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Risk sharing or contagion in the build up to the crisis?

Evidence from the international interbank market 1985-2009

Oxford-Man Institute Quantitative Finance Seminar

May 14th 2012

http://www.econ.ucsb.edu/~garratt/faculty/contagious_capacity.pdf

Rodney J Garratt, Lavan Mahadeva and Katsiaryna Svirydzenka

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Overview

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- **Motivation:** Understand spread of contagion and role of interconnectedness
- **Focus:** International interbank network and Cross-sectional systemic vulnerability
- **Key question:** Was the network prior to the crisis contagious?

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Clarification of concepts

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- Trigger, vulnerability, aftermath (Distinction made by Bernanke, 2010)

Cross-sectional systemic vulnerability

- System is vulnerable if it can generate a costly aftermath from a small trigger, not because the financial sector in aggregate (after netting out) is open to default but because of the pattern of interlinkages between members of that sector
- Aftermath is systemic if it impacts taxpayers
- Paper: tracking cross-sectional systemic vulnerability in the interbank market, country level

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- Our focus is on the international banking network
- A set of bilateral claims (links) of different banking groups (nodes) on each other
- A banking group includes all the banks operating in a particular country
- Our aim is to summarize and compare the network pattern-highlighting risk of contagion
- Compare against a calibrated model of contagion
- Two interacting channels of contagion
  1. Banks defaulting on loans transmit stress to their creditors via a credit channel.
  2. Banks refusing to make loans transmit stress via a funding channel.

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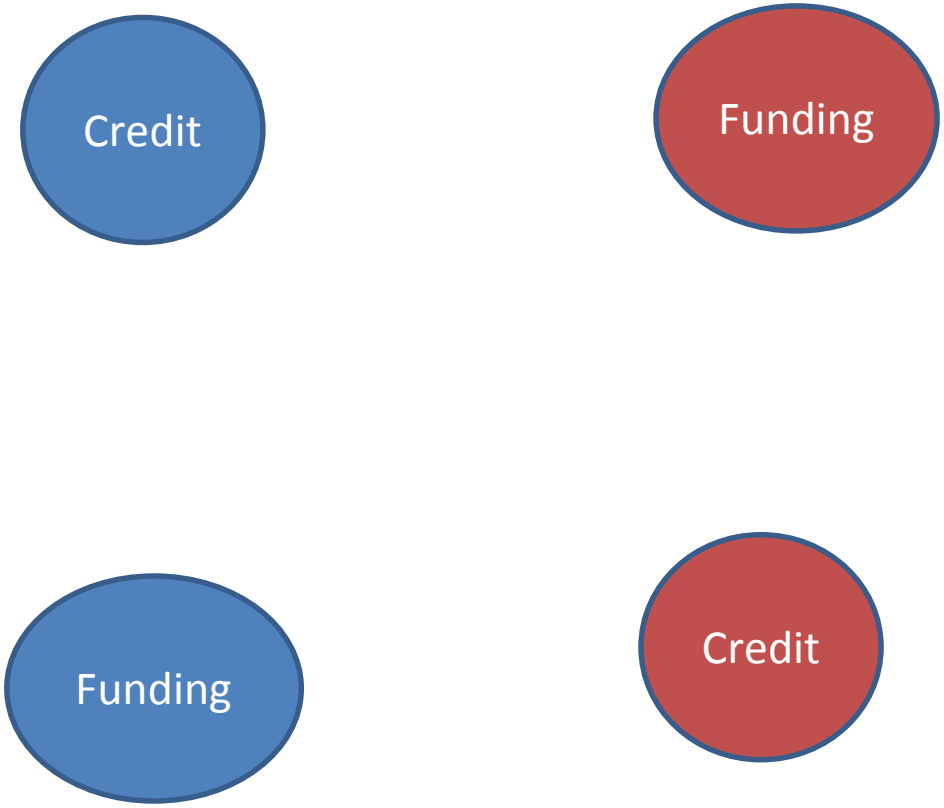
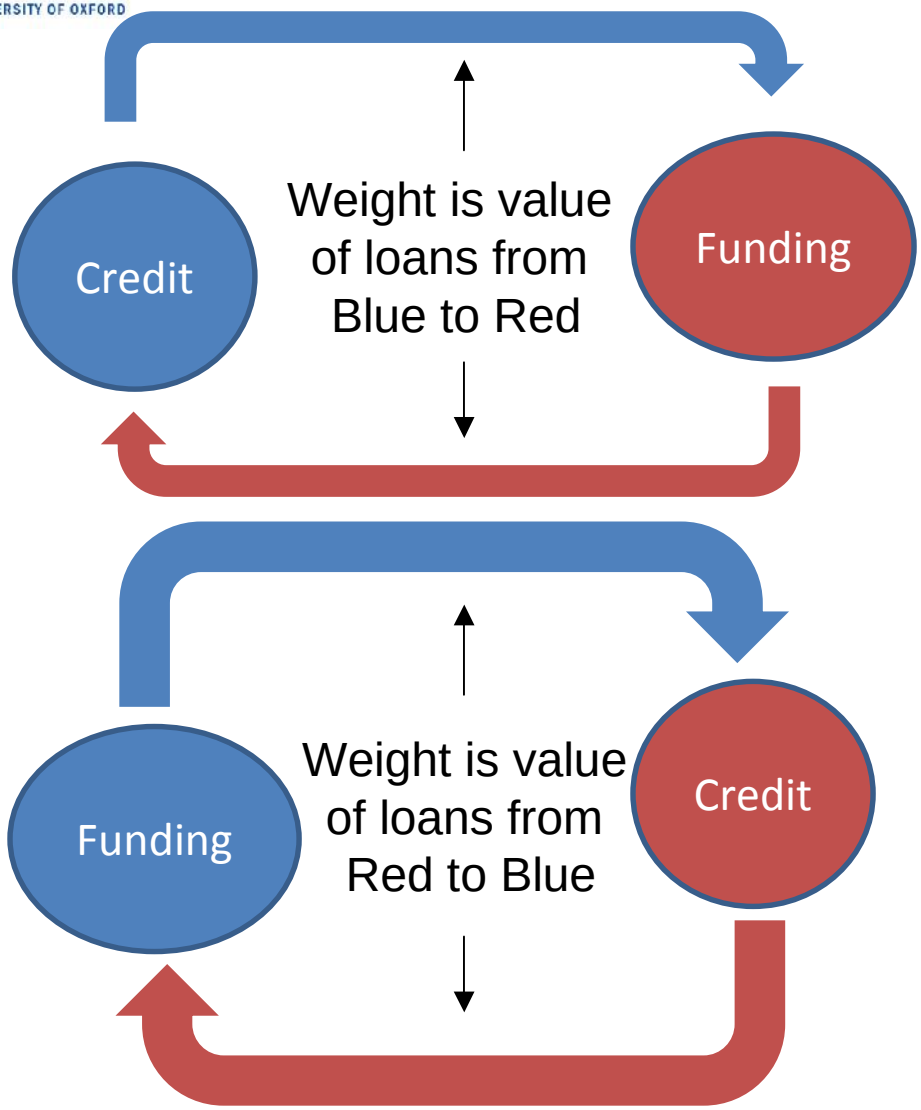
Specification of the Network: Banking Groups

