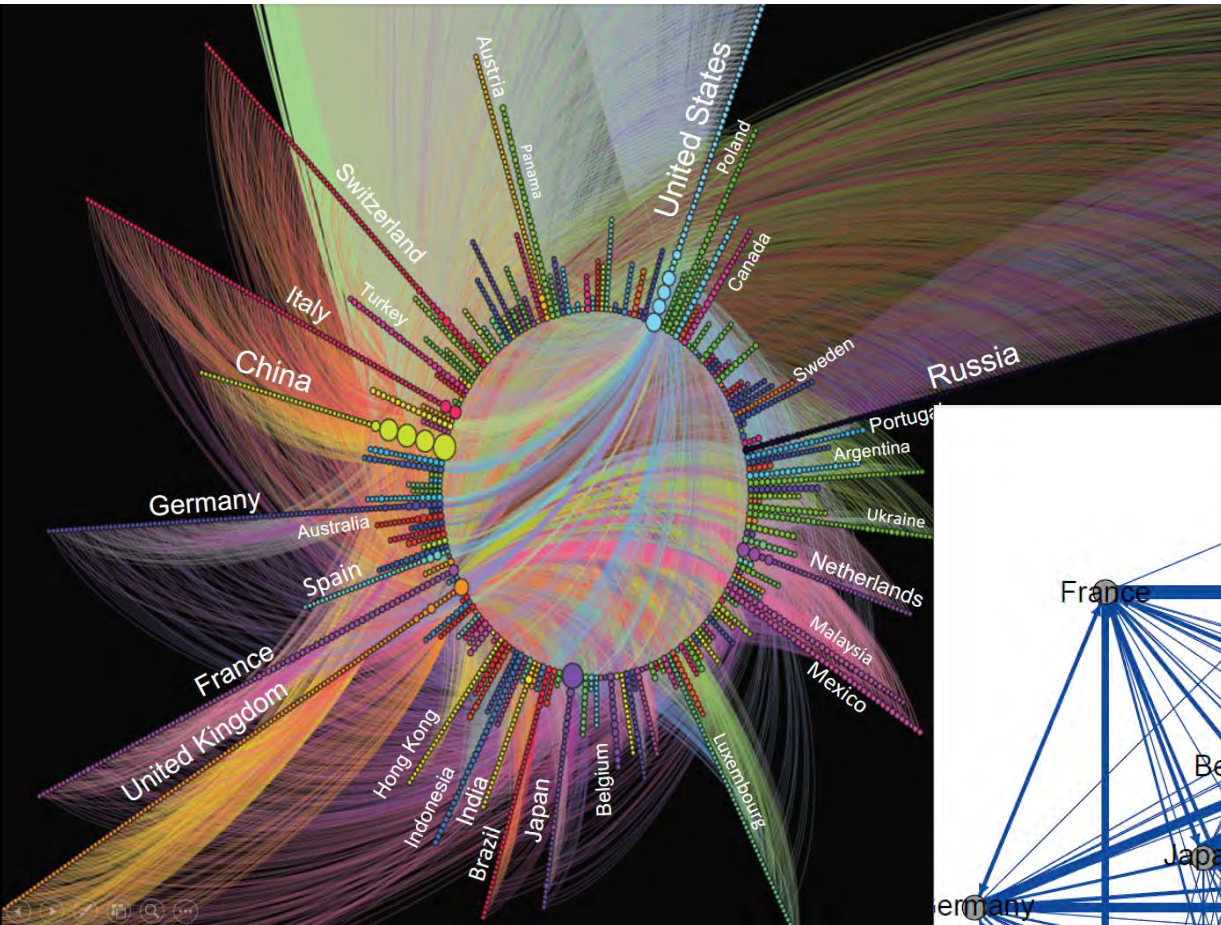
Systemically Important Financial Institutions 7

