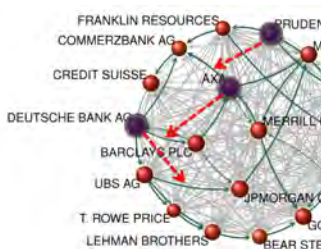


# Distress and systemic risk in financial networks

**Stefano Battiston, UZH**  
*SRC Lunch Time Seminar. LSE*

December 3, 2013



University of  
 Zurich<sup>UZH</sup>

# Acknowledgments

- Swiss National Fund, Institute of Banking and Finance, UZH (from Nov. 1st 2013)
  - SNF Professorship at IBF, UZH - Financial Networks and Systemic risk



# Acknowledgments

- Swiss National Fund, Institute of Banking and Finance, UZH (from Nov. 1st 2013)
  - SNF Professorship at IBF, UZH - Financial Networks and Systemic risk
- FOC - Forecasting Financial Crises (EU FET-OPEN, 2010-2013)
  - Coordinator G. Caldarelli, 14 partners, including ECB. Tools from network science for financial regulation
- SIMPOL: Financial Systems Simulation and Policy Modeling (EU FET-OPEN, 2013-2016)
  - Coordinator S. Battiston, 6 partners, collaborations central banks, innovations, climate, crowdsourcing.



# Acknowledgments

- Swiss National Fund, Institute of Banking and Finance, UZH (from Nov. 1st 2013)
  - SNF Professorship at IBF, UZH - Financial Networks and Systemic risk
- FOC - Forecasting Financial Crises (EU FET-OPEN, 2010-2013)
  - Coordinator G. Caldarelli, 14 partners, including ECB. Tools from network science for financial regulation
- SIMPOL: Financial Systems Simulation and Policy Modeling (EU FET-OPEN, 2013-2016)
  - Coordinator S. Battiston, 6 partners, collaborations central banks, innovations, climate, crowdsourcing.
- INET - Financial Stability Program directed by J. Stiglitz.
  - WG on Financial Networks - Chair A. Haldane
  - Political economy aspects of fin. stability



# Research Agenda

- Teaming up network scientists, economists and regulators  
[Galbiati 2013 Nat Phys; Battiston 2013 Nat Phys]



# Research Agenda

- Teaming up network scientists, economists and regulators  
[Galbiati 2013 Nat Phys; Battiston 2013 Nat Phys]
- Characterizing financial network structure
  - ownership, TNC [Glattfelder 2010 PRE; Vitali 2011 PLoS-ONE]
  - e-mid, interbank, TARGET2 [Delpini 2013 Sci Rep; Di Iasio 2013 WP; Galbiati 2013 Nat Phys]
  - derivatives (BuBa) [Roukny 2013 progr.]



# Research Agenda

- Teaming up network scientists, economists and regulators  
[Galbiati 2013 Nat Phys; Battiston 2013 Nat Phys]
- Characterizing financial network structure
  - ownership, TNC [Glattfelder 2010 PRE; Vitali 2011 PLoS-ONE]
  - e-mid, interbank, TARGET2 [Delpini 2013 Sci Rep; Di Iasio 2013 WP; Galbiati 2013 Nat Phys]
  - derivatives (BuBa) [Roukny 2013 progr.]
- Reconstructing financial networks:
  - Time series, partial info [Kaushik 2013 PLoS-ONE; Puliga 2013 Nat Phys],[Musmeci 2013 JOSS]




# Research Agenda

- Teaming up network scientists, economists and regulators  
[Galbiati 2013 Nat Phys; Battiston 2013 Nat Phys]
- Characterizing financial network structure
  - ownership, TNC [Glattfelder 2010 PRE; Vitali 2011 PLoS-ONE]
  - e-mid, interbank, TARGET2 [Delpini 2013 Sci Rep; Di Iasio 2013 WP; Galbiati 2013 Nat Phys]
  - derivatives (BuBa) [Roukny 2013 progr.]
- Reconstructing financial networks:
  - Time series, partial info [Kaushik 2013 PLoS-ONE; Puliga 2013 Nat Phys],[Musmeci 2013 JOSS]
- Distress propagation: systemic risk vs diversification [Battiston 2012 JEDC; Battiston 2012 JFS; Vitali 2013 JEBO rev.; Tasca 2012]
- Optimal architectures vs cascades and market illiquidity  
[Roukny 2013 Sci Rep]





