

The banking system as network – A supervisor's perspective

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Disclaimer

The opinions expressed in this presentation are those of the authors and do not necessarily reflect those of the OeNB or the Euro System.

The authors would like to thank Michael Boss, Helmut Elsinger, Robert Ferstl, Gerald Krenn, Stefan W. Schmitz, Reinhardt Seliger, Michael Sigmund, Martin Summer), and Stefan Thurner for their contributions to network analytical work at the OeNB and their support preparing this presentation.*

**) To anyone interested in the subject we wholeheartedly recommend Summer, 2012, one of the big inspirations for us in general and this presentation in particular.*

Agenda

Introduction

Network analysis to map the banking system

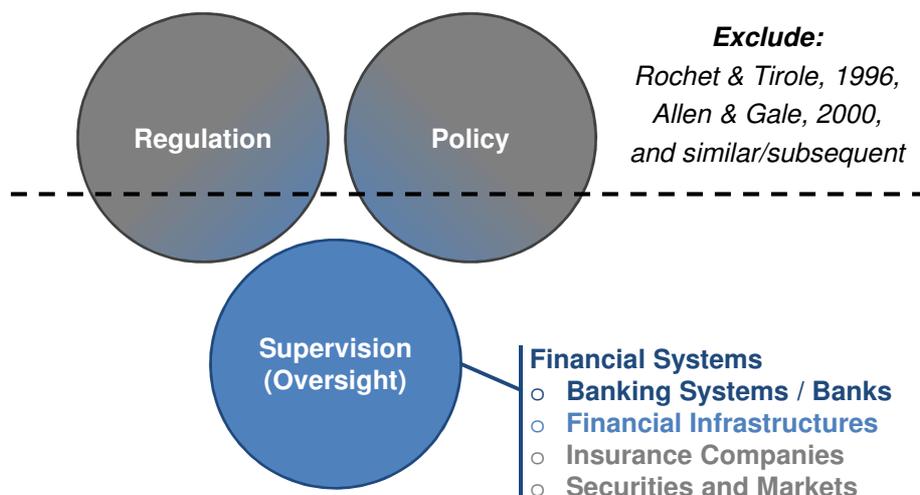
Network analysis to investigate contagion

Network analysis to inform policy makers

Conclusion

This presentation will focus on the supervisory perspective rather than regulation or policy

Let's start with some definitions to focus the presentation:



As a supervisor, why should we consider networks and/or network analysis

And more definitions (for the purpose of this presentation):

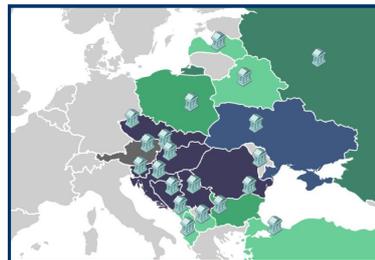
- Micro- vs Macroprudential Supervision
- Systemic Risk
- (Financial) Networks

Macroprudential supervision focusses on the stability of the system instead of individual banks

Micro- vs Macroprudential Supervision:



- Focus on individual banks' risks
- Answering e.g. questions regarding
 - the economic situation of individual banks
 - compliance with legal requirements



- Focus on systemic risk
- Answering e.g. questions regarding
 - system stability
 - contagion risk
 - impact on other sectors

Systemic risk describes the macro perspective of risk management

Systemic Risk, see Cont et al., 2010:

(Systemic Risk) “*is concerned with the joint distribution of losses of all market participants and requires modeling how losses are transmitted through the financial system*” <add:> and beyond.

Operationalizing the definition, at OeNB we look at:

- the common exposures of market participants,
- the collective behaviour of the systems' agents,
- the **intensity of network connectivity**, and
- the economic interactions between financial markets and the macro economy.