Network Reconstruction

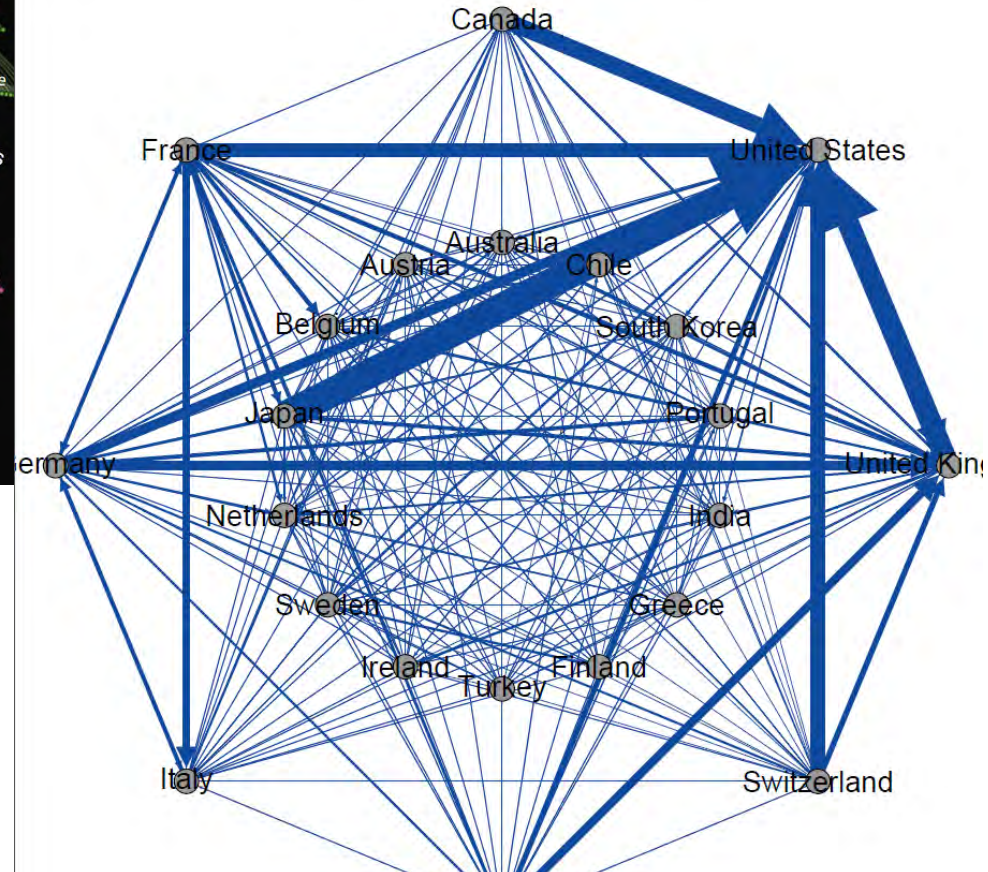
- The related bilateral exposure information is not always collected or disclosed.
- Need of a method to reconstruct (estimate) the bilateral exposure network via the incomplete information from Financial Institutions balance sheet data on liabilities and assets
- Using computational algorithms to satisfy balance sheet constraints and create **sparse core-periphery** structures