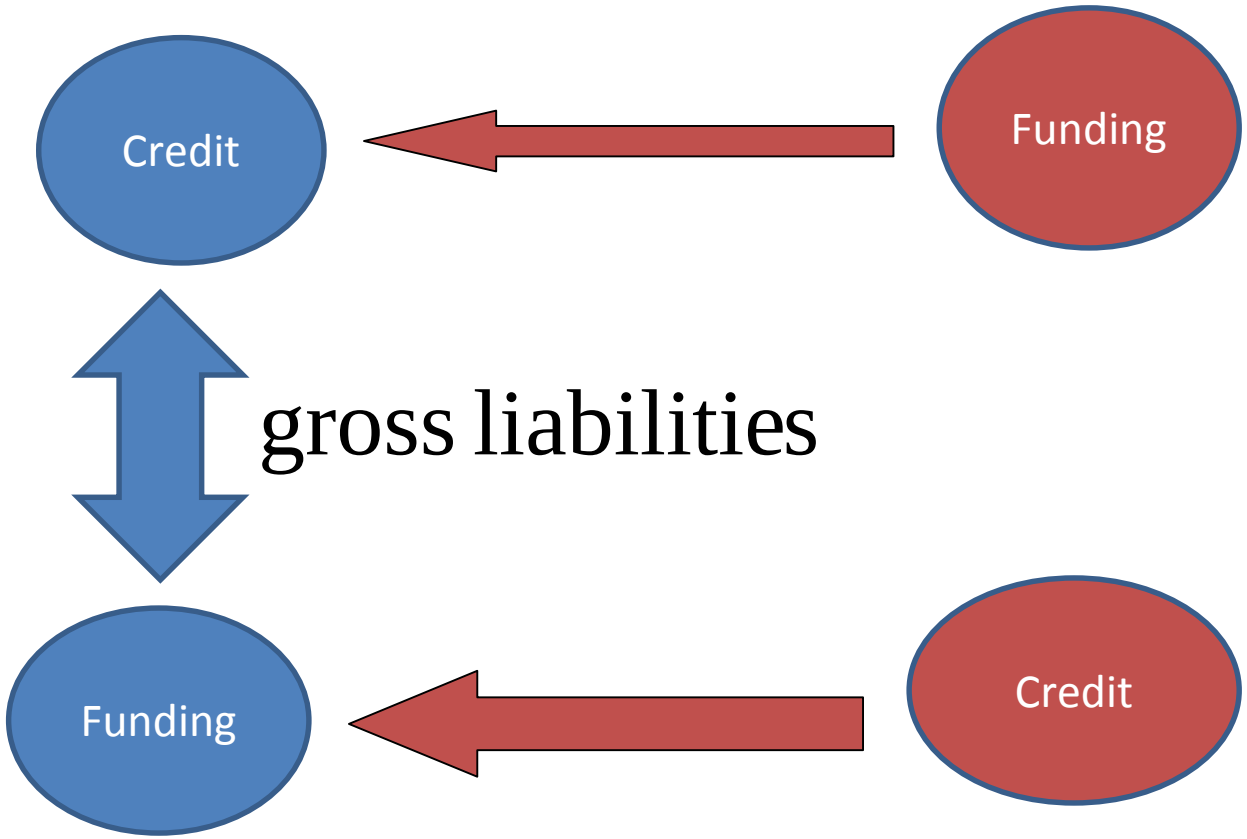
Bring in funding and credit by splitting nodes



Define Relationships: Symmetry



Allow for absorption



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Data

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- Bank for International Settlements locational statistics.
- We included the following 21 reporting countries in our network: Austria, Australia, Belgium, Canada, Cayman Islands, Switzerland, Germany, Greece, Denmark (excluding Faeroe Islands and Greenland), Spain, Finland, France (including Monaco), United Kingdom (excluding Guernsey, Isle of Man and Jersey), Ireland, Italy, Japan, Luxembourg, Netherlands, Portugal, Sweden, and the United States.
- Includes many short-term claims between banks
- These countries representing about 73% of total reported claims on banks.
- 1985 Q1 to 2009 Q3

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Matrix of Contagion Frequency

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$$V = (v_{\sim_{J\ K}})_{\sim_{J\ K}}$$

where $\sim$, $\in \{1,\ldots,n\}$, $J,K \in \{C,F\}$.

- 2n x 2n matrix
- Premise is that stress is transmitted through the financial network in a manner that is proportional to these capacities.

Probability Transition Matrix

$$\Pi = (matrix\_of\_normalized\_link\_weights)$$

now describes conditional movement:

$$p_t = \Pi p_{t-1}$$

where $p_t = [p_{1t}, \ldots, p_{2nt}]'$
is the probability of stress being at each bank in round t

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Long run

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$$p_{lr} = \Pi p_{lr}$$

where $p_{lr} = [p_{1lr}, \ldots, p_{2nlr}]'$.

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Video: see the FNA package (http://fna.fi/)

Pie chart

Network

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Raw data 1989 Q3

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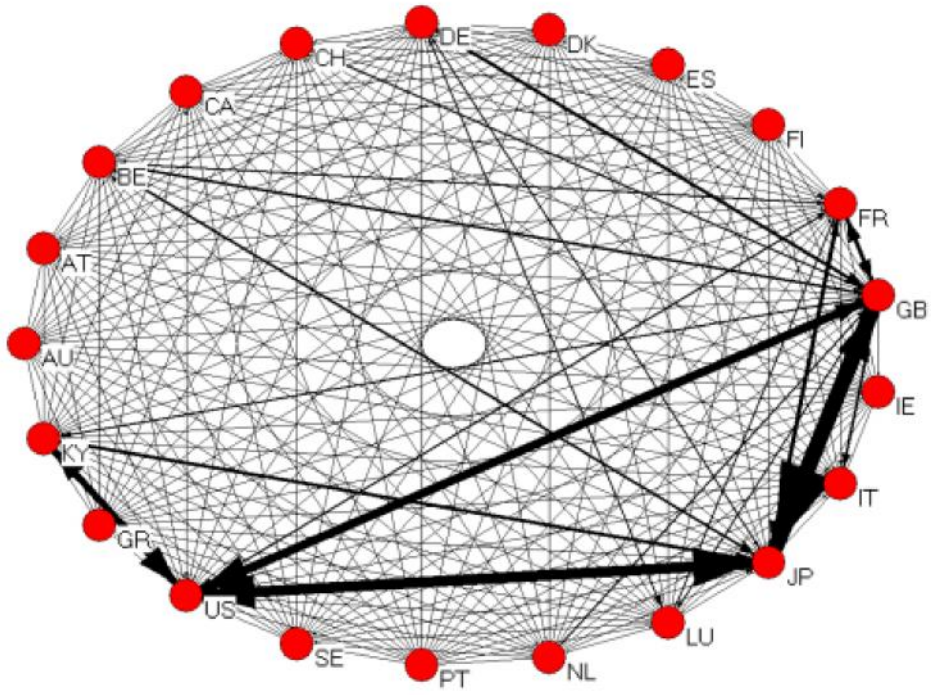