Financial networks are a key driver of systemic risk

We consider three types of (financial) networks:

- **Interbank exposure networks**
Characteristics: a network of stocks
Main data source: Central Credit Registries (CCR)
- **Interbank payment networks**
Characteristics: a network of flows
Main data source: payment systems
- **Bank networks inferred from market data**
Characteristics: a network of co-movements
Main data source: equity returns

The remainder of the presentation will focus on four aspects of systemic risk

And finally, the issues we (supervisors) are interested in*):

- The structure of the banking system
- “Early Warning”, i.e. the timely / ex-ante detection of vulnerabilities
- Structural weaknesses and contagion
- Mitigating measures to address systemic risk

***Also refer to the BoE body of work:
Haldane (2009) and Haldane & May (2011)***

**) Issues that can and have been address by means of network analysis*

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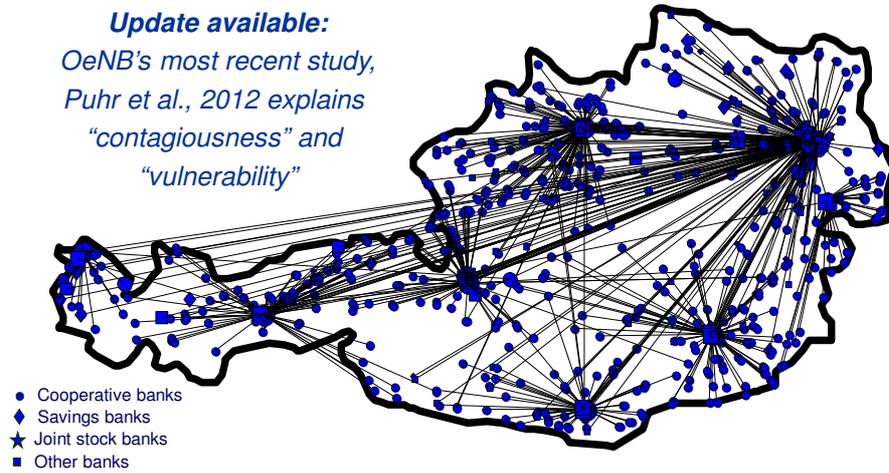
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Mapping the Austrian Banking System

(OeNB interbank exposure analyses, see Boss et al., 2004)

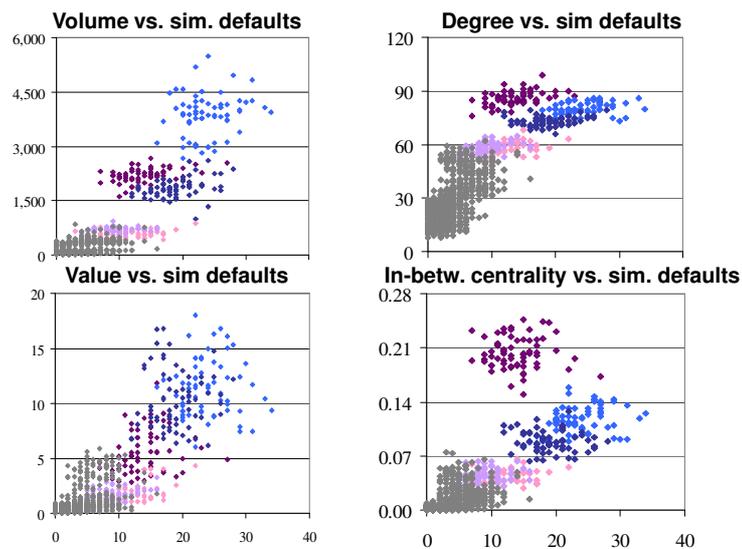
Update available:
 OeNB's most recent study,
 Puhr et al., 2012 explains
 "contagiousness" and
 "vulnerability"



Note: The figure shows for each bank its largest loan exposure to other banks. The size of the marker reflects the size of the bank (small, medium, large and the largest five).

