



EUROPEAN CENTRAL BANK

BANKING SUPERVISION

Systemic Risk in Finance Public Lecture Series

Lecture 1
Systemic risk and networks

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Agenda

Lecture 1

1. Systemic risk: definitions to lay foundations for describing quantitative methods
2. Financial system as a network: graph representation of connectivity

Lecture 2

1. Partial information: Financial network (re)construction methods
2. Systemic risk measures: simple (mathematical) tools to capture systemic risk

Lecture 3

1. Shock transmission in financial network: contagion mechanisms and simulations
2. Financial agents' behaviors and emergence of systemic risk: Portfolio choice, ALM, and endogenous systemic risk

Lecture 4

1. Stress Tests and calibration of macroprudential measures
2. Ways forward – complex financial system as a whole, its regulation and open questions

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Systemic Risk

Systemic risk – one of key concerns of interconnected global financial system

- Banks, and other financial institutions are part of a tight, international network – global or regional, depending on business needs
 - Benefits: risk transfer and risk sharing, cost efficiency, diversification and competition
- However, this financial network creates a systemic risk, i.e., risk that a shock, distress, instability in one part can impact other parts of the financial system
 - Interbank losses incurred by bank A leading to losses of bank B holding equity of A
 - Losses of a bank in one region can imply cutting lending in another
- We want to measure this risk
 - Risk regulation and management adapted methods based on a **graph representation** of the financial system

Systemic risk – phrase embedded into the public vocabulary, became commonly used

“Wall Street watchdog says private credit is ‘not a systemic risk’”

Source: Financial Times, 2026

Federal Reserve Chairman Ben Bernanke said “systemic risk” can be broadly defined, including unsafe amounts of leveraging by banks, gaps in regulatory oversight and the possibility that the failure of a large interconnected firm could lead to a breakdown in the wider financial system.

Source: Wall Street Journal, 2009

As we have learned, **systemic risk** may stem from any part of the financial system, including the shadow banking sector. That is why we also need more data to monitor unregulated financial institutions and markets.

Source: Mario Draghi, 2012

We are also announcing a similar systemic risk exception for Signature Bank, New York, New York, which was closed today by its state chartering authority. All depositors of this institution will be made whole. As with the resolution of Silicon Valley Bank, no losses will be borne by the taxpayer.

Source: FDIC, March 2023

Like all forms of financial intermediation, NBFIs can entail financial vulnerabilities, which – if left unchecked – can lead to a build-up of systemic risk.

Source: Strengthening the macroprudential lens in the regulation of non-bank financial intermediation. May 2026(!)

The ESRB contributes to preventing or mitigating systemic risks through the use of “soft powers”. In particular, it may issue warnings or recommendations to address significant systemic risks to financial stability in the European Union. The ESRB then monitors the follow-up to its warnings or recommendations and analyses if, and to what extent, the systemic risk has been mitigated.

Source: European Systemic Risk Board

Definitions – systemic risk in spotlight after GFC*

Definition	Key features	Source	Year	(Journal)
Following the work of the IMF, FSB and BIS for the G20, "a risk of disruption to financial services that is caused by an impairment of all or parts of the financial system and has the potential to have serious negative consequences for the real economy ."	2007-2008 GFC-rooted concern in the events with widespread consequences; distinguish investment risk for a firm from its consequences to broader market, incl. real economy	BIS	2010	
Risk of experiencing a strong systemic event, effecting a range intermediaries or makets, important for the whole (financial) system	No commonly accepted definition; triggers can be exogenous (idiosyncratic) to the financial system or can emerge endogenously	ECB Financial Stability Report	2010	FSR
Implicitly: systemic risk is a risk of failure of its component that would have adverse impact on the real economy and the internal (EU) market	There are institutions that have an objectie to set policies helping to mitigate systemic risk	REGULATION (EU) No 1092/2010 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL	2010	Official Journal of the European Union
Systemic risk is the risk of threats to financial stability that impair the functioning of a large part of the financial system with significant adverse effects on the broader economy	Real side of the economy must be impacted to call a risk systemic. Challenging to distinguish from transmission of shocks from endogenous consequences of risk-taking, or rational adjustments based on news from panic. Cyclical (related eg to credit booms or asset price bubbles) and cross-sectional (direct and indirect spillovers). Real side impacted via impaired financial services: provision of payment services, risk-sharing and management, and credit supply.	Freixas	2015	Book (MIT)

*) Global Financial Crisis (2007–2009)