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Raw data 2008 Q2

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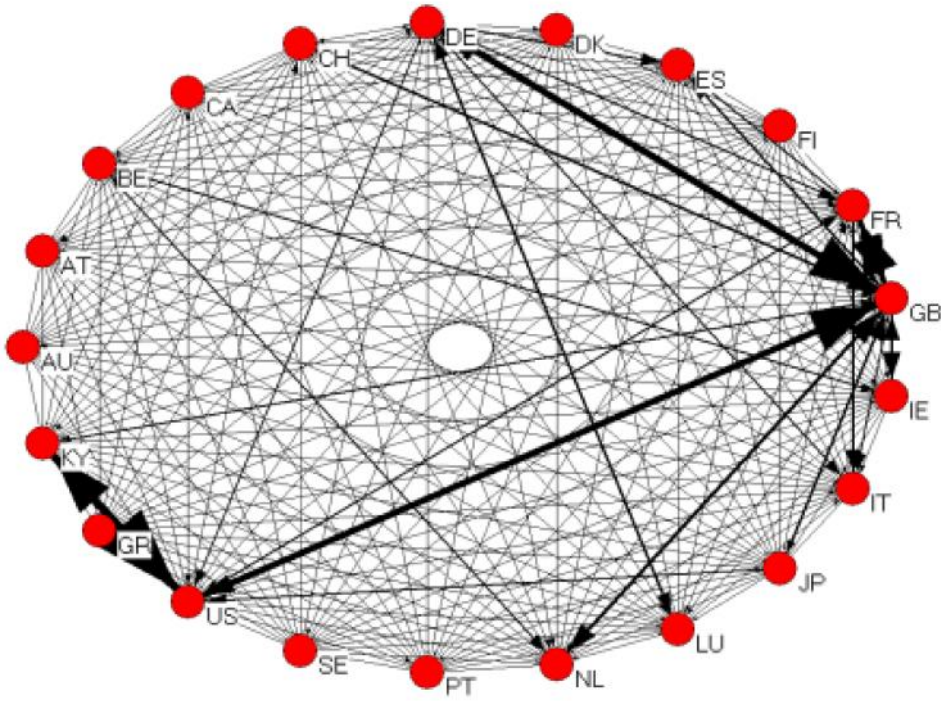

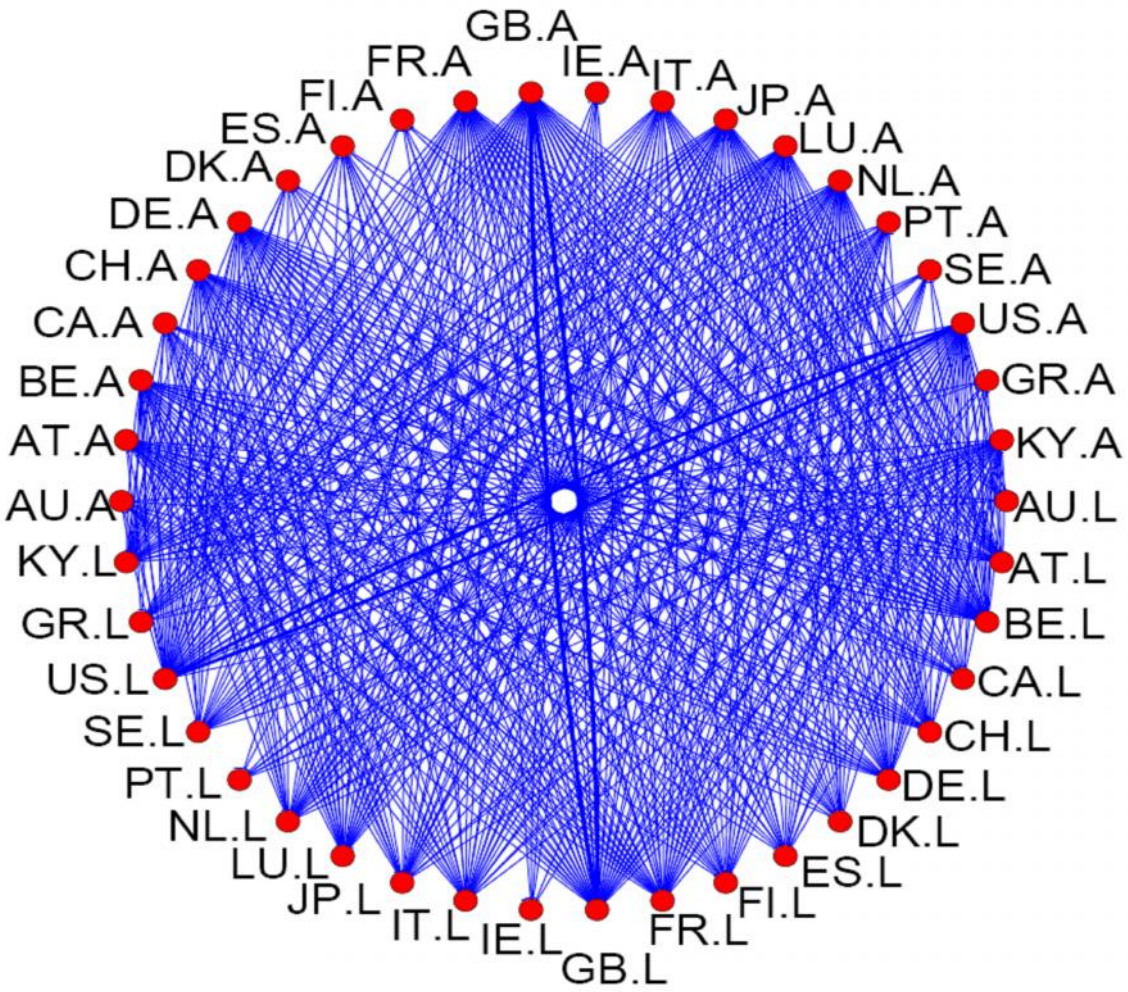

Chart 3. Nodes after split (

Source: Bank for International Settlements, Locational by Residence data and own calculations.

Notes: Austria (AT), Australia (AU), Belgium (BE), Canada (CA), the Cayman Islands (KY), Switzerland (CH), Germany (DE), Greece (GR), Denmark (DK), Spain (ES), Finland (FI), France (FR), United Kingdom (GB), Ireland (IE), Italy (IT), Japan (JP), Luxembourg (LU), Netherlands (NL), Portugal (PT), Sweden (SE), and the United States (US).

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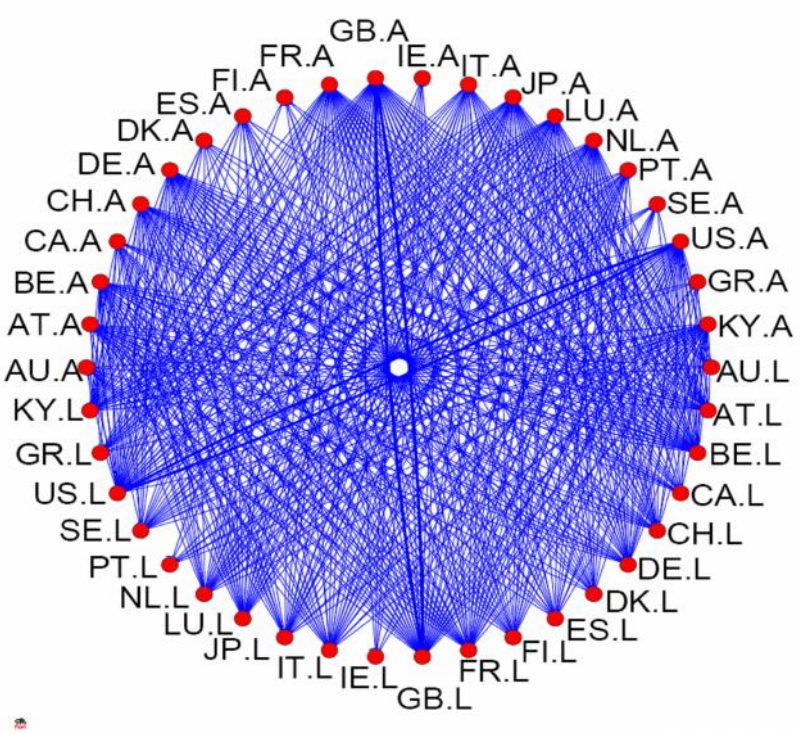