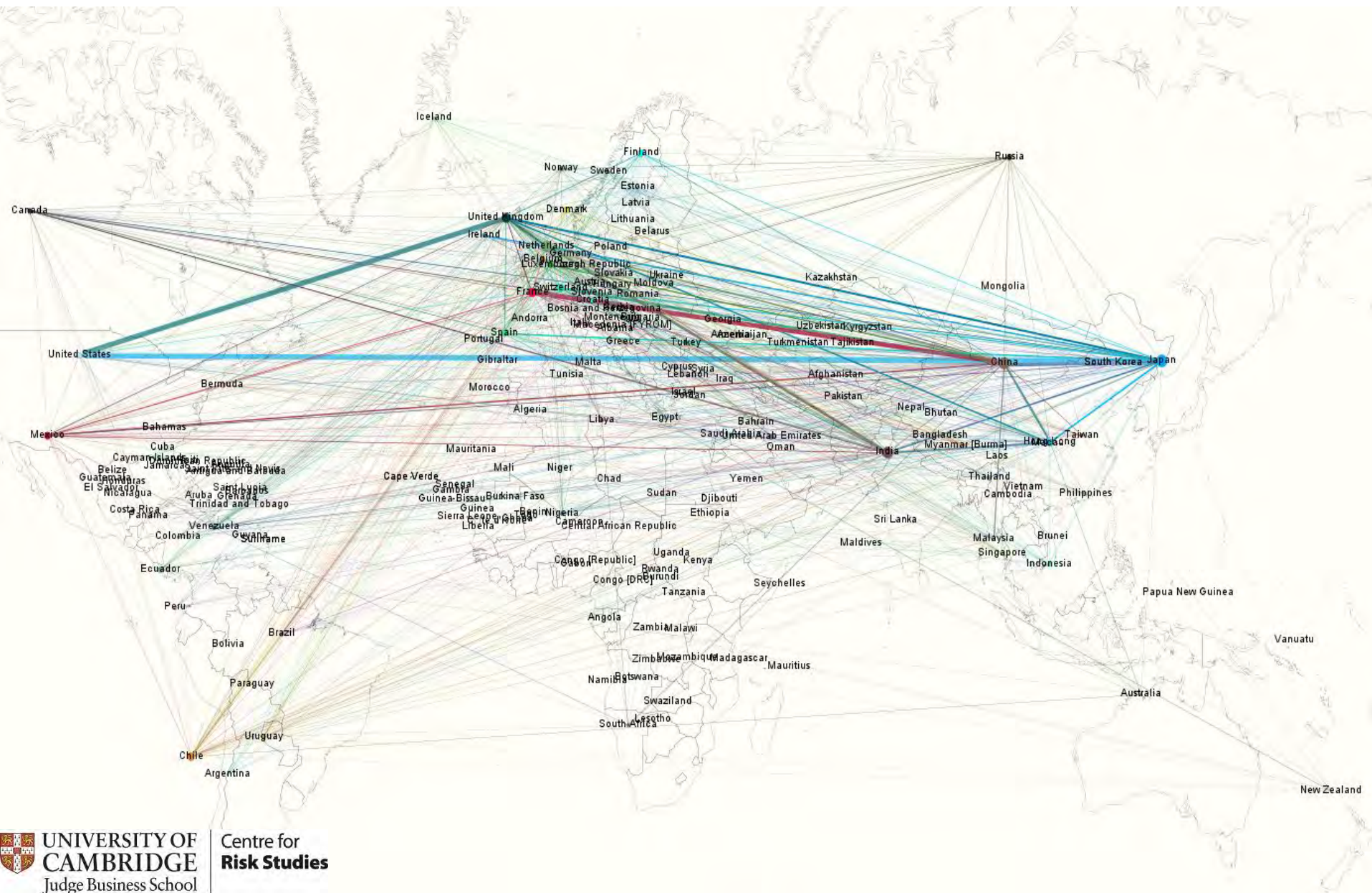
Cross-Border Exposures



Bank level data combined with aggregate country level cross border exposure data



Centre for Risk Studies Network Model of Financial System



Distress Propagation

■ Asset Losses

- negative shock on the value of assets causes losses in banks, which is absorbed by equity.

■ Inter-Bank Losses

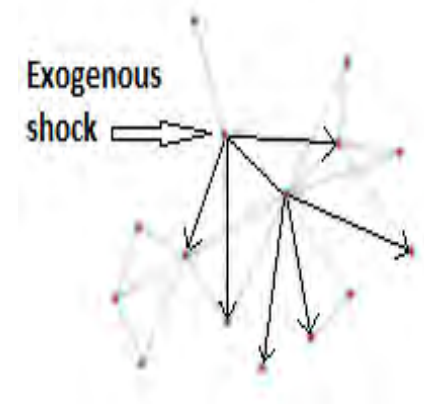
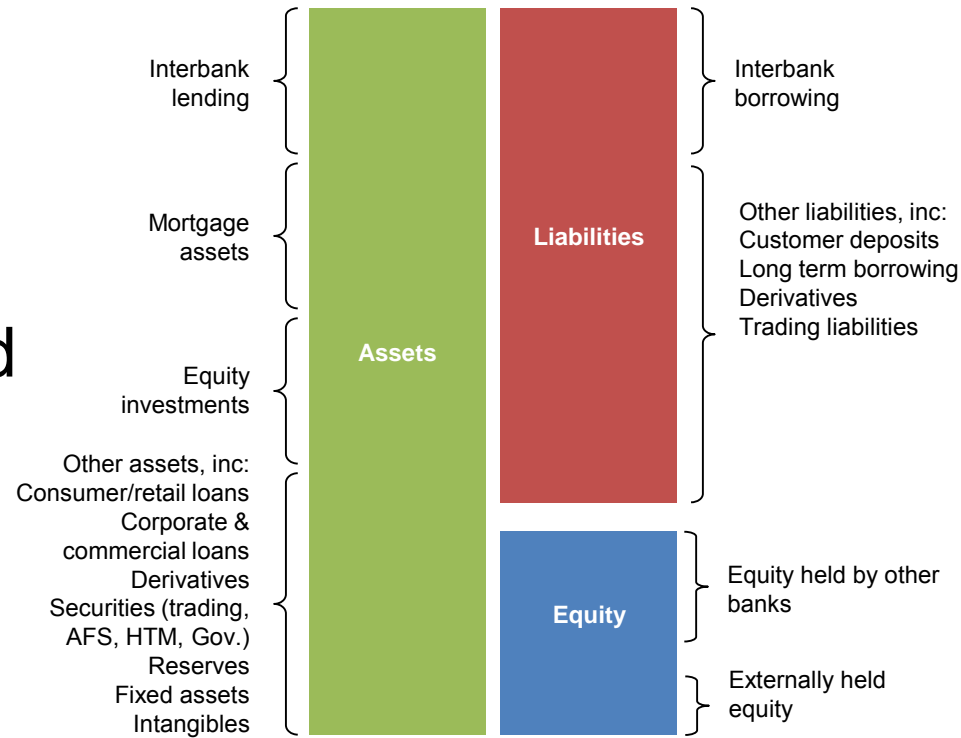
- distress from asset losses puts inter bank obligations under pressure. Those losses are again absorbed by equity.