Mapping the Austrian Payment System

(OeNB ARTIS analyses, see Puhr & Schmitz, 2007)

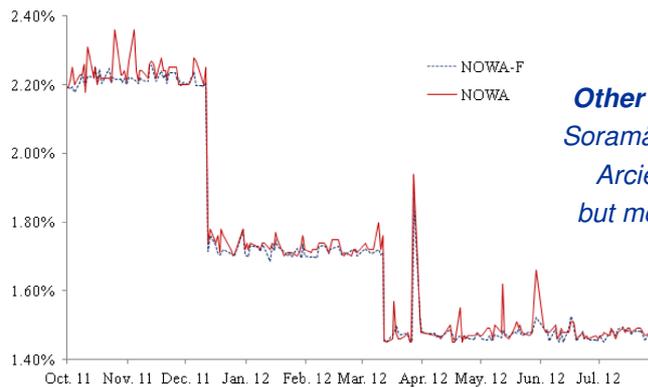


Norwegian Overnight Interbank Rates

(NB interbank lending analysis, see Akram & Christophersen, 2013)

Norwegian overnight interbank rates, from 10-2011 to 7-2012

- Based on the Furfine, 1999, algorithm (NOWA-F)
- Based on daily bank reports (NOWA)



*Other studies of note:
Soramäki's body of work,
Arciero et al., 2013,
but more across NCBs
available*

Where IB exposures or flows cannot be observed, networks can be estimated from public data

Linkages are typically estimated from (equity) price co-movements

- **CoVar** (Brunnermaier, 2011):
 - VaR of the system conditional on the state of one member of the system
 - Systemic risk contribution individual bank: Delta-CoVaR
 - Delta between system VaR when bank i is at its VaR vs at its median
- **SRISK** (Brownlees & Engle, 2015):
 - Expected capital shortfall in case of a systemic stress event
 - Function of size of the firm, its leverage and expected equity devaluation during a market decline
 - SRISK can be aggregated to get total expected capital shortfall of the system
- While both are not network literature in the narrow sense, they can be used to infer networks (e.g. via shrinkage techniques)

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Contagion Risk Assessment

From isolated contagion analyses to stress test integration

- Furfine (2003), first published as BIS WP in 1999
- Eisenberg & Noe (2001)
- Upper & Worms (2004), first published as BuBa WP 2002
- SRM, see Boss et al. and Elsinger et al., both 2006
- RAMSI, see Alessandri et al., 2009
- ARNIE, see Feldkircher et al., 2013

Early contagion models focus on sensitivity-analysis-type default cascades

(for US data, see Furfine, 2003; for DE data, see Upper & Worms, 2004)

Furfine used payment system data to investigate bilateral exposures

- exploits a unique data source of bilateral credit exposures from overnight federal funds transactions
- explores the likely contagious impact of a significant bank failure
- shows that both the magnitude of exposures and the expected LGD are both important determinants of the degree of contagion

Upper & Worms uses BuBa reports and entropy maximization

- use balance sheet information to estimate matrices of bilateral credit relationships for the German banking system
- also explore the likely contagious impact of a significant bank failure
- find that safety mechanisms like the institutional guarantees for savings banks and cooperative banks mitigate contagion

More advanced models include contagion as part of wider macro-stress testing models

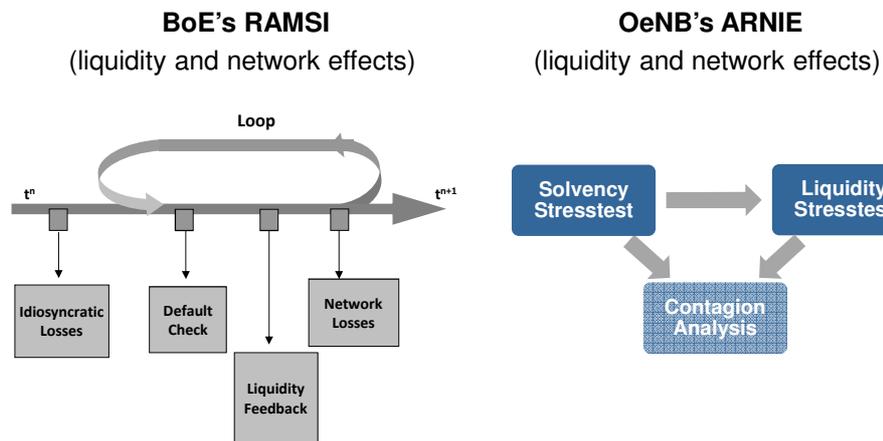
(OeNB Systemic Risk Monitor, see Boss et al., 2006)