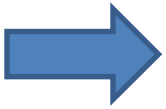

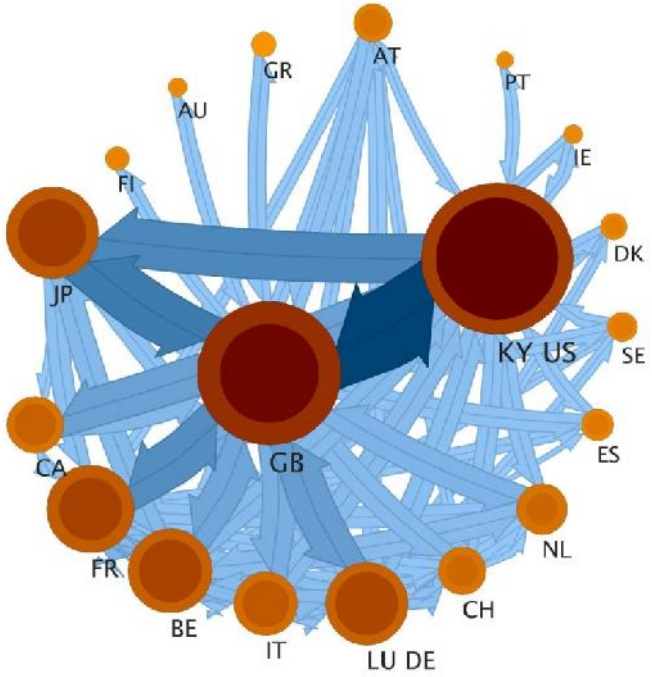

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Modular network (1985 Q1)

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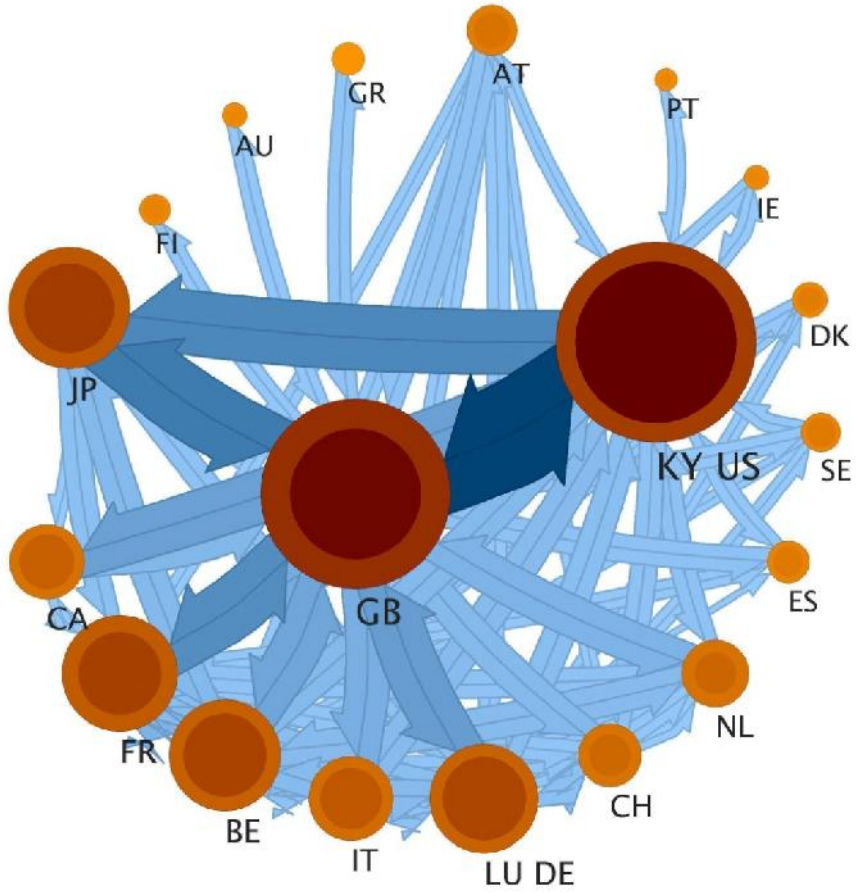
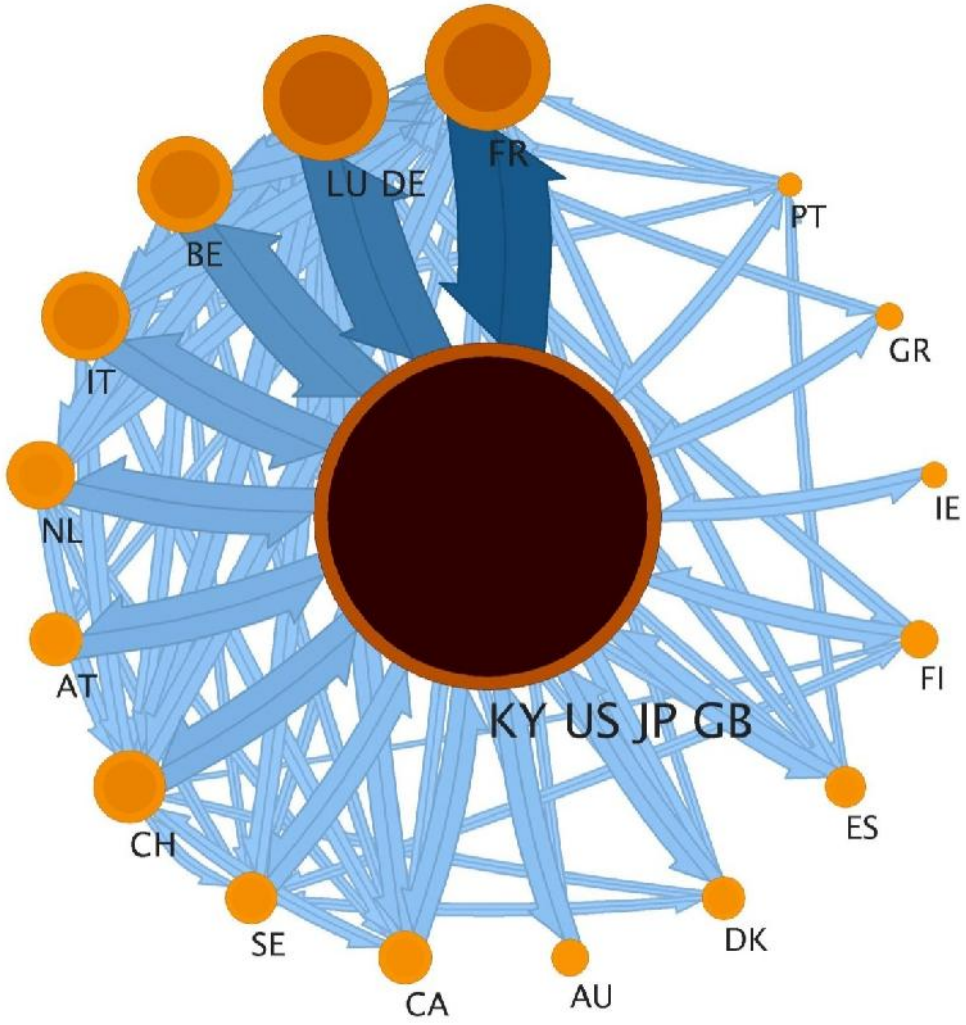
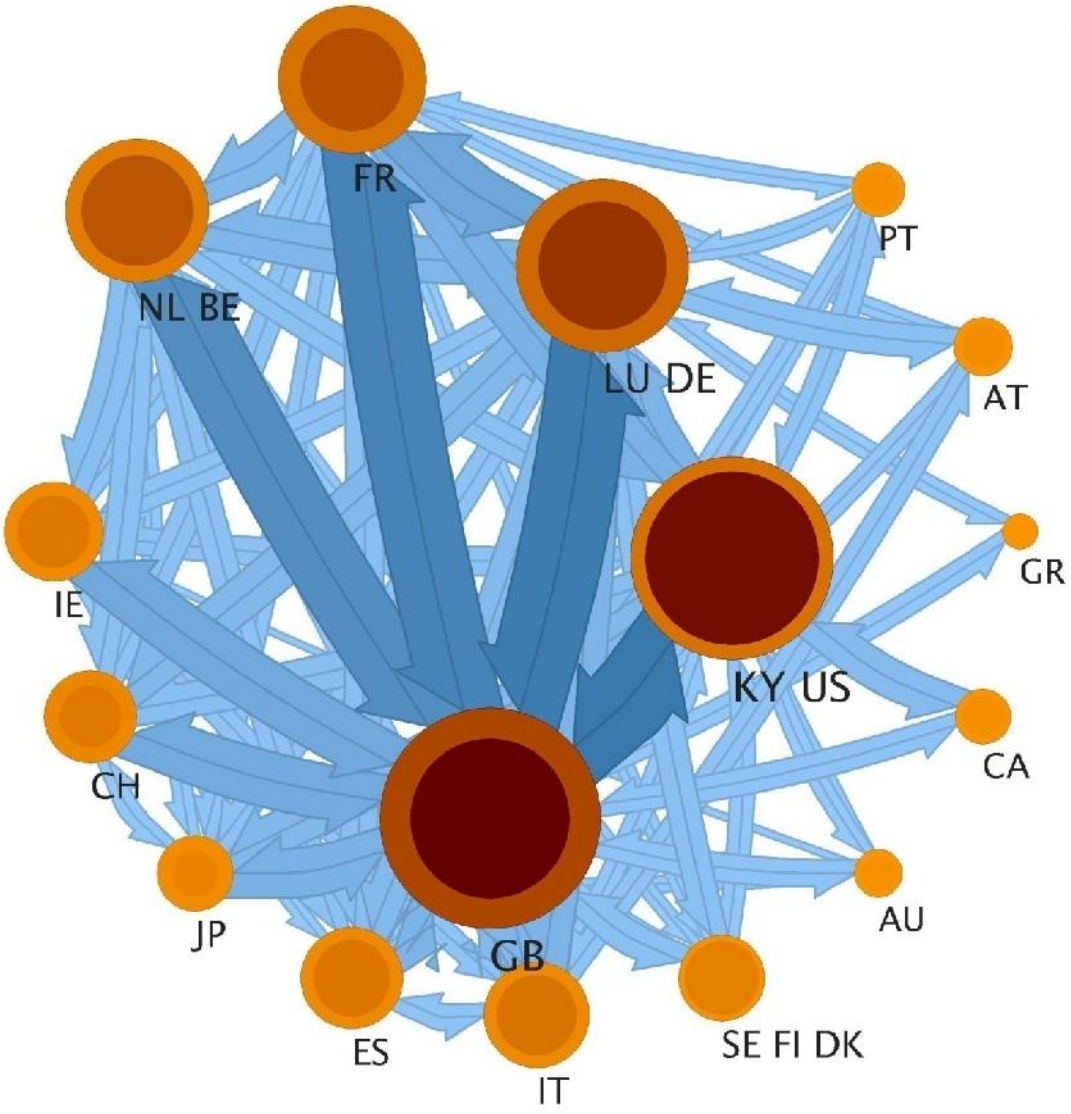