# Research Agenda

- Teaming up network scientists, economists and regulators  
[Galbiati 2013 Nat Phys; Battiston 2013 Nat Phys]
- Characterizing financial network structure
  - ownership, TNC [Glattfelder 2010 PRE; Vitali 2011 PLoS-ONE]
  - e-mid, interbank, TARGET2 [Delpini 2013 Sci Rep; Di Iasio 2013 WP; Galbiati 2013 Nat Phys]
  - derivatives (BuBa) [Roukny 2013 progr.]
- Reconstructing financial networks:
  - Time series, partial info [Kaushik 2013 PLoS-ONE; Puliga 2013 Nat Phys],[Musmeci 2013 JOSS]
- Distress propagation: systemic risk vs diversification [Battiston 2012 JEDC; Battiston 2012 JFS; Vitali 2013 JEBO rev.; Tasca 2012]
- Optimal architectures vs cascades and market illiquidity  
[Roukny 2013 Sci Rep]
- Indicators for policy: **DebtRank: SIFI** [Battiston 2012 Sci Rep]  University of Zurich  
**Controllability** [Delpini 2013 Sci Rep; Galbiati 2013 Nat Phys]

# Risk in Network Context

- Extending credit + trading credit implies to measure and price default risk
- Feasible if we assume a bank is isolated
- Challenging if banks are in a network of liabilities (even more with derivative contracts)
  - Issues: e.g. under(over)-estimating risk due to network effects, amplifications, multiple equilibria



# Ex-Ante vs Ex-Post Distress

## Ex-post

- Goal: Assess systemic impact of shock on given asset class or bank; design more resilient architecture
- Methods and Literature
  - Shock is known. Stress testing, fix point default cascade: Eisenberg-Noe 2001; Elsinger ea. 2006; Gai-Kapadia 2010; Cifuentes ea. 2005
  - Homogenous networks: Battiston ea. 2012 JFS; heterogenous networks and optimal architecture: (Roukny ea. 2013 Sci Rep)
  - Compute monetary value of systemic impact: Battiston ea. 2012 Sci Rep (DebtRank)
- Findings
  - Diversification can be detrimental
  - No single optimal topology, it depends on liquidity and correlation capital-centrality
  - Go beyond default-only: Systemic impact can be estimated even in absence of defaults; there is more than just size.



# Ex-Ante vs Ex-Post Distress

## Ex-ante

- Goal: Characterize evolution of distress, measures of distance to default, default probability in system context
- Methods
  - Merton framework and Cox, with default at intermediate time.
  - Continuous time, stochastic [Liaisons Dangereuses, Battiston 2012 JEDC; Tasca 2012 WPa,b]
  - Two-stage, stochastic, fix point approach [in progr.]
- Findings
  - Interior optimal diversification (contract density)
  - Private incentives towards over-connectedness
  - Complexity hampers systemic default assessment



# Perspectives

- (In)efficiency of equilibrium financial networks
  - Building on [ Koenig ea. 2011 JEBO, 2012 GEB]
- Strategic interaction and moral hazard: concentration, complexity, interconnectedness
- Games and meta-games, sustainability.