Definitions – more mature take

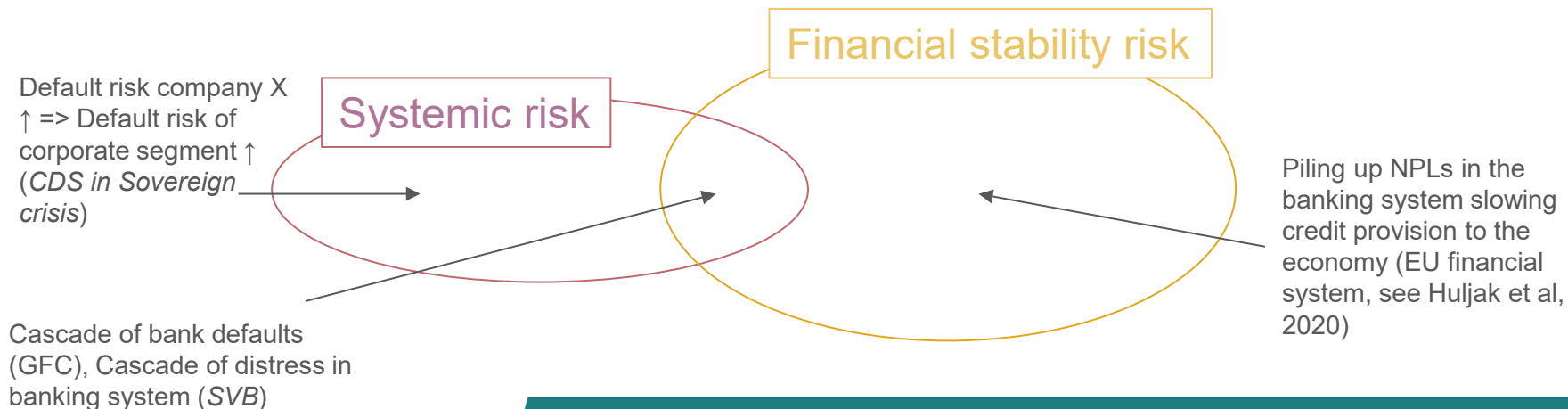
Definition	Key features	Source	Year	(Journal)
Undercapitalization of the financial sector as a whole is assumed to harm the real economy, leading to a systemic risk externality	System is a combined environment of financial and real sectors. Vulnerability of the financial system harm the broader economy, so this transmission can be interpreted as systemic impact. Risk of it is then systemic risk	Acharya	2016	Review of Finance
The distinction [with individual risk] lies in the aggregate nature of systemic risk, i.e. a risk that manifests itself at the level of the financial system as a whole.	Individual institutions are large or numerous to create systemic risk	Butzbach	2016	Policy and Society
Breakdown of an entire system rather than simply the failure of individual parts	Risk of cascades of failing institutions, related to linkages	CFA Institute	2022	
We have gained a sharper understanding of the systemic vulnerabilities in our financial system. The last 15 years have underscored the importance of financial stability as a cornerstone for effective central banking.	But a question: Is systemic risk a risk of financial instability?	Olli Rehn	2024	Speech at BIS

Definitions – drivers and omnipresence

Definition	Key features	Source	Year	(Journal)
Impaired financial institutions cut on intermediation, with adverse impact on real economy	Impaired financial firms amplify shocks to real economy	Acharya, Brunnermeier	2025	NBER
Systemic financial risks typically stem from five categories: liquidity mismatches, common exposures, interconnectedness , lack of substitutability and leverage .	A catalogue of channels	ESRB	2025	
Cyclical : related to excessive debt growth and leverage, instable funding AND structural : interconnectedness, concentration, incentives shaping behaviours	Systemic risk depend on the structure of the financial system, i.e., may not be present in the NBFIs sector	National Bank of Poland	2025	Financial Stability Report
Crypto-investment products (CIPs) has introduced new drivers of systemic risks and contagion. A key concern is that risks in the CIPs market will spill over to the traditional financial system, undermining its critical intermediation role for the real economy .	Systemically important crypto intermediaries (e.g., in US T-bills); credit institutions issuing/ sponsoring crypto subject to shocks compromising their role in payment systems; bail-outs of the crypto issuers/ holders (sic!)	ESRB	2025	Crypto-assets and decentralised finance - report

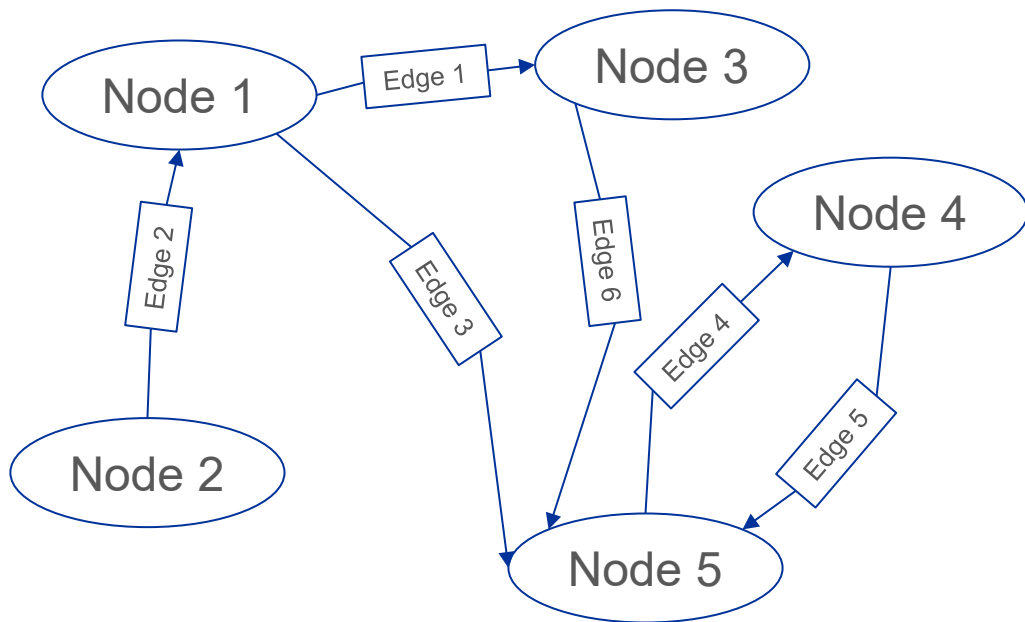
Is systemic risk a risk of financial instability?