Source: Bank for International Settlements, Locational by Residence data and own calculations.

Modular network (1989 Q3)



Modular network (2008 Q2)



The state variables in the model are the pressure on a banking group's capital. $0 \rightarrow$ no pressure, and $1 \rightarrow$ maximum pressure. To capture the fact that capital can be strained from the funding side (liquidity) and the credit side (solvency), we let $\mathrm{e}^{r}_{\alpha_J}$ denote the capital pressure on the credit or funding arm of banking group α for each round of contagion, r (for $J, K \in \{C, F\}$).
Then system of difference equations

$$\mathrm{e}^{r+1}_{\alpha_J} = \begin{cases} \sum_{\beta_K}^{2N} \pi_{\alpha_J \beta_K} \mathrm{e}^{r}_{\beta_K} + \varepsilon^{r} & \text{if } 0 \leq \mathrm{e}^{r}_{\alpha_J} < 1 \\ 1 & \text{if } \left(\mathrm{e}_{\alpha^{r}_{C}} - 1\right)\left(\mathrm{e}_{\alpha^{r}_{F}} - 1\right) = 0 \end{cases} \tag{1}$$

where $\alpha, \beta \in G$, $J, K \in \{C, F\}$,

$$\varepsilon^r = \begin{cases} \sigma \mathit{sign}\left(\mathrm{e}^r_{\alpha_J} - \mathrm{e}^{r-1}_{\alpha_J}\right) & \text{if } \operatorname{sgn}\left(\mathrm{e}^r_{\alpha_J} - \mathrm{e}^{r-1}_{\alpha_J}\right) > \frac{\mu}{l_{\alpha_J}} \\ 0 & \text{if } \operatorname{sgn}\left(\mathrm{e}^r_{\alpha_J} - \mathrm{e}^{r-1}_{\alpha_J}\right) \leq \frac{\mu}{l_{\alpha_J}} \end{cases} \tag{2}$$

and

$$l_{\alpha_J} = \begin{cases} \sum_{\beta=1}^{N} \left(\frac{x_{\beta\alpha}}{\sum_{\beta=1}^{N} x_{\beta\alpha}} \right)^2 & \text{if} \quad J = C \\ \sum_{\beta=1}^{N} \left(\frac{x_{\alpha\beta}}{\sum_{\beta=1}^{N} x_{\alpha\beta}} \right)^2 & \text{if} \quad J = F. \end{cases}$$

The steady-state frequencies used in the map equation model are derived from the equation $e_{\alpha_J}^{r+1} = \sum_{\beta_K}^{2N} \pi_{\alpha_J \beta_K} e_{\beta_K}^{r}$ for $\alpha, \beta \in G$ and $J, K \in \{C, F\}$. *sgn* denotes the signum function. The difference with our simulations model (equation 1) is the drift term (ε^r) which captures the financial accelerator. Because of this additional term, capital pressure can reach a maximum level in a banking group, either by the funding or the credit side, and then it is assumed that both sides of that banking group will continue to experience only maximum capital pressure thereafter. In the map equation, capital pressure will always remain between zero and one.

Equation 2 defines the drift term. Because of the financial accelerator, there could be more capital pressure this round if there was strong pressure last round. The financial accelerator is also controlled by a parameter $\sigma > 0$. But how strongly the last round's rise has to be to trigger the accelerator also depends on risk sharing: the degree of diversification of each node (I_{α_J}) relative to an overall parameter, μ.