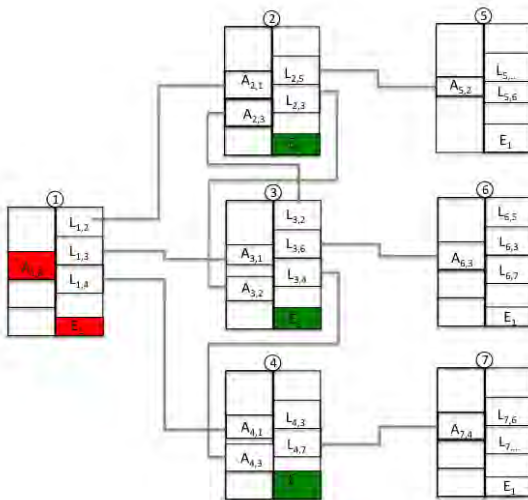


## PART I

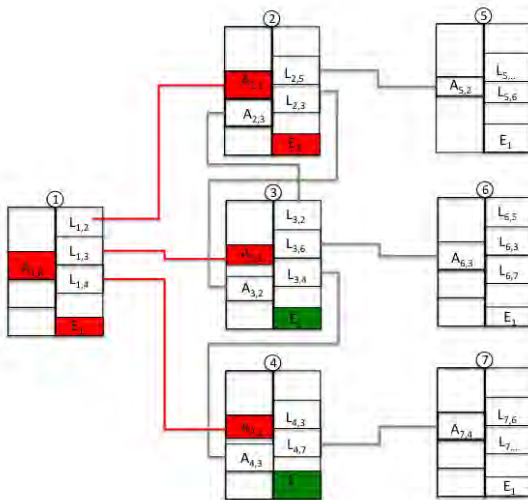
- Computing impact in system context
  - Deterministic, dynamic
  - Ex-post
  - refs.
- 
- Battiston, S., Puliga, M., Kaushik, R., Tasca, P. and Caldarelli, G. DebtRank: Too Central to Fail? Financial Networks, the FED and Systemic Risk. Sci. Rep. 2, (2012).
  - Battiston ea. J. Fin. Stability (2012)
  - Roukny, T., Bersini, H., Pirotte, H., Caldarelli, G., Battiston, S. Default Cascades in Complex Networks: Topology and Systemic Risk. Sci. Rep. 3, (2013).



# Default Cascade

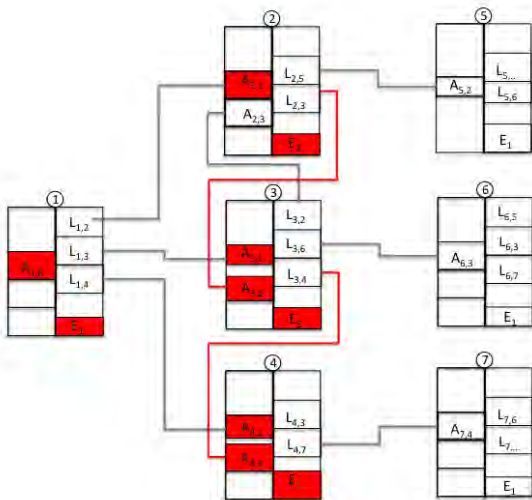


# Default Cascade

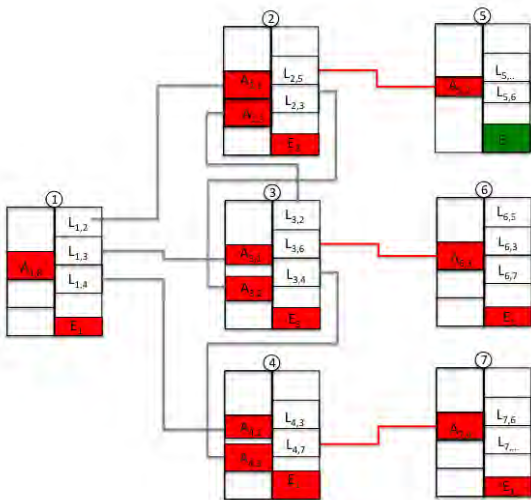




# Default Cascade



# Default Cascade



# Beyond Default-only Cascades

- Question 1. What is the most resilient network architecture?
- Question 2. Given an architecture, who is most systemically important?



# Beyond Default-only Cascades

- Question 1. What is the most resilient network architecture?
- Question 2. Given an architecture, who is most systemically important?
- PROBLEM with stress tests: cascades **almost never occur** unless
  - Additional externalities at work : **expectations**
    - : e.g. fire-sales, credit runs, market procyclicality, illiquidity (see talks by Tarik; Irena)
  - Distress propagation **before** default: **valuation issue**
    - e.g. DebtRank

- [Battiston, Delli Gatti, Gallegati, Greenwald, Stiglitz, Default Cascades ... (2012) JFS]

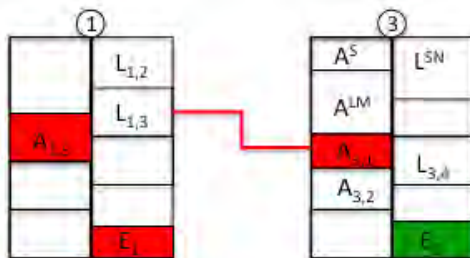
- [Roukny, Bersini, Pirotte, Caldarelli, Battiston, Default Cascades ... (2013) Sci Rep.]