- Financial stability risk = risk of financial instability
- Financial stability = “a condition in which the financial system – which comprises financial intermediaries, markets and market infrastructures – is capable of withstanding shocks and the unravelling of financial imbalances”, ECB

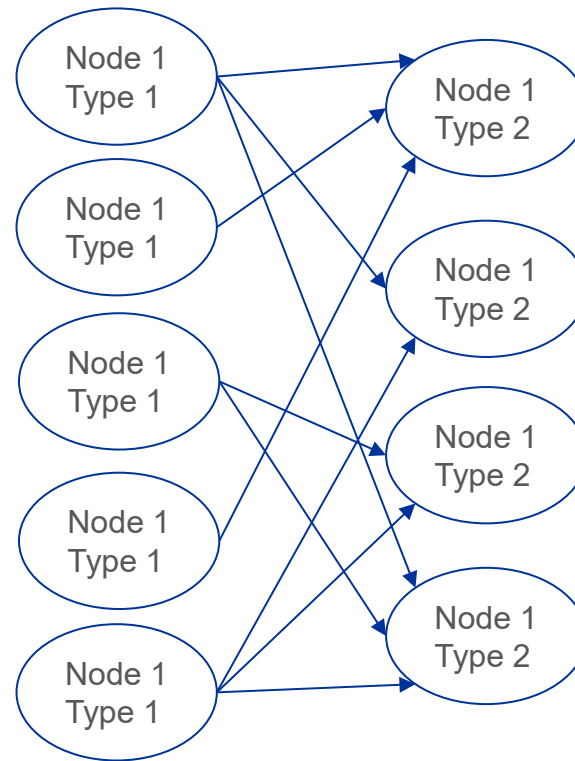


Network representation

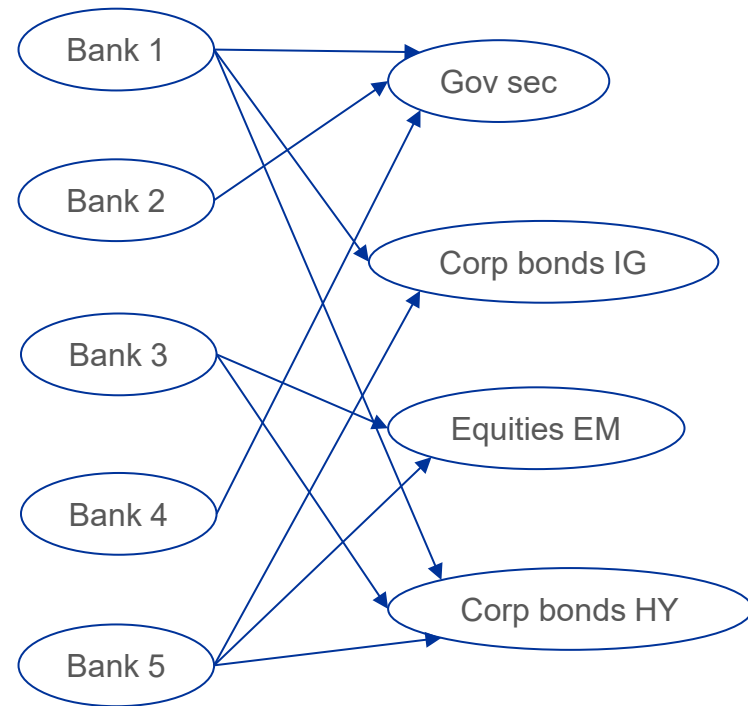
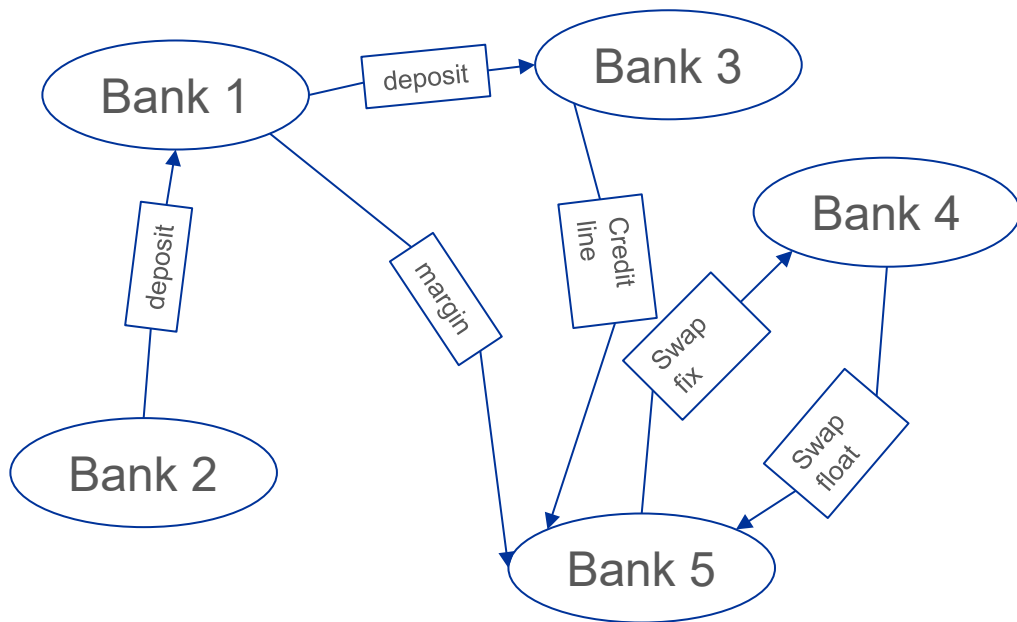
Financial system can be represented as a network