Simulation results from a macro-stress test contagion model



Stress Tests with Network Contagion Models are already used as part of Supervisory Exercises

(e.g. BoE's RAMSI, see Alessandri et al., 2009 or
or OeNB's ARNIE, see Feldkircher et al., 2013)



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The idea of Early Warning Systems (EWS) is to signal problems / crises before they occur

Rationale

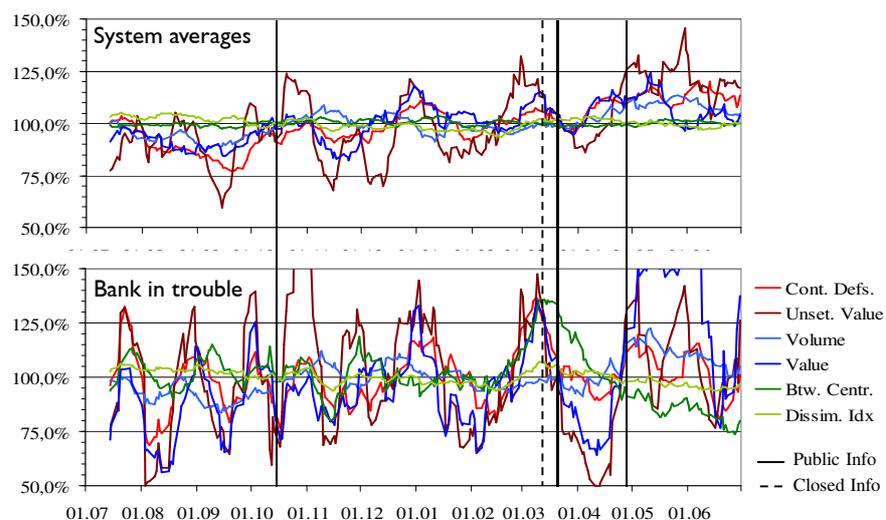
- “Why did we miss the bank failure / financial crisis”?
- Identify (build-up of systemic) imbalance(s) before they unravel
- Allow for counteracting measures / early intervention

Perspective

- There is untapped potential in all three network types
- Frequency of payment system data is as of yet underutilised
- Formal network-based Early Warning Systems almost non-existent

Pre-crisis Failure of a Large Austrian Bank an Attempt at Detecting Signals from ARTIS Data

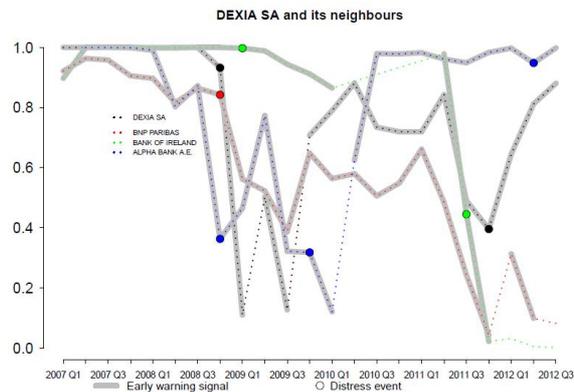
(OeNB event study, unpublished, 2006)



Estimation of a formal Early Warning System including network linkages

(Expansion of an ECB EWS, see Peltonen et al., 2015)

Controlling for common factors, the inclusion of network measures improves signalling power:



Mitigating Measures

Lessons from the crisis

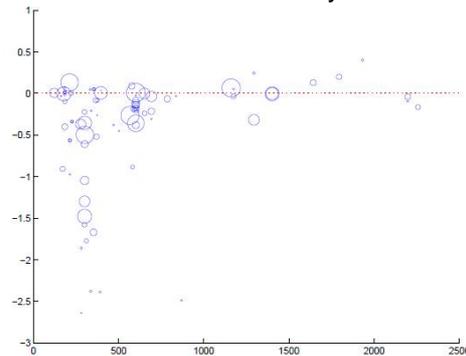
- Non-regulation of systemic risk creates moral hazard (too-big-too-fail)
- Sanctioning of systemic risk contributions is problematic (accountability for other's vulnerability)
- Efforts to dis-incentivise systemic risk contributions are needed