- [Tasca, Battiston (2012), Market Procyclicality and Systemic Risk ETH RC]

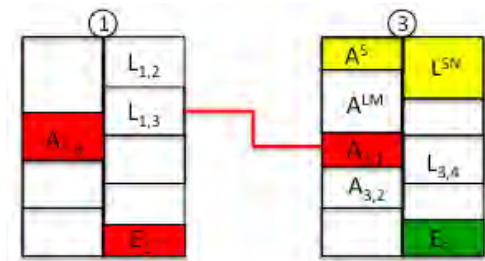
- [Battiston, Puliga, Kaushik, Tasca, Caldarelli, DebtRank: Too-central-to-fail? (2012) *Sci. Rep.* 2:541]



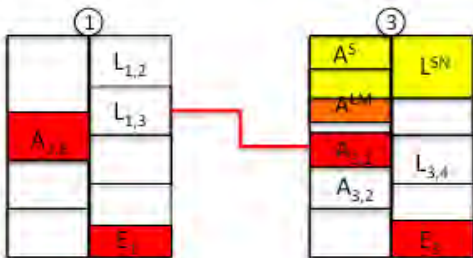
# Run of Short Term Lenders



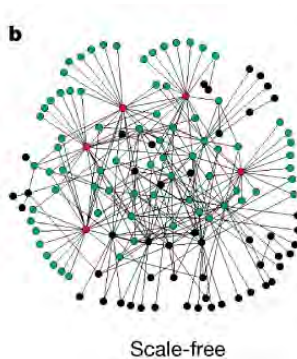
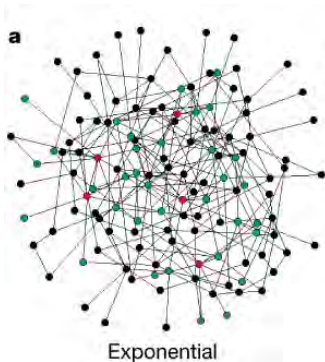
# Run of Short Term Lenders



# Run of Short Term Lenders



# What Optimal Network Architecture?





# Bottom Line

- Necessary to analyse phase diagram to locate in which regime the system is/could be

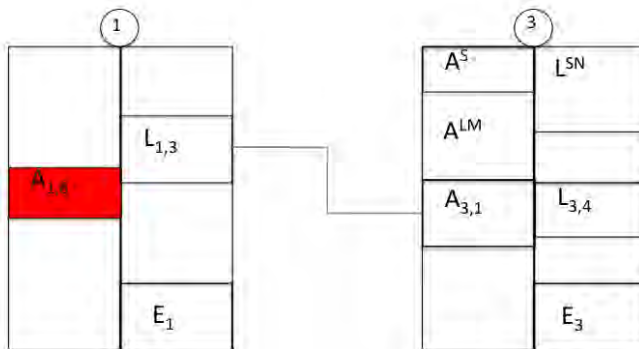


# Bottom Line

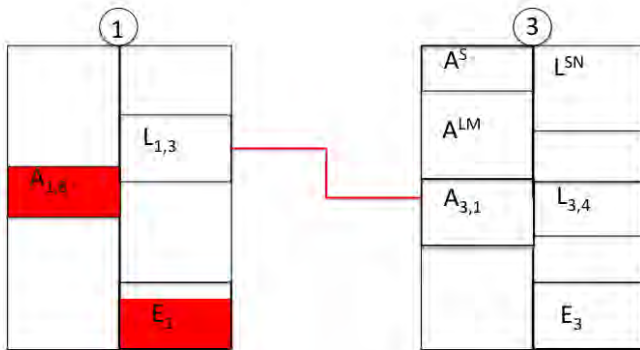
- Necessary to analyse phase diagram to locate in which regime the system is/could be
  - 1 There is **no single topology** that is just superior
  - 2 The most robust architecture depends on:
    - 1 market liquidity
    - 2 types of shocks
    - 3 correlations btw capital buffer and degree
  - 3 This story should not come as a surprise, but it is analyzed now systematically