Network \equiv Graph \equiv (Nodes, Edges)



...and can be tailored to a sub-system at hand, depending on the analytical needs



Network ≡ Graph ≡ (Nodes, Edges)

Why is this a useful representation of the system?

Micro perspective:

- Who is the client or who provides funding?
- Are counterparties concentrated or diversified?

Macro perspective:

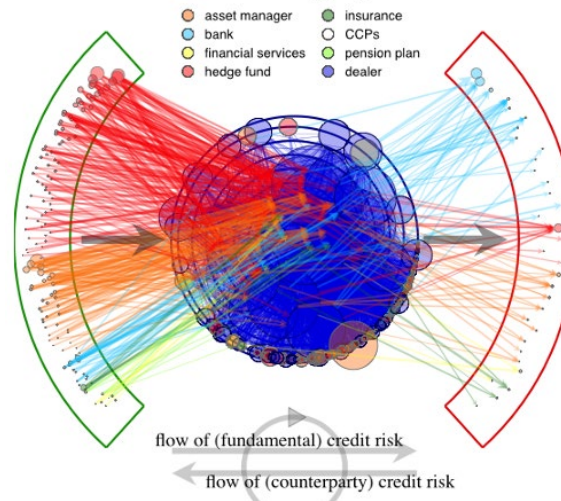
- What is the structure of the market?
- What are the risk transmission mechanisms within financial systems?
- Failure of which financial institution (FI) can cause trouble for other FIs?
Are there pockets of **vulnerable** banks?

Structural vulnerabilities?

FSB*: “*structural weaknesses in the financial system (such as misaligned incentives, amplification mechanisms or other forms of potential market stress)*”

- Structure of the linkages can indicate how much systemic risk is in the system

Some structures are known for proneness to spread and amplify shocks more than the other, for instance, a bow-tie structure

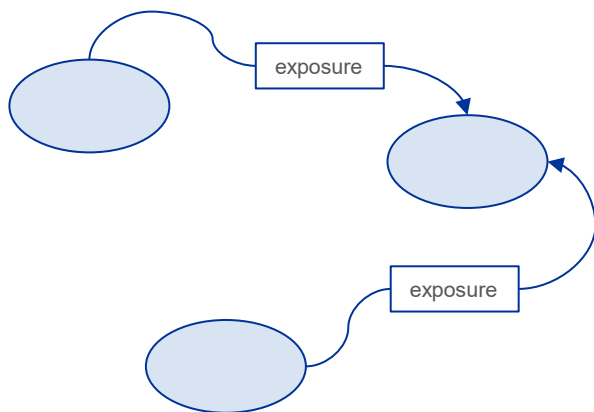


Source: D’Errico et al. (2017)

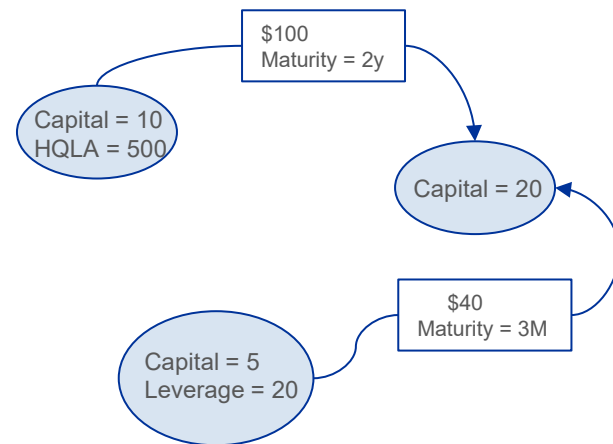
*) Financial Stability Board

Choice of the right network representation

- Characteristics of nodes and links implied by objectives of the analysis:
 - Banks or sectors? Capital or liquidity buffer?
 - Transactions or positions?