■ Fire Sale

- banks need to adjust their leverage to meet regulatory requirements by selling assets. The price impact leads to further pressure on asset prices. This closes the virtuous circle.

Contagion Model Description

- Interbank system as a directed network whose nodes are banks
- Every node is characterised by an internal structure given by its balance sheet
- **Contagion Dynamics:** the effect of a bank being under distress is almost immediately incorporated into the value of the interbank assets held by a directly connected creditor bank



Network Stability

- Understanding the vulnerability of the system to failure
- Quantify the stability of a network system
- Distinguish between stable and not stable systems

There are few ways in which stability of the financial network can be achieved:

1. Constrain the bilateral exposure of financial intermediaries.
2. Change the topology of the network
3. Levy a capital surcharge commensurate to the centrality of a financial institution

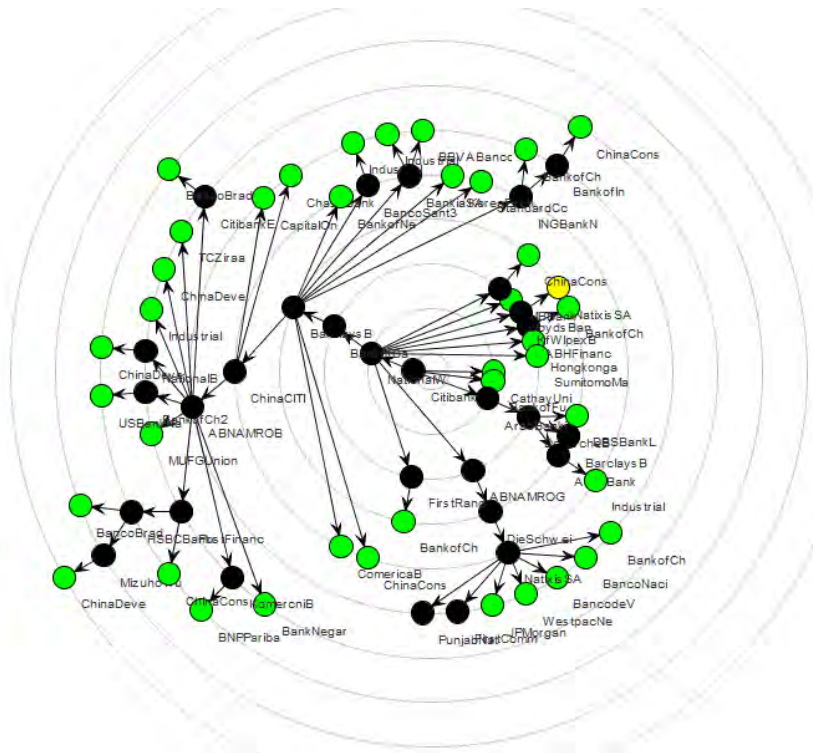
Network topologies emerge endogenously and are hard to manipulate exogenously.