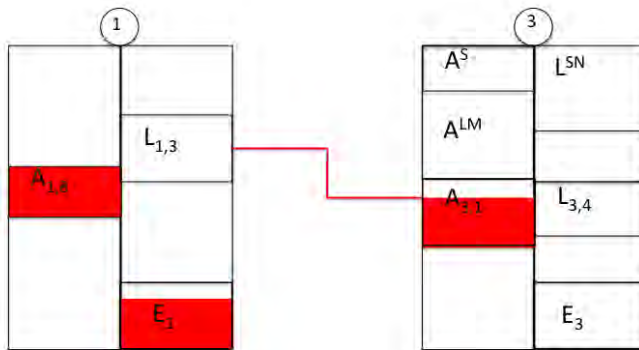
# Devaluation Effect



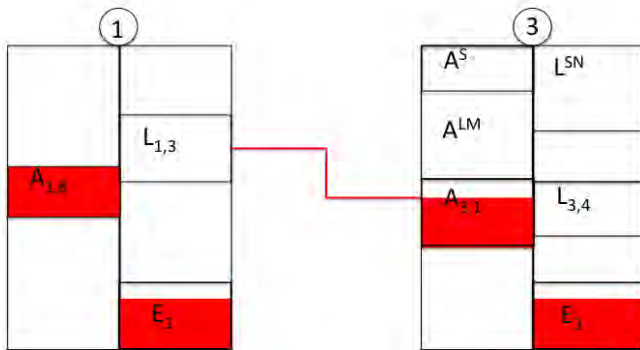
# Devaluation Effect



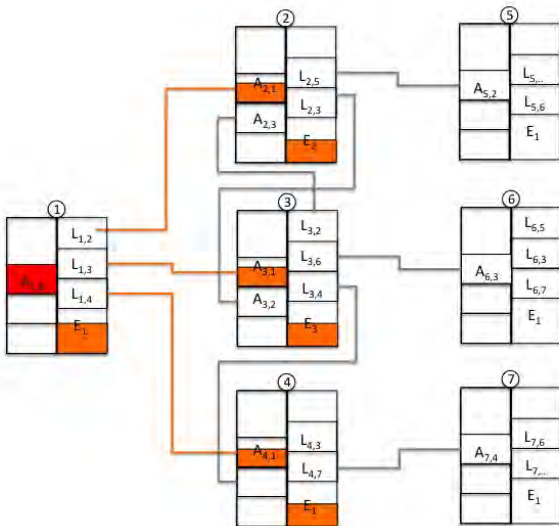
# Devaluation Effect



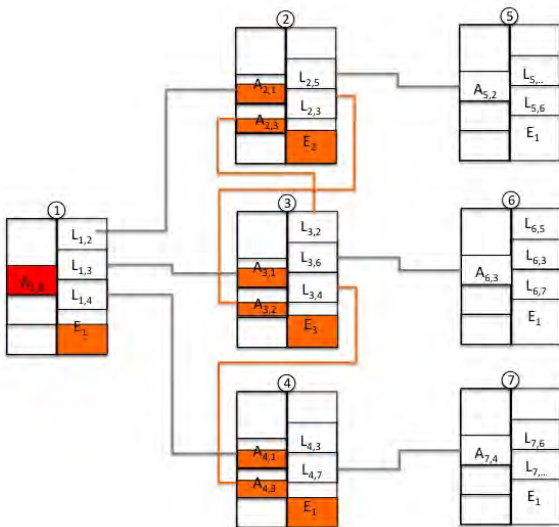
# Devaluation Effect



# Distress Propagation: DebtRank

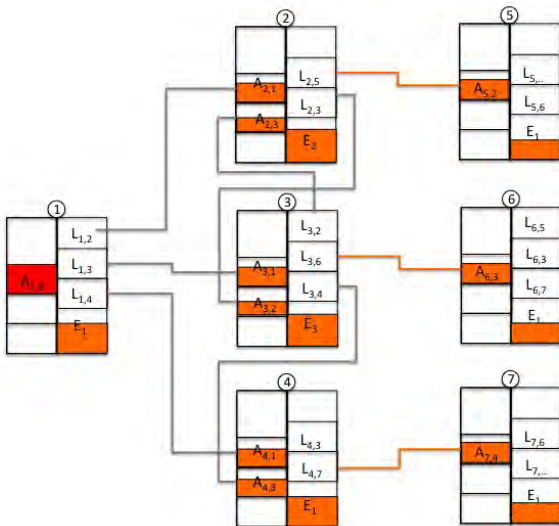


# Distress Propagation: DebtRank

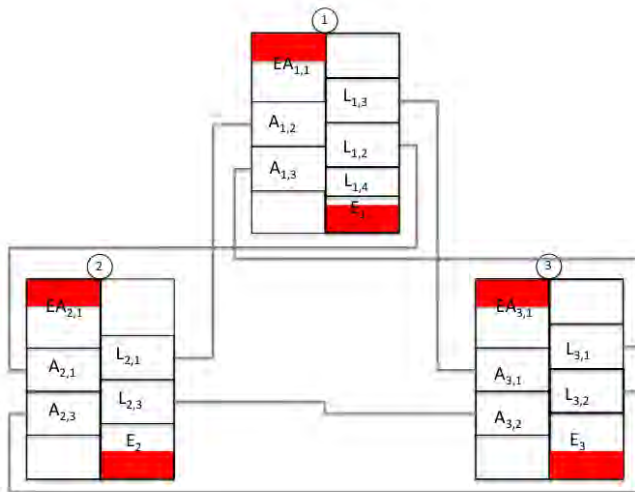




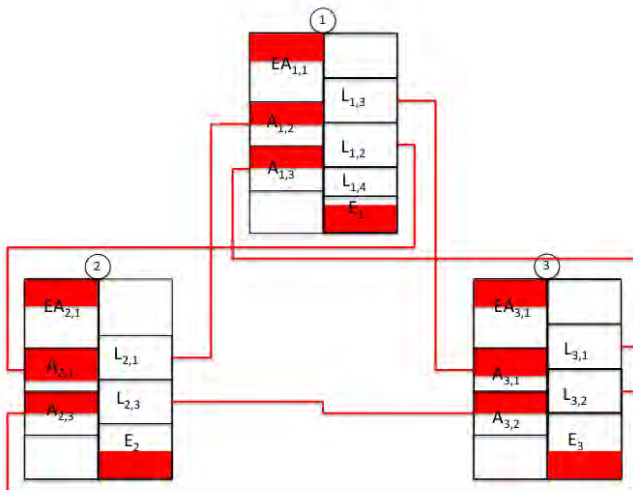
# Distress Propagation: DebtRank



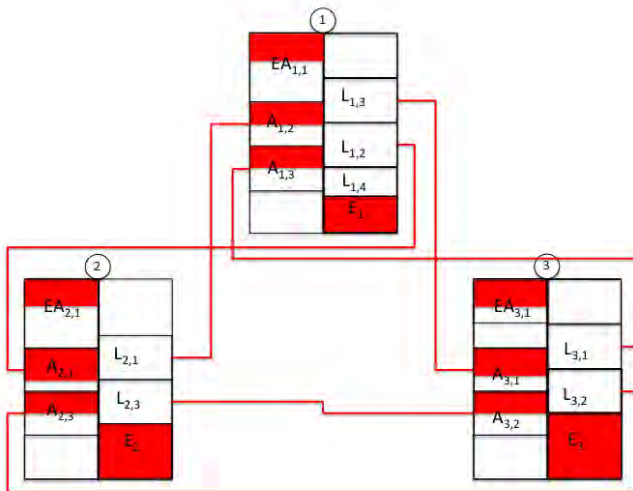
# Shock to a Common External Asset



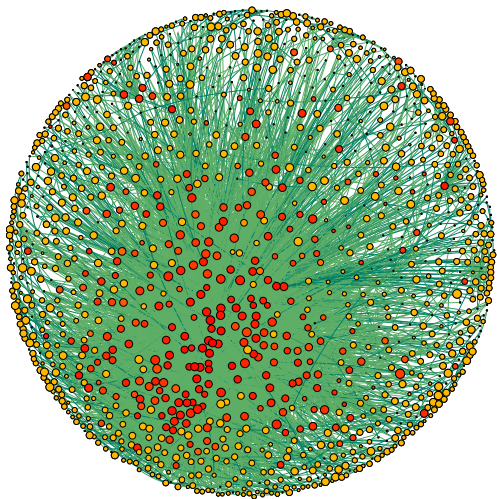
# Shock to a Common External Asset



# Shock to a Common External Asset



## DebtRank



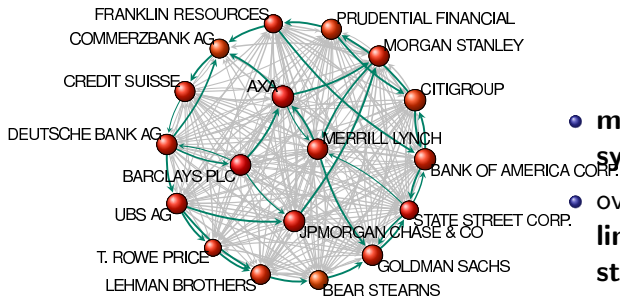