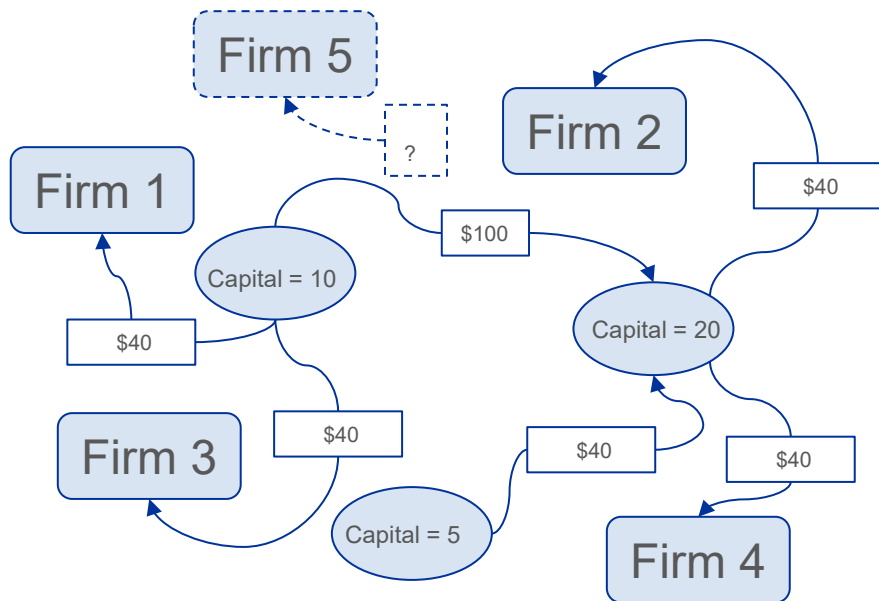


Structure of connection in the interbank...

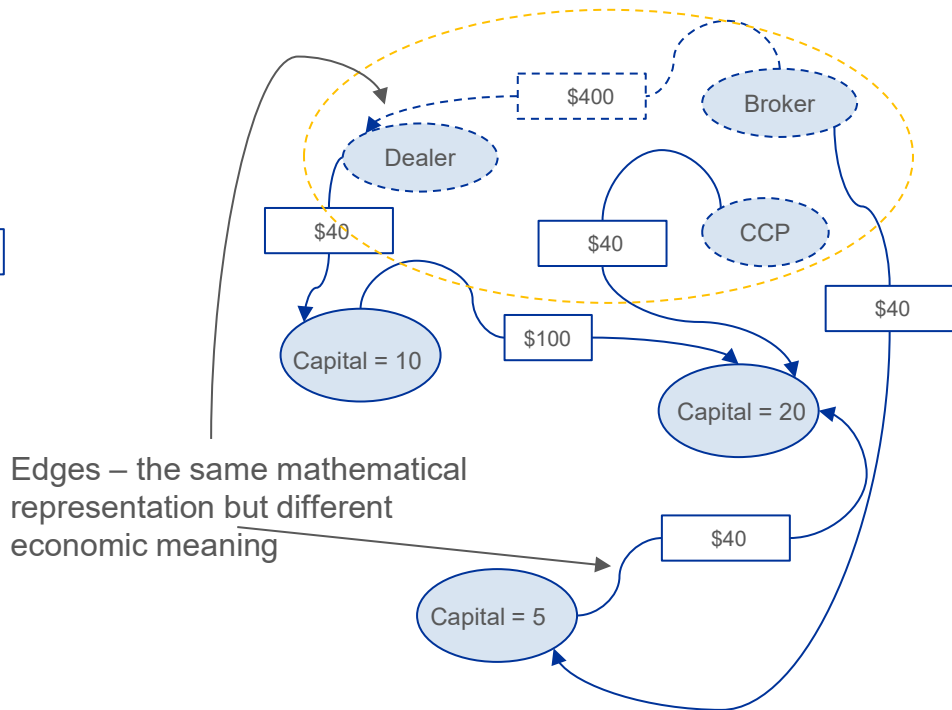


... And characteristics of the FIs and linkages

The network representation can capture linkages beyond banking system



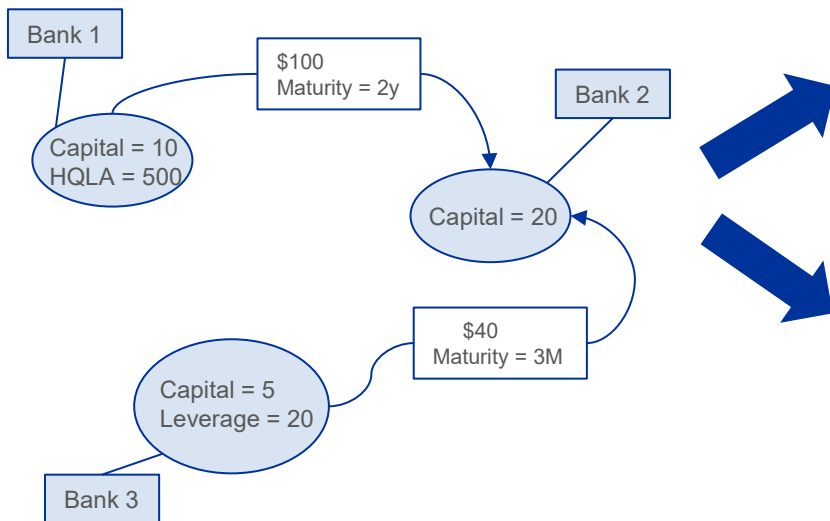
Bank-corporate network



Edges – the same mathematical representation but different economic meaning

Multilayer networks of financial institutions

Structural measures – basics



Adjacency matrix,
indicating whether
there is a link or not

$$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

Weighted adjacency
matrix, indicating
whether there is a link
or not and what is a
measurable property
of the links