Cascading Failures

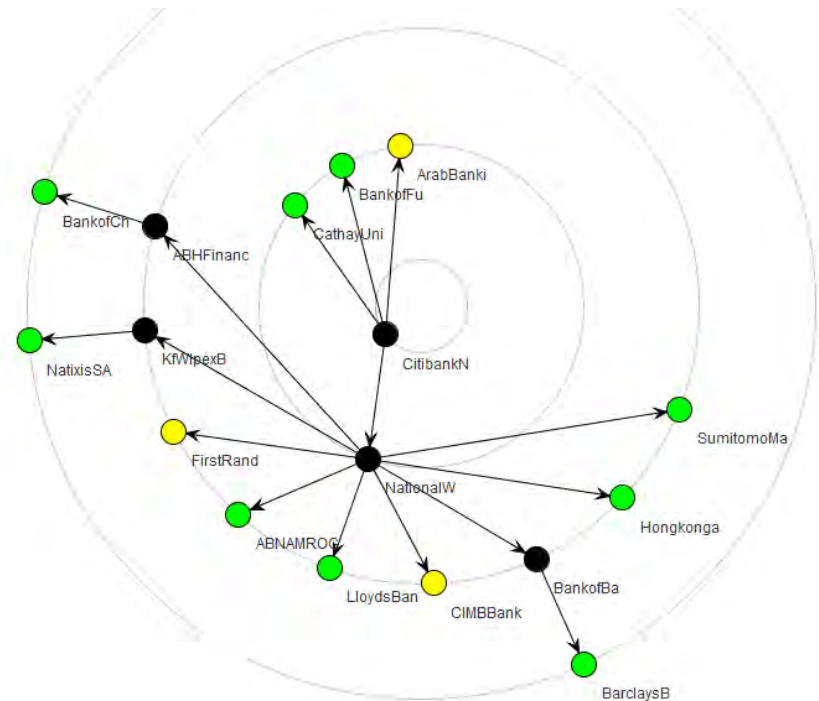
Reconstructed global interbank-net Q4 2014

1 trigger bank defaults

Black nodes are defaulted banks green and yellow banks are in distress



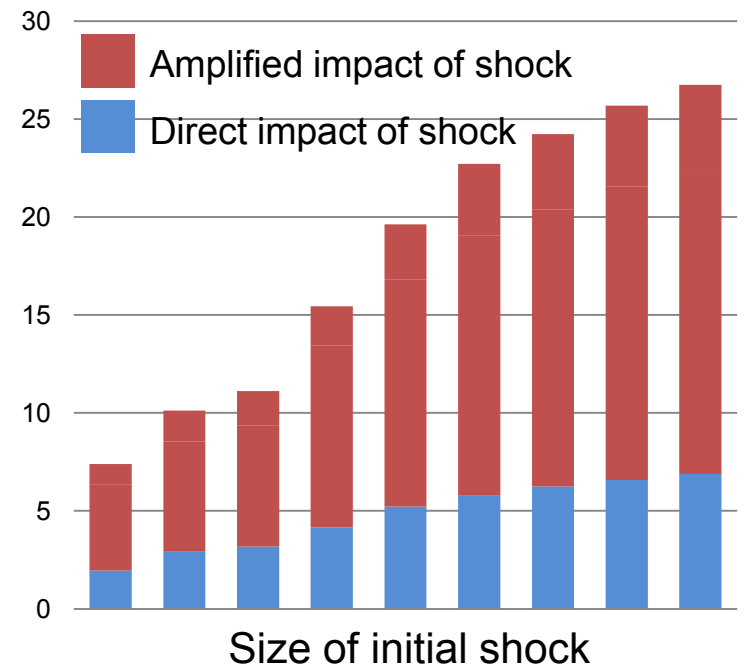
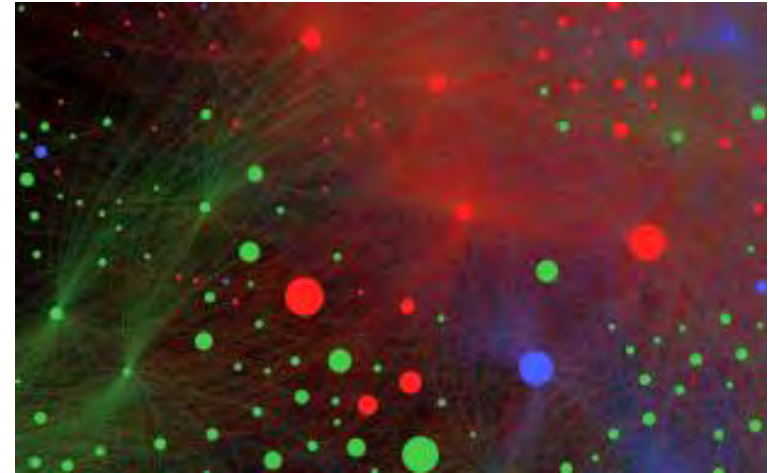
Network with original capital buffer