Incentive systems have the potential to significantly reduce the build-up of systemic risk (1/2)

(Lower Large Exposure Limits, see Hałaj & Kok, 2014)

Simulating the impact of inter alia lower large exposure limits

- A reduction in limits leads to substantially less contagious defaults



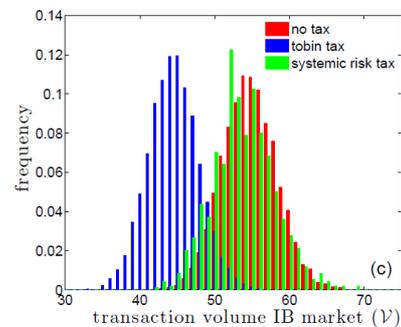
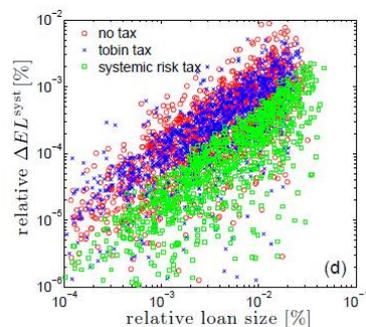
Note: x-axis: CDS spread (in bps). y-axis: difference of CAR after adverse stress testing shock between LE=15% and LE=25% regime (in pp, positive number means that by lowering LE limit contagion losses rise). No CVA adjustment (i.e. $\gamma \equiv 0$). The size of a circle is proportional to a bank's total assets.
Source: own calculations

Incentive systems have the potential to significantly reduce the build-up of systemic risk (2/2)

(Systemic risk tax, see Poledna and Thurner 2014)

Simulating the impact of a systemic risk tax

- Targeted tax can significantly reduce systemic risk
- Impact on transaction volumes is low compared to alternatives



European regulators are beginning to issue binding acts aimed at reducing systemic risk

Example from Austria's Financial Market Stability Board (FMSB):

- “In Austria, supervisors have been able to use macroprudential tools since early 2014. Based on current legislation, they can require banks to **maintain systemic risk buffers**...” (FMSB, 2nd Meeting, Nov 2014)
- “Based on a guideline issued by the European Banking Authority (EBA), the FMSB identified and discussed an initial list of **systemically relevant financial institutions** in Austria.” (FMSB, 23rd Meeting, Feb 2015)
- “Benchmarks include the size of the institution, **its interconnectedness with the financial system**, the ease of substitution, and the complexity of cross-border activities.” (FMSB, 23rd Meeting, Feb 2015)

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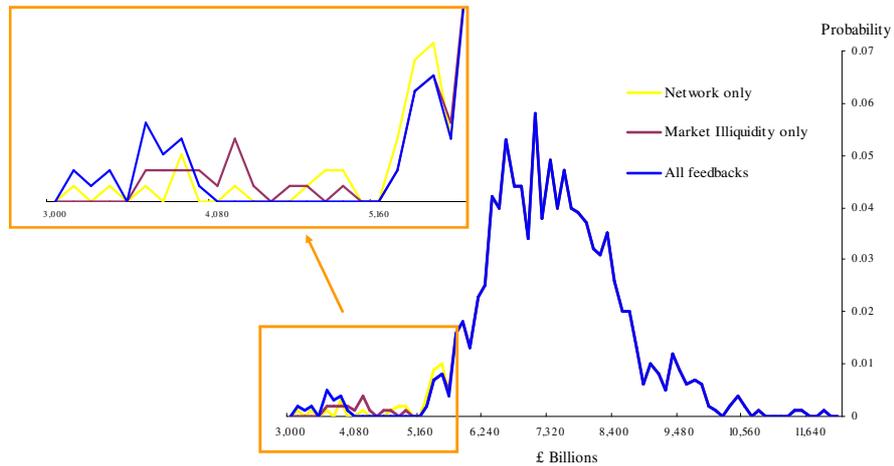
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Focus on network contagion alone is not enough, empirical results from UK stress tests (market liquidity)

(BoE stress tests, see Alessandri et al., 2009)

RAMSI Model Output: Return on Assets, 12 quarter average (in %)



Note: RoA defined as system net profits (including bankruptcy costs) relative to assets.