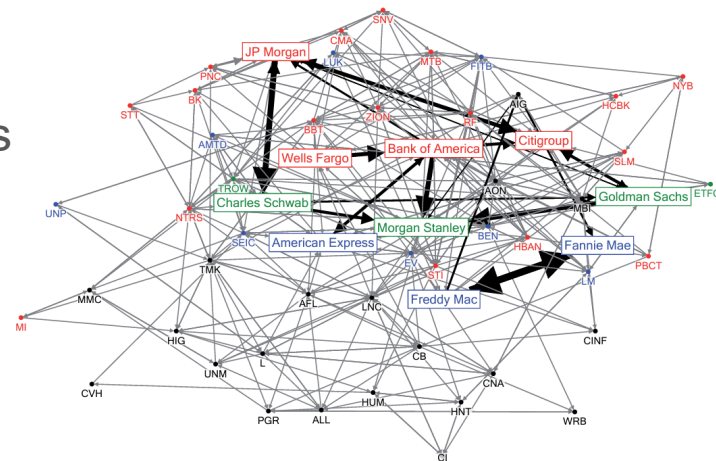
$$\begin{bmatrix} 0 & 100 & 0 \\ 0 & 0 & 0 \\ 0 & 40 & 0 \end{bmatrix}$$

Exposure data to represent contractual linkages

- Transactions create a network of exposures between financial and non-financial market participants
 - (i) Deposit placement from bank A to bank B; (ii) bond issued by bank A purchased by bank B; (iii) interest rate swap exchanging fix payments of bank A to bank B in exchange of float payment from B to A
- They help to share and transfer risk but also spread contagion
 - (i) Default of bank B leading to a fraction of deposit to be lost; (ii) deterioration of credit quality of bank A leading to revaluation losses in bank B assets; (iii) cash-deprived A leading to a delay in fixed payment or an increase in interest rates worsening net cash of B

Interconnectedness seen in the market data

- Market movements should reflect fundamental links
- See [Craig et al. \(2023\)](#)
- Prices are correlated, esp., when things “go south”
- E.g., equities or indices for equities
- Derivative, for instance Credit Default Swaps
- Not only prices carry information on contagion
- Credit ratings, and relatedly, Default Probabilities
- Volatility of prices



From Hautsch, Schaumburg, Schienle (2015), showing impact of extreme return of banks i on Value-at-Risk of bank j

What instead of market data?

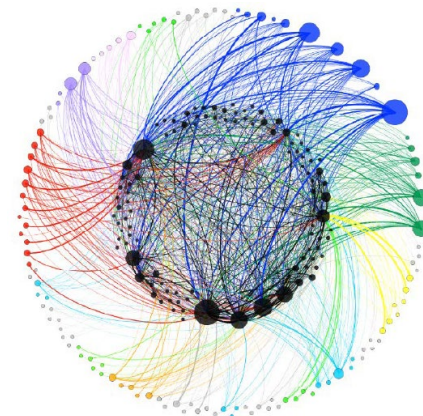
- Network of contractual or balance sheet exposures
 - Deposits between banks
 - Payments (+public ledgers, DTLs)
 - Trade between countries or sectors
 - Political networks
- News-based
 - FIs mentioned in the same article or tweet, indicating not only a fundamental link but a sentiment-based one as well (similarity of institutions perceived by the market)

Payments data

- From payments systems, like European Target 2
- Each day, 400K transactions daily, creating a time series
- Patterns can be discerned and can be used to predict the structure of the network of payments and...
- ...which node may be critical, i.e., payments of other participants depend on this node's activity (payment timing, delays)
- Econometric models and simulation models (e.g., Finnish Payment System [Simulator](#))

Interbank direct exposures

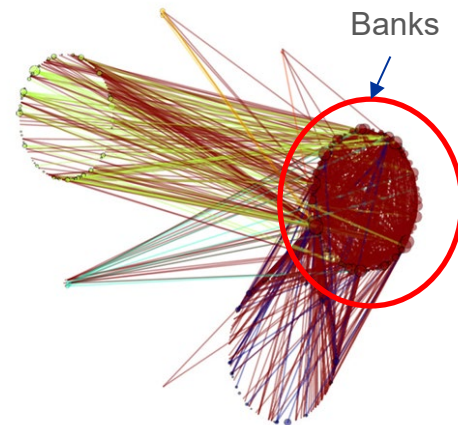
- Banks fund themselves through deposits and placements or manage liquidity in the interbank
 - Initially, a more prominent market but limited by large exposure limits and central bank funding
- Moreover, banks use own debt issued and equity cross holdings to manage balance sheet structure
- Data on this typically collected by supervisors, e.g.:
 - Canada: OSFI EBET return (supervisory returns)
 - Europe: COREP large exposure data



Cross-border exposure of EU banks, based on COREP C.27-C.28
Source: [Covi et al \(2021\)](#)

Derivative exposures

- Banks hedge themselves
 - Interest rate risk through interest rate swaps, or swaptions
- Exposure via contractual payments or by margin requirements, also vis-à-vis CCPs
- Data from trade repositories:
 - Europe: EMIR data (vast, difficult to reconcile and clean, since the reporting is not straightforward)
 - US: CDCC



Exposures between FIs related to CDS contracts for the EU sovereign debt
Source: Halaj, Peltonen, Scheicher (2018)