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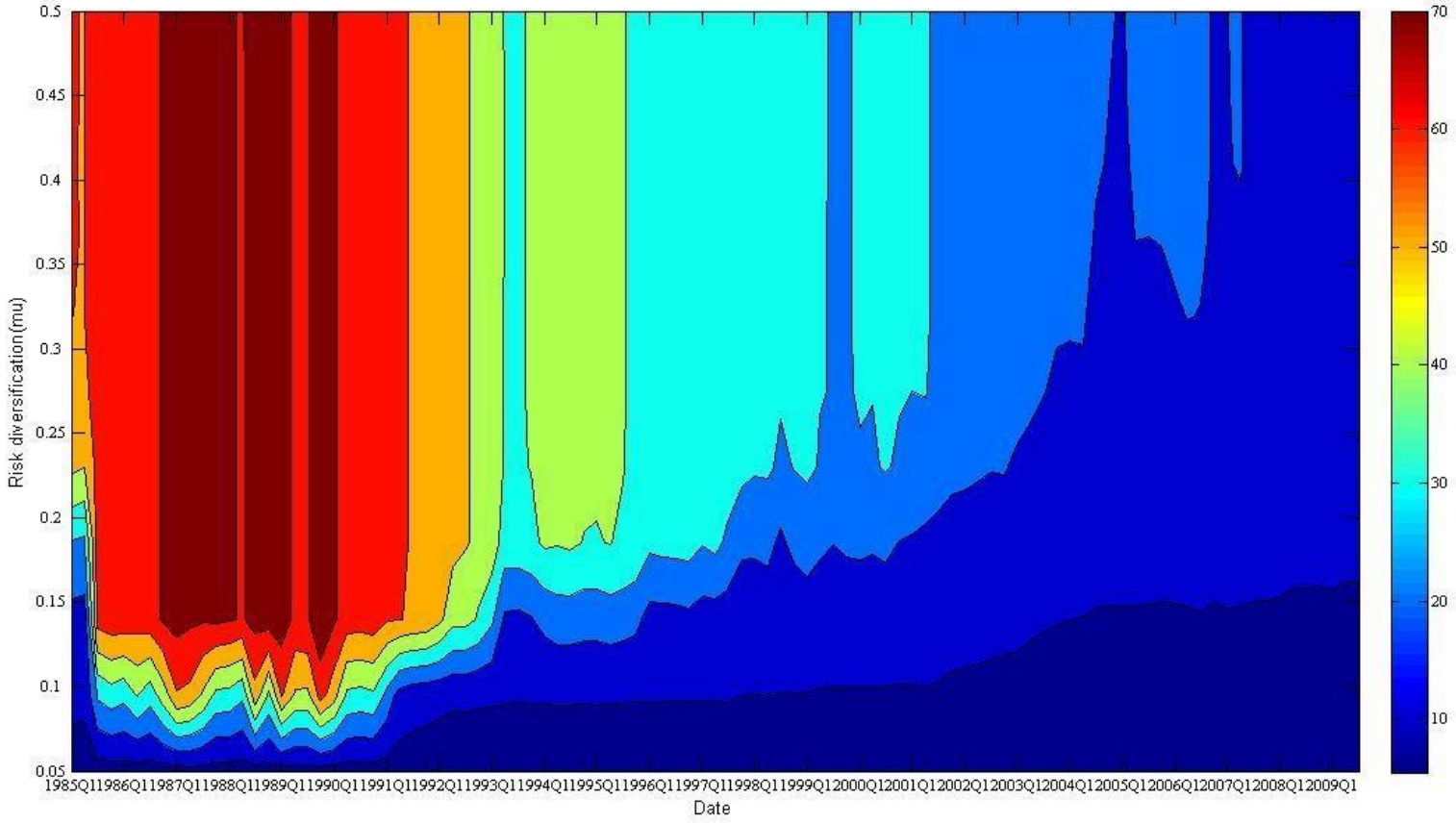

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Conclusion

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- Key result: Network became more contagious prior to the crisis .
- Interconnectivity did not imply risk-sharing

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Other examples of cross-sectional vulnerability

- CDOs squared
- Icelandic banking system
- Great depression: investment trusts

Share performance of splits and cross-holdings

Market Changes 31.03.99 to 31.03.02 (%)	
FTSE 100	-16.2
FTSE All Share	-11.7
Examples of share price movements of Splits (Zero divided Preference Shares)	
No cross holdings	-39.1
Cross holdings of: under 20%	-82.21
21-40%	-88.23
41-70%	-97.85
Over 70%	-97.97

Source FSA (2003)

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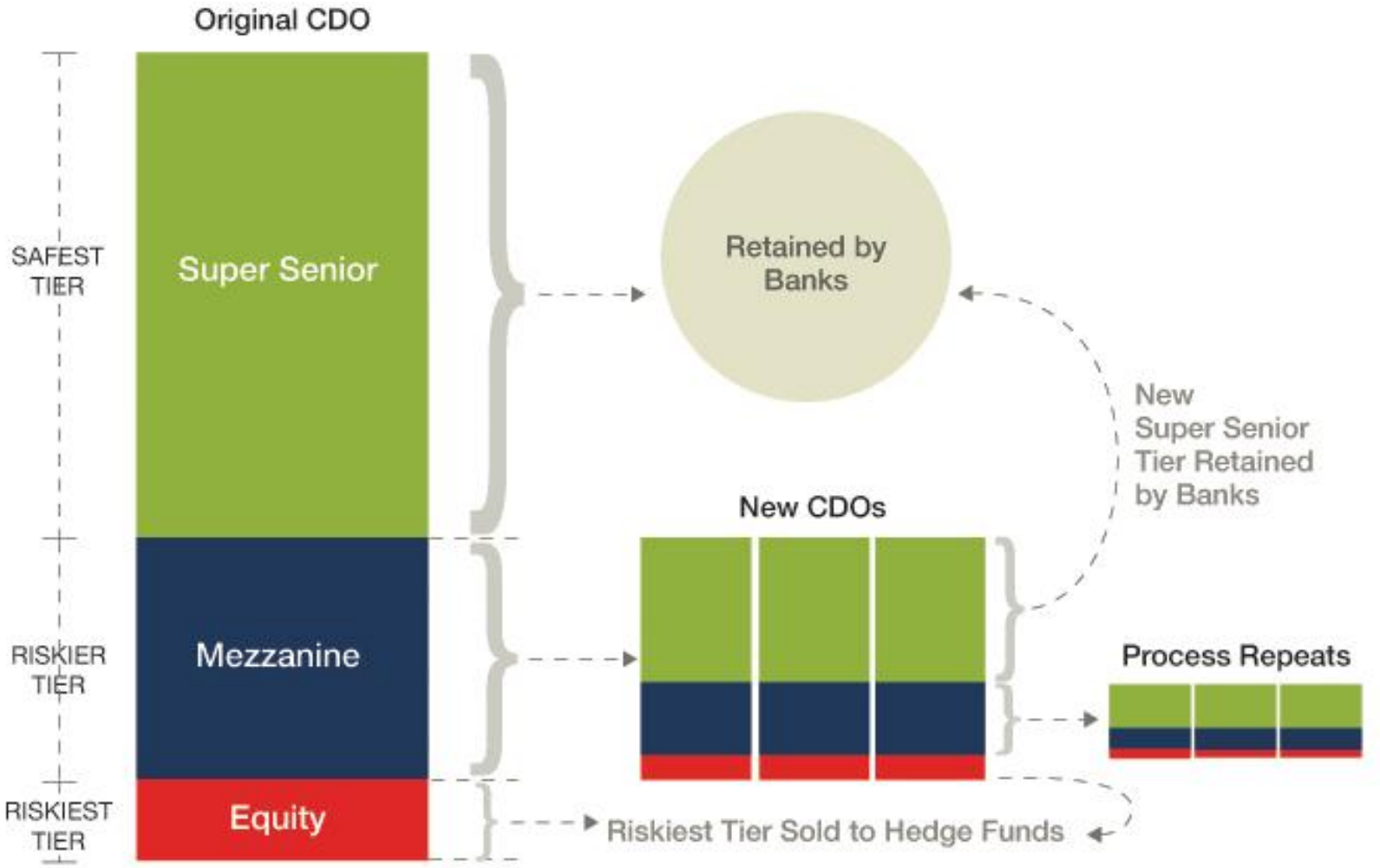