Focus on network contagion alone is not enough, amplifying effects from common exposures

(Santa Fee simulations, see Caccioli et al., 2015)

Overlapping portfolios and counterparty failure risk

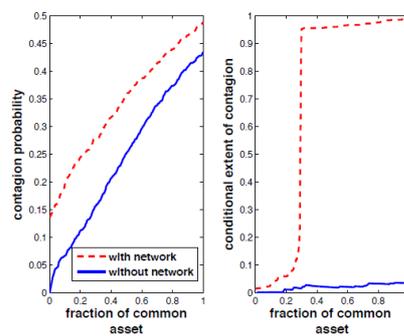


Figure 7: Results of stress tests. Left panel: Contagion probability due to liquidation of the common asset in absence (blue solid line) or presence (red dashed line) of contagion due to counterparty loss. Right panel: Conditional extent of contagion due to liquidation of the common asset in absence (blue solid line) or presence (red dashed line) of contagion due to counterparty loss. The presence of a network of direct interbank exposures can substantially amplify contagion due to liquidation of common assets.

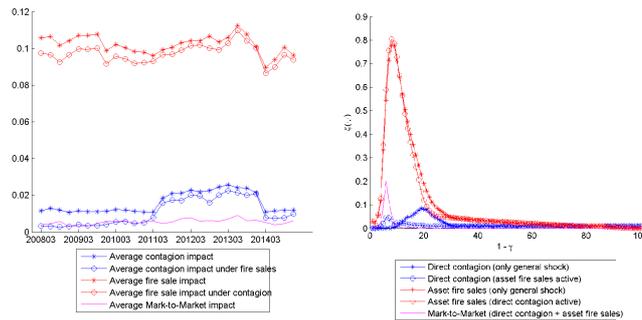
Focus on network contagion alone is not enough, disentangling asset fire sales and mark-to-market losses

(Quantifying contagion channels, see Siebenbrunner 2015)

Impact comparison of different contagion channels

(work in progress, preliminary results!)

- Direct contagion, asset fire sales and mark-to-market effects
- Asset fire sales have by far the highest impact



Focus on network contagion alone is not enough, liquidity hoarding in times of crisis

(Liquidity hoarding, see Gai et al., 2011)

- The authors “*demonstrate both analytically and via numerical simulations how repo market activity, haircut shocks, and liquidity hoarding in unsecured interbank markets may have contributed to the spread of contagion and systemic collapse.*”

<i>Assets</i>	<i>Liabilities</i>
Fixed Assets (A^F)	Retail Deposits (L^D)
‘Collateral’ Assets (A^C)	Repo (L^R)
Reverse Repo (A^{RR})	Unsecured Interbank Liabilities (L^{IB})
Unsecured Interbank Assets (A^{IB})	Capital (K)
Liquid Assets (A^L)	

Conclusions

Main take-aways from today's presentation

- Network analytical descriptive statistics are useful for supervisors
- The same holds for (simple / isolated) contagion analyses
- Both have been used to inform policy makers
- However, an isolated view of networks / default cascades provides limited information gain (potentially underestimates contagion)
- A lot of research has recently investigated these amplifying mechanisms
- However, some areas remain under-researched
 - The most important relates to network's intertemporal dimension (the concept of liquidity risk in network analysis is largely flawed)
 - More broadly, the interaction between different amplification mechanisms

The logo of the Oesterreichische Nationalbank (OENB), featuring a stylized Euro symbol (€) followed by the letters 'ONB'.

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Thank you very much for your attention!