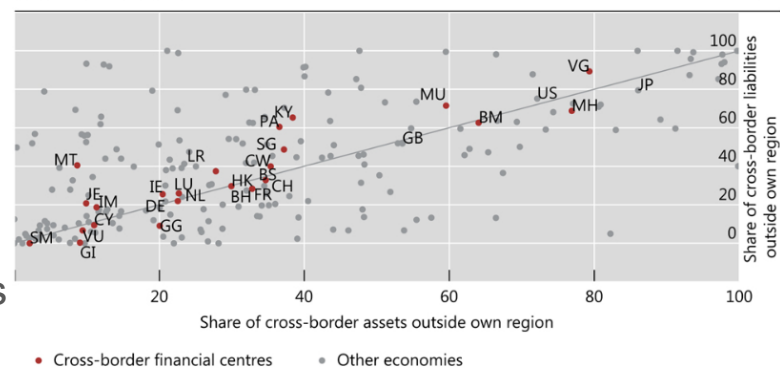
Bi-partite network of exposures to asset

- FIs connected through exposures to common asset classes
 - Commonality in gains and losses via changes in market prices
 - Or selling assets (esp., fire sales)
- Data in securities holding statistics:
 - Europe: SHS data
 - or, in supervisory reporting:
 - EU and Canada: geographical location of assets
- Or market data:
 - Lipper (LSEG Data): assets holdings by investment funds

Most cross-border financial centres have a regional focus

Share of cross-border banking business with counterparties in other regions, at end-2021

Graph 5

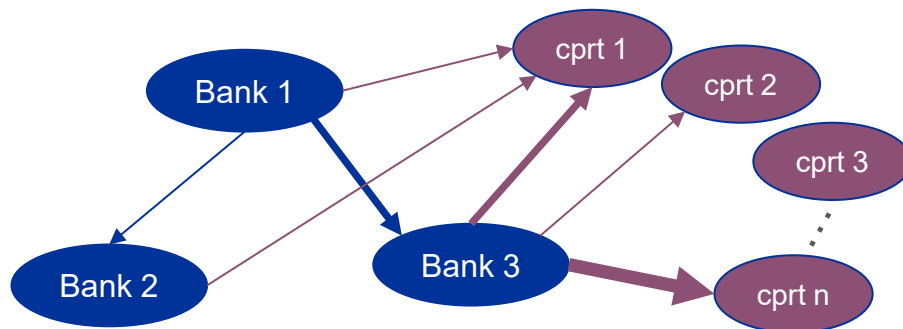


<https://data.bis.org/topics/LBS#research-publications>

Case study: interconnectedness of counterparties

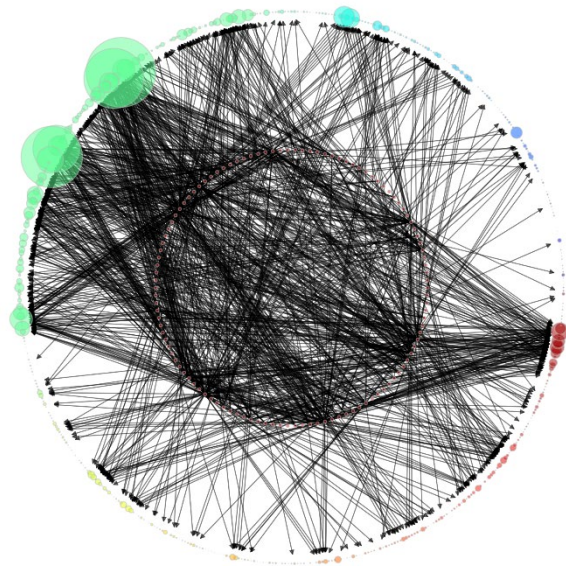
Regulatory reporting in EU:

- COREP, tables 27 (large exposures) and 28 (exposures in non-trading and trading book), including information about economic sectors (NACE) => interbank exposures, i.e., deposits and placements
- FINREP: table 20.04 (geographical breakdown of exposures, considering central banks, central government, credit institutions, other financial institutions, and non-financial corporations)



cprt=counterparty, i.e., financial entity

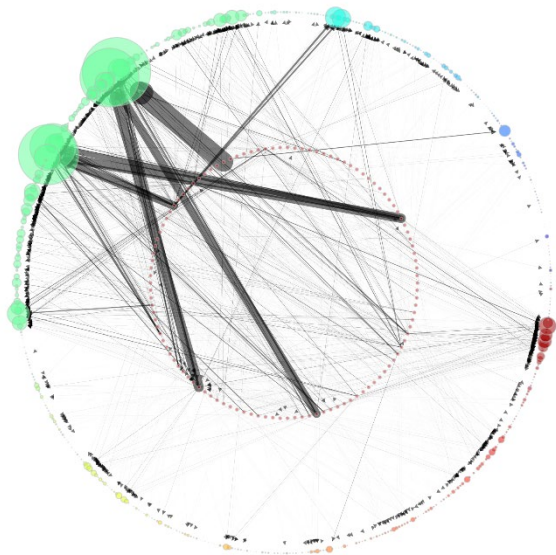
Counterparties mainly in EU countries but also G7



- Inner circle: reporting banks
- Outer circle: external counterparties, colours indicating countries
- A link if there is an exposure, no matter what size
- Exposures unevenly distributed but what if size of exposures is depicted...