Increased capital buffer

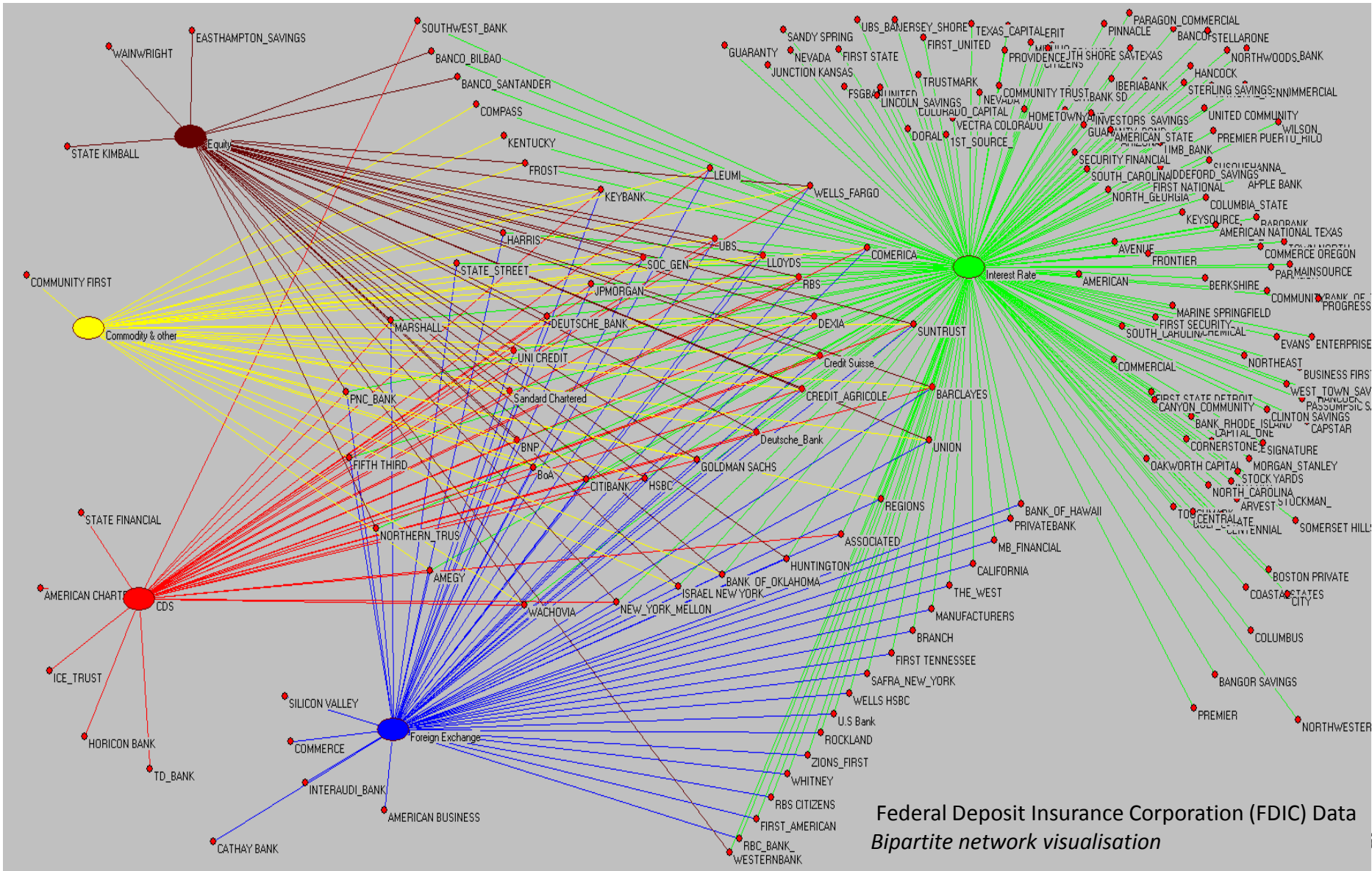
Understanding Contagion and Systemic Shock

- The financial system is increasingly interconnected and integral to the economic system
 - Understanding the structure of the financial system and all its connections is vital
 - ‘Financial Cartography’
- Financial instability spreads through a variety of mechanisms
- Contagion amplifies:
 - severity of the shock impact
 - extent of who is affected
- It is behavioural
 - issues of trust, perception, and self-interest drive the collapse
 - Can we model ‘confidence’?
- This is a key research field
 - Working with the community of researchers on networks in finance



Landscape of US Financial Derivatives Market (2009,Q4

202 participants): Green(Interest Rate), Blue (Forex), Maroon (Equity); Red (CDS); Yellow (Commodity); Circle in centre Broker Dealers in *all* markets