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CDOs

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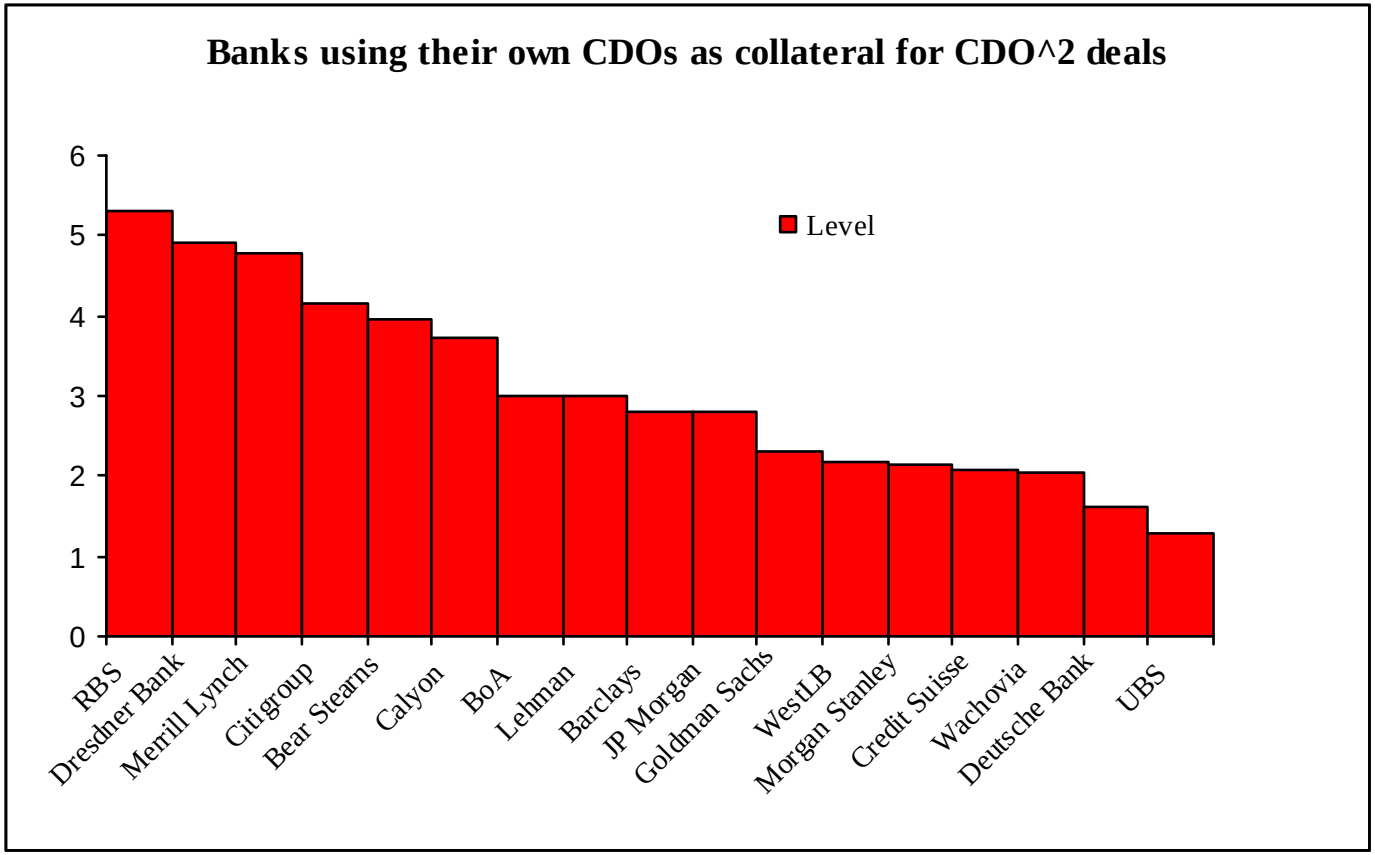
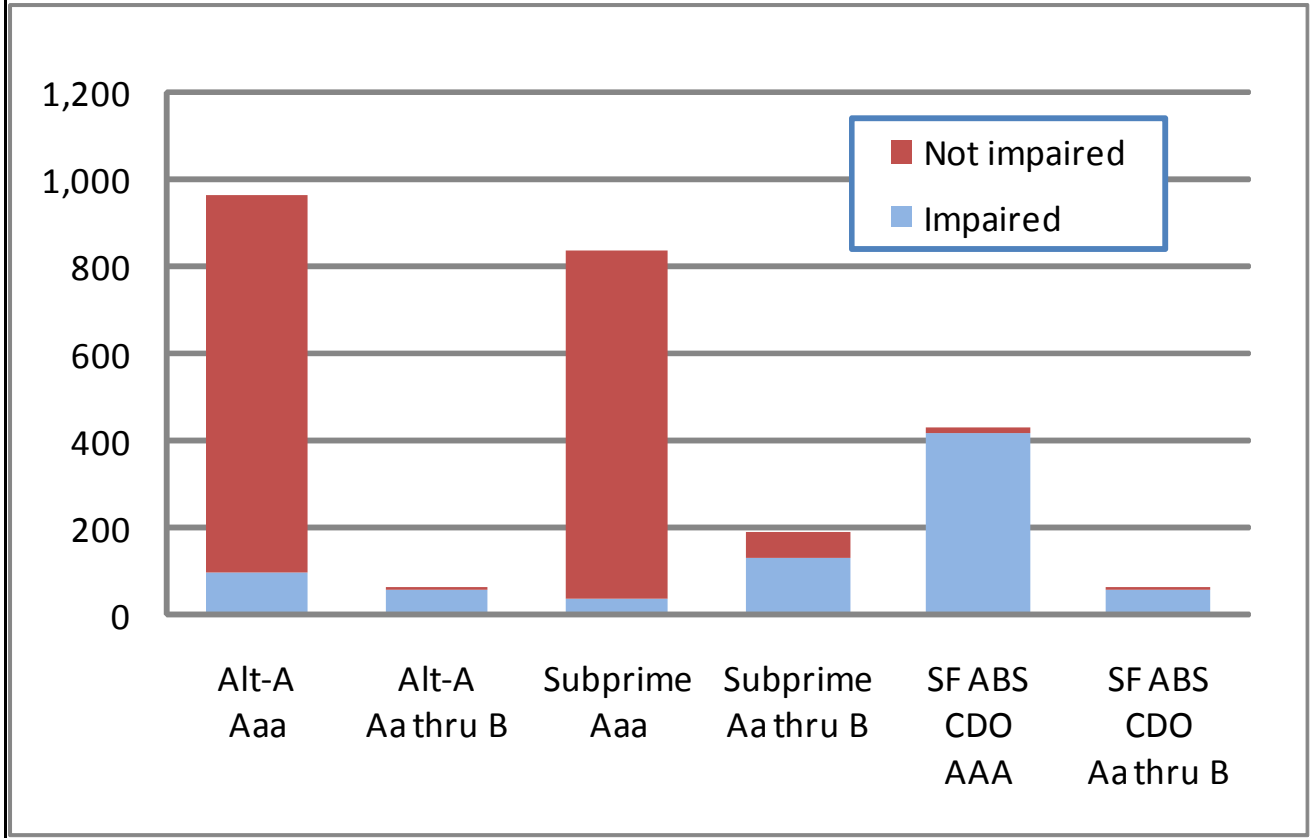


Source: The Story of the CDO Market , Barnett Hart 2009

Figure 3

Impaired MBS and SF ABS CDO Securities
2005-2007 Issuance
(in $ billions)



Note: This figure compares impaired securities as determined by Moody's (2010) for Alt-A and subprime MBS issued from 2005-2007 to our loss estimates on SF ABS CDOs issued over the same time period. Impairment of MBS is as of year-end 2009 and is defined when a security is downgraded to C or Ca, or when it suffers a principal loss. Impairment