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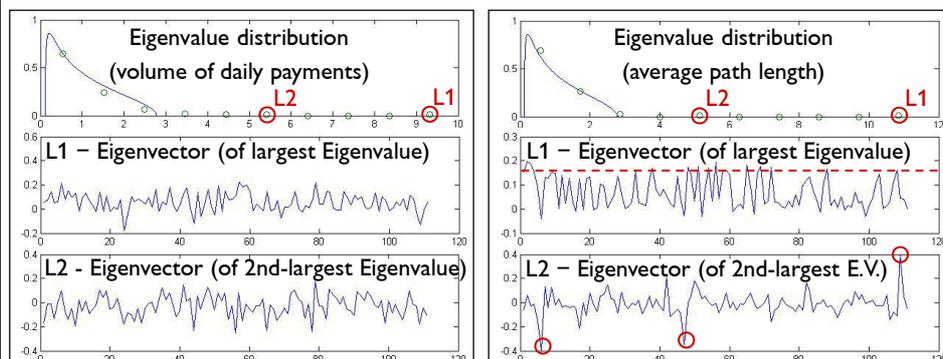
Soramäki, Bech, Arnold, Glass, Beyeler (2007), 'The topology of inberbank payment flows', Physika A, 379:317-33.

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Additional examples, AT payment system data

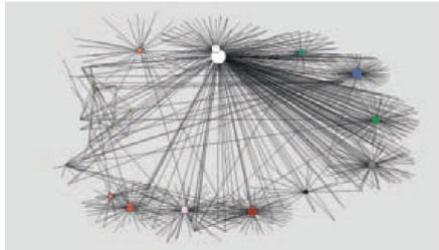
(OeNB ARTIS analyses, see Kyriakopoulos et al., 2009)



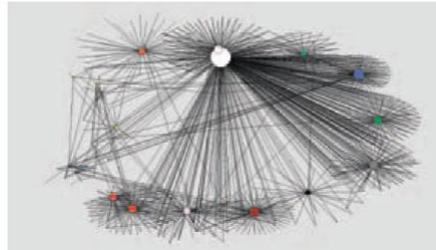
Additional examples: AT Banking System

(OeNB interbank contagion analyses, see Puhr et al., 2012)

Contagiousness Network as at End-2008



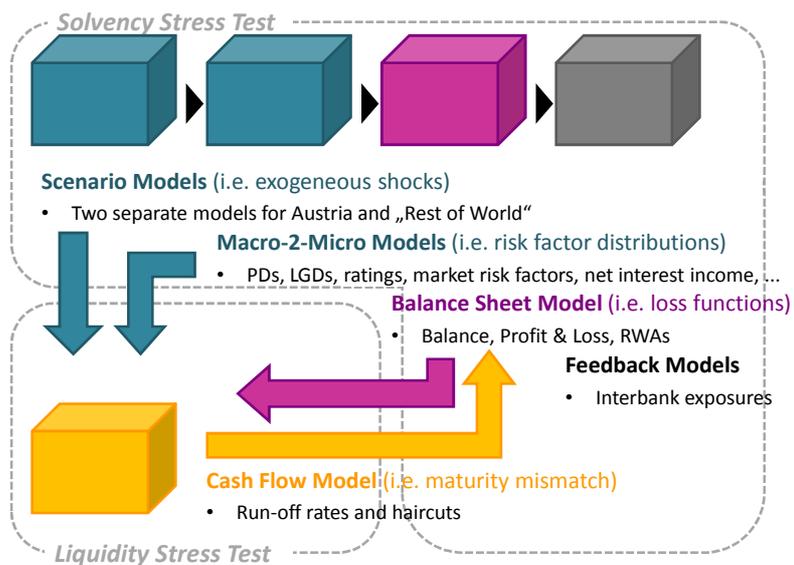
Contagiousness Network as at End-2011



Source: OeNB calculations

Background: current stress testing models

(OeNB's stress testing model, see Puhr & Schmitz, 2013)



Background: Early Warning Systems

(ECB EWS, see Lo Duca & Peltonen, 2013 and Betz et al., 2014)

Typical setup of early warning model

- Vulnerability measure (typically based on panel regressions)
- Signalling thresholds (typically based on loss functions)