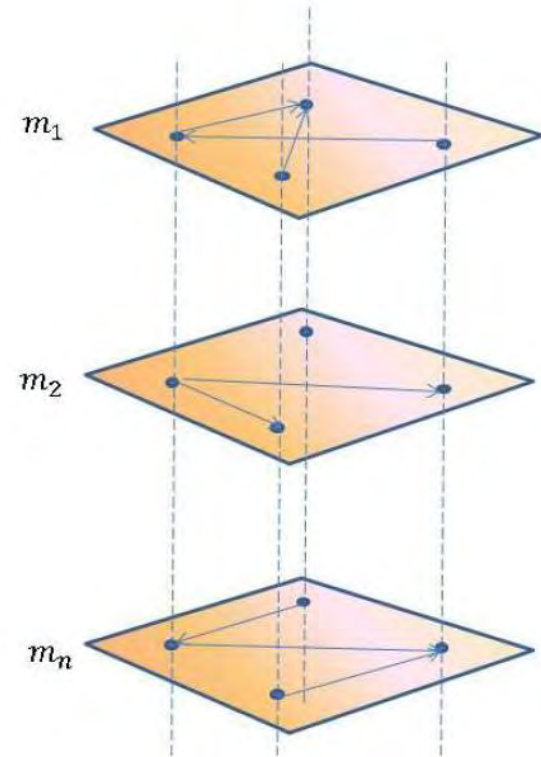


Implementation of reforms in priority areas by FSB jurisdictions

Reform Area	Basel III				Compen- sation	Over-the-counter (OTC) derivatives				Resolution#			Shadow banking	
	Risk-based capital	Liquidity coverage ratio (LCR)	Higher loss absorbency for G-SIBs (home jurisdictions)	Requirements for domestic systemically important banks (D-SIBs)		Trade reporting	Central clearing	Platform trading	Margin	Availability of transfer / bail-in / temporary stay powers for banks	Recovery planning for systemic banks	Resolution planning for systemic banks	Money market funds (MMFs)	Securitisation
	2013 (2019)	2015 (2019)	2016 (2019)	2016		end-2012	end-2012	end-2012	Sep 2016 (2019)					
<i>Agreed phase-in (completed) date</i>														
Argentina	Δ				Δ							**	**	
Australia	C											*	*	
Brazil	C			&	Δ								**	
Canada	C					D, F						**		
China	C	Δ			Δ	R, D, F				Δ		**		
France	MNC	Δ										**	*	
Germany	MNC	Δ										**	*	
Hong Kong	C	C										**		
India	C	LC			Δ	D, F								
Indonesia	Δ					R						**		
Italy	MNC	Δ									Δ		*	
Japan	C					D								
Mexico	C	C				D						**	*	
Netherlands	MNC	Δ										**	*	
Rep. of Korea						D						**		
Russia	Δ				Δ							**	**	
Saudi Arabia	C	LC				R, D						*		
Singapore	C	Δ										**		
South Africa	C	C			Δ	D, F						**		
Spain	MNC	Δ											*	
Switzerland	C				Δ					Δ	Δ	**		
Turkey		Δ				D, F						**		
United Kingdom	MNC	Δ										**	*	
United States	LC	Δ			Δ	D								

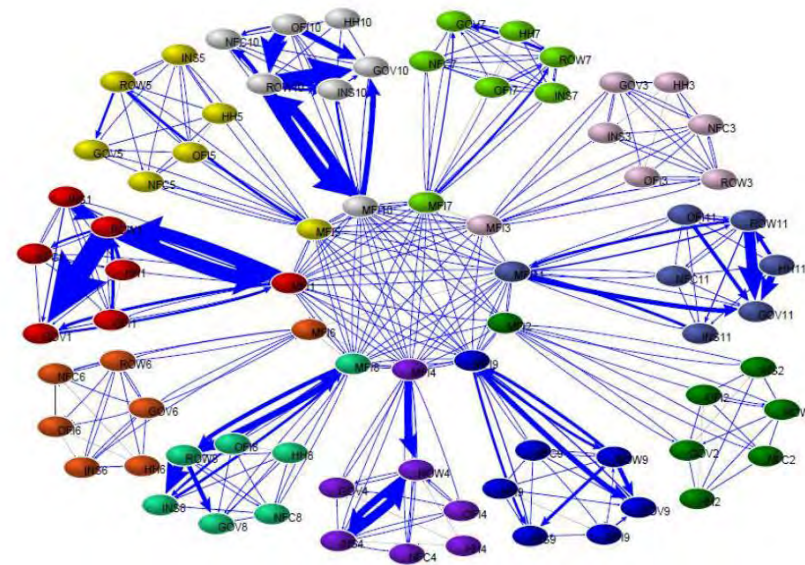
Multi-Layer Networks

- In reality banks are interrelated in several **dimensions** of their business activities.
 - The basic notion is that unless contagion risk across the **many layers of interrelations** between banks are taken into account, it is likely that contagion effects will be substantially underestimated.
- The complexity of the financial system and the existence of **multiple channels of contagion** naturally leads to the concept of multilayered networks (also referred to as multiplex networks).
- Such representations enable researchers and practitioners to carefully map the various **direct and indirect** channels of contagion in a system.
- We also believe that a multilayer network methodology could enable more precise **representation** of the financial obligations and exposure networks.