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Cross-holding of CDOs 2005-2008

Propublica data on cross holdings

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Cross-holdings among Icelandic Banks

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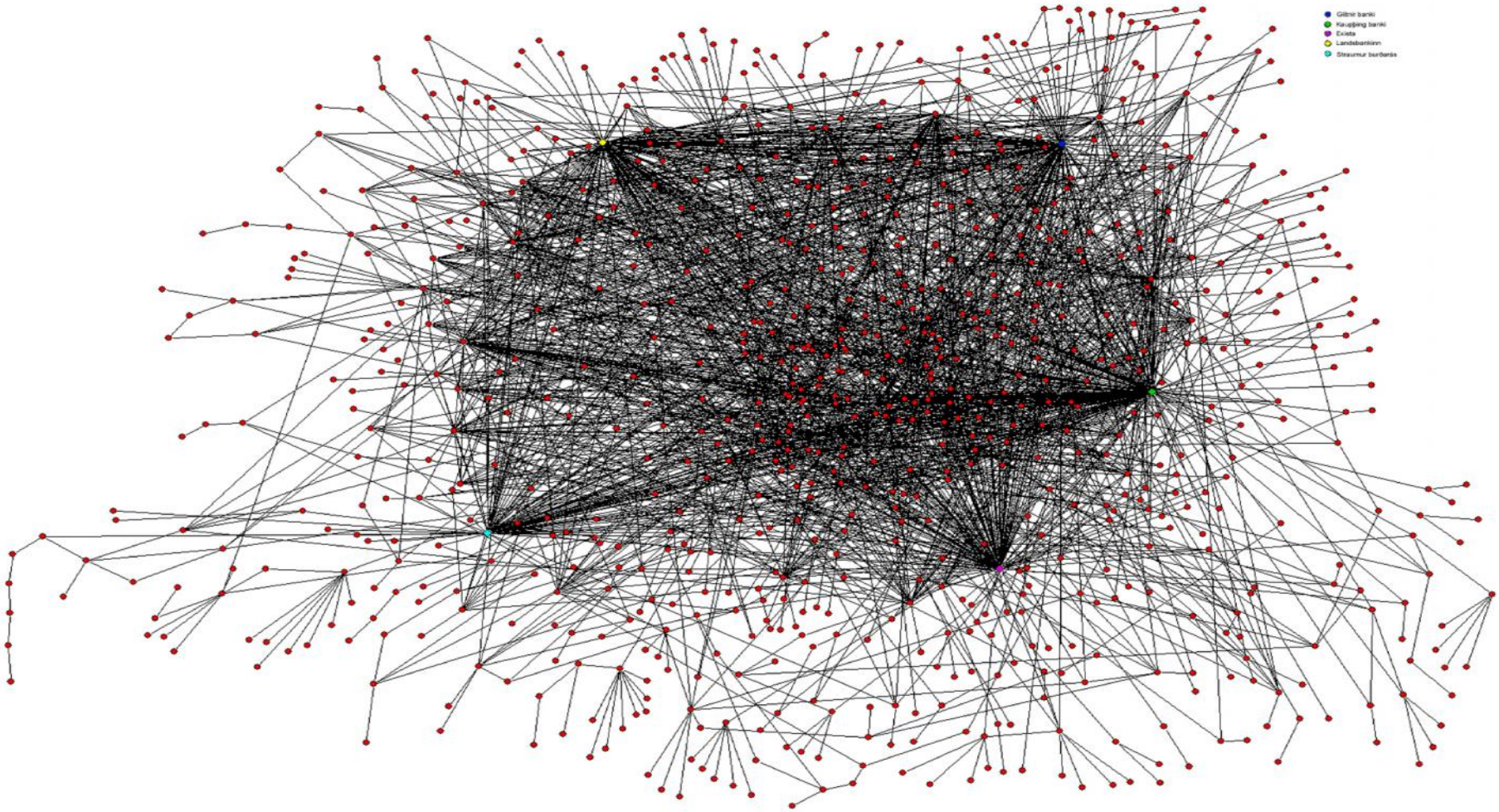

Source: SIC report, Vol. 9., Appendix 2, pp. 23

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Next step:

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How are interbank networks formed?
When networks are formed how well do prices accurately signal the risk of aftermath?

Allen, Franklin and Douglas Gale, (2001). "Financial Contagion," Journal of Political Economy, University of Chicago Press, vol. 108(1), pages 1-33, February.

Battiston, Stefano, Delli Gatti, Domenico, Gallegati, Mauro, Greenwald, Bruce C. N. and Stiglitz, Joseph E., (2009)Liaisons Dangereuses: Increasing Connectivity, Risk Sharing, and Systemic Risk (January 2009). NBER Working Paper Series, Vol. w15611, pp. -, 2009. Available at SSRN: http://ssrn.com/abstract=1532069

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Paper to accompany this presentation

http://www.econ.ucsb.edu/~garratt/faculty/contagious_capacity.pdf

Map equation

Rosvall M., D. Axelsson and C.T. Bergstrom, The map equation, arXiv:0906.1405v2 [physics.soc-ph]

Rosvall, M. and C. T. Bergstrom, Mapping change in large networks, arXiv:0812.1242v1 [physics.soc-ph]

http://www.tp.umu.se/~rosvall/livemod/mapequation/index.html

Examples of interconnectedness in the build up to the crisis

CDOs

http://orgnet.com/cdo.html

http://ftalphaville.ft.com/blog/2010/11/04/394416/collateralised-contagion/

http://www.propublica.org/article/banks-self-dealing-super-charged-financial-crisis

http://www.propublica.org/special/interactive-cdos-interlocking-ownership#cdo/b43awlr

Barnett Hart, A (2009), The Story of the CDO Market Meltdown http://www.hks.harvard.edu/m-rcbg/students/dunlop/2009-CDOmeltdown.pdf

Cordell, L, Huang, Y and M. Williams, "Collateral Damage: Sizing and assessing the Subprime CDO crisis", Federal Reserve Bank of Philadelphia Working paper

http://www.philadelphiafed.org/research-and-data/publications/working-papers/2011/wp11-30.pdf

Heitfield, E (2009). "Parameter Uncertainty and the Credit Risk of Collateralized Debt Obligations," Board of Governors of the Federal Reserve System Working Paper

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Iceland

An Autopsy Report of the Icelandic Financial System: Guðrún Johnsen, The Special Investigation Commission

http://www.voxeu.org/index.php?q=node/4965

Empirical evidence of contagion

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FSA and Split Capital Trusts

FSA (2003), Investment Companies, Financial Services Authority consulation paper 164

On the key question: Contagion or risk sharing?

Franklin Allen and Douglas Gale, 2001. "Financial Contagion," Journal of Political Economy, University of Chicago Press, vol. 108(1), pages 1-33, February.

Battiston, Stefano, Delli Gatti, Domenico, Gallegati, Mauro, Greenwald, Bruce C. N. and Stiglitz, Joseph E., Liaisons Dangereuses: Increasing Connectivity, Risk Sharing, and Systemic Risk (January 2009). NBER Working Paper Series, Vol. w15611, pp. -, 2009. Available at SSRN: http://ssrn.com/abstract=1532069

Zawadowski, A, 2011. “Entangled Financial Systems” and “Interwoven Lending, Uncertainty, and Liquidity Hoarding.” Boston University, http://people.bu.edu/zawa

Bernanke, B, 2010, “On the causes of the Recent Financial and Economic Crisis,” Testimony before the Financial Crisis Inquiry Commission, http://federalreserve.gov/newsevents/testimony/bernanke20100902a.htm

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Methodology of simulations

Gai and Kapadia (Bank of England Working Paper, 2010).

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