- **monetary value of systemic loss**
- **overcomes limitations of state-of-the art:**  
e.g. default-only, eigenvec. centrality

[Battiston, Puliga, Kaushik, Tasca, Caldarelli, DebtRank: Too-central-to-fail? (2012)  
Sci Rep. 2:541]



University of  
Zurich<sup>UZH</sup>

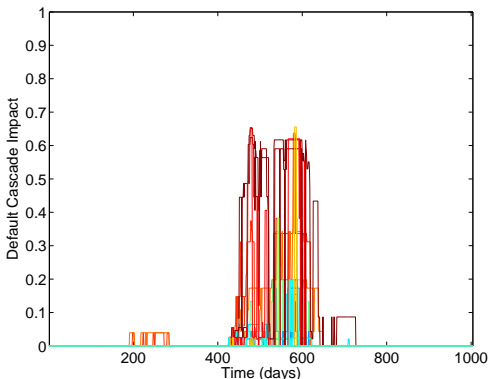
# DebtRank



- **monetary value of systemic loss**
- **overcomes limitations of state-of-the-art:**  
e.g. default-only, eigenvec. centrality

[Battiston, Puliga, Kaushik, Tasca, Caldarelli, DebtRank: Too-central-to-fail? (2012) Sci Rep. 2:541]

# DebtRank

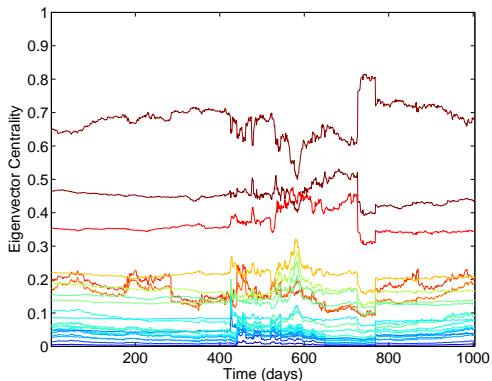


- **monetary value of systemic loss**
- **overcomes limitations of state-of-the-art:**  