Future Work

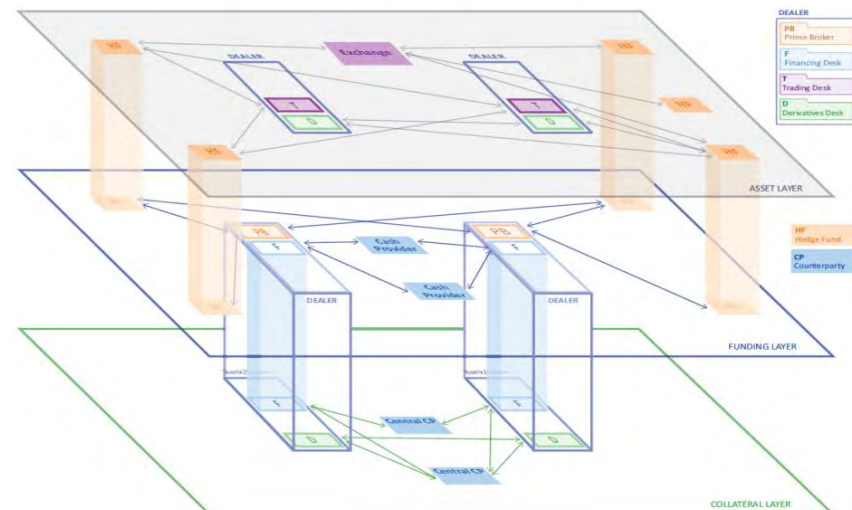
- The complex nature of the financial system requires further methodological research
 - Extend the current banking model to include other dynamics of the financial system; **regulation and policy implications, central banks Macprudential policy**
- Characterizing the financial system as a **multilayer** interdependent network can provide new insights into the underlying structure of the financial system, its vulnerabilities, and its resilience.
 - Eg. Corporate Bond Market, CDS Market, Interbank lending



Macro network of eleven euro area countries.
Olli Castrén and Michela Rancan 2013

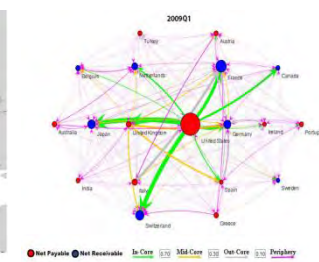
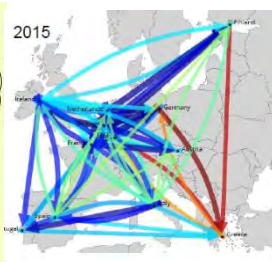
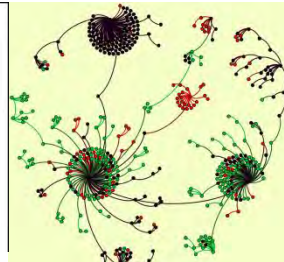
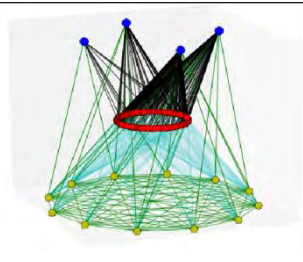
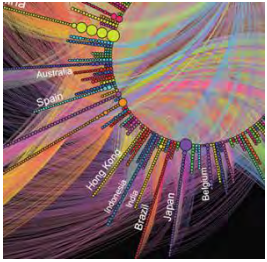


- Collaboration with **OFR** (Office of Financial Research)
 - The Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 established the OFR
 - Building a Multi-layer network model



Multi-layer characteristics of financial systems, OFR Research

The CRS Financial Risk and Network Seminar



- 2015 seminar In collaboration with **Journal of Network Theory in Finance**
- Many papers from key players in the field presenting cutting-edge research
- Attendees included
 - Regulators
 - Financial practitioners
 - Academics
- **Network Visualisation** Competition
- Keynotes included central banks presenting their techniques for assessing systemic risk and capital requirements in their market
- Next Seminar
- **14th of September, 2016**
- Venue: University of Cambridge, UK



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