e.g. default-only, eigenvec. centrality

[Battiston, Puliga, Kaushik, Tasca, Caldarelli, DebtRank: Too-central-to-fail? (2012)  
Sci Rep. 2:541]



# DebtRank



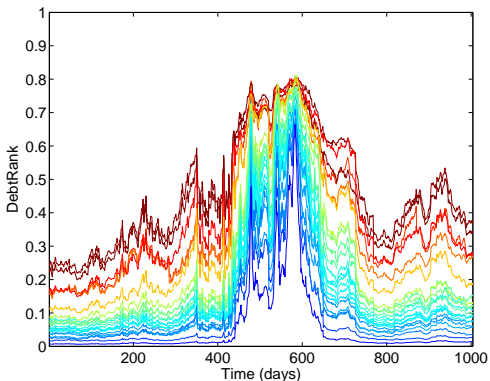
- **monetary value of systemic loss**
- **overcomes limitations of state-of-the-art:**  
e.g. default-only, eigenvec. centrality

[Battiston, Puliga, Kaushik, Tasca, Caldarelli, DebtRank: Too-central-to-fail? (2012)  
Sci Rep. 2:541]





# DebtRank



- **monetary value of systemic loss**
- **overcomes limitations of state-of-the-art:**  
e.g. default-only, eigenvec. centrality

[Battiston, Puliga, Kaushik, Tasca, Caldarelli, DebtRank: Too-central-to-fail? (2012)  
Sci Rep. 2:541]