Source: COREP 27, 28 and FINREP 20.04

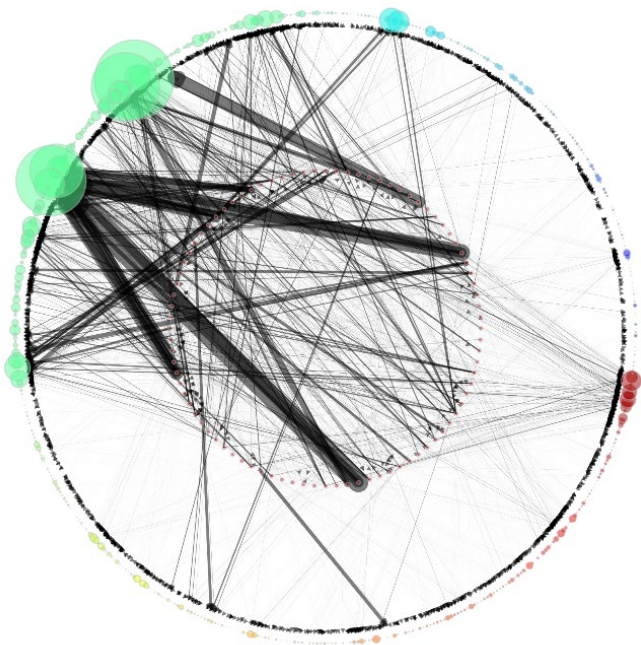
Concentration of exposures when looking at volumes in EUR



Source: COREP 27, 28 and FINREP 20.04

- Inner circle: reporting banks
- Outer circle: external counterparties, colours indicating countries
- ...Exposure-weighted graph showing material concentration of a small subset of banks into a small subset of exposures in... a small subset of countries
- But the size of exposure may only matter more if it is large relative to the size of the FI...

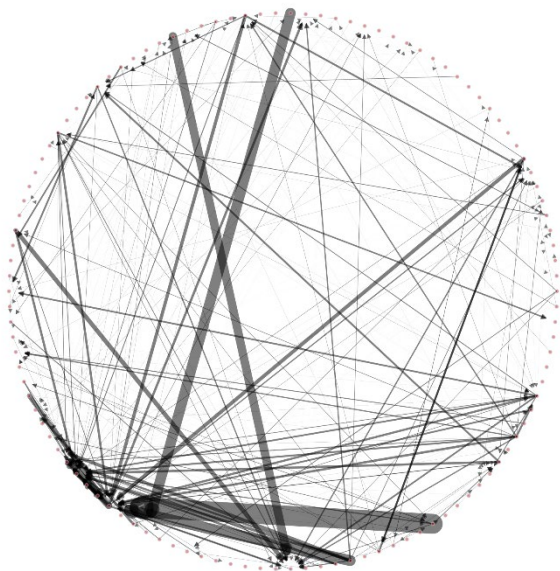
Leveraged exposure a measure of vulnerability



- Inner circle: reporting banks
- Outer circle: external counterparties, colours indicating countries
- Leverage exposure, i.e., exposure divided by capital of the financial institution.
- Picture largely consistent with the previous one but many more FI with significant exposures

Source: COREP 27, 28 and FINREP 20.04

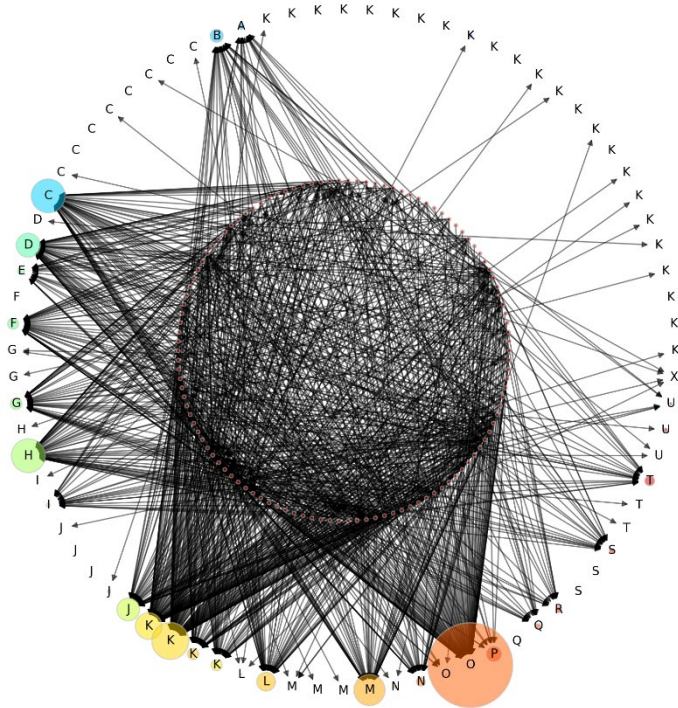
Interbank network



- Inner circle: reporting banks
- Outer circle: external counterparties, colours indicating countries
- Zooming into the interbank market...
- ...that reveals that in a sub-segment of the financial system different players may stand out as most interconnected (more important for functioning of the market?)

Source: COREP 27, 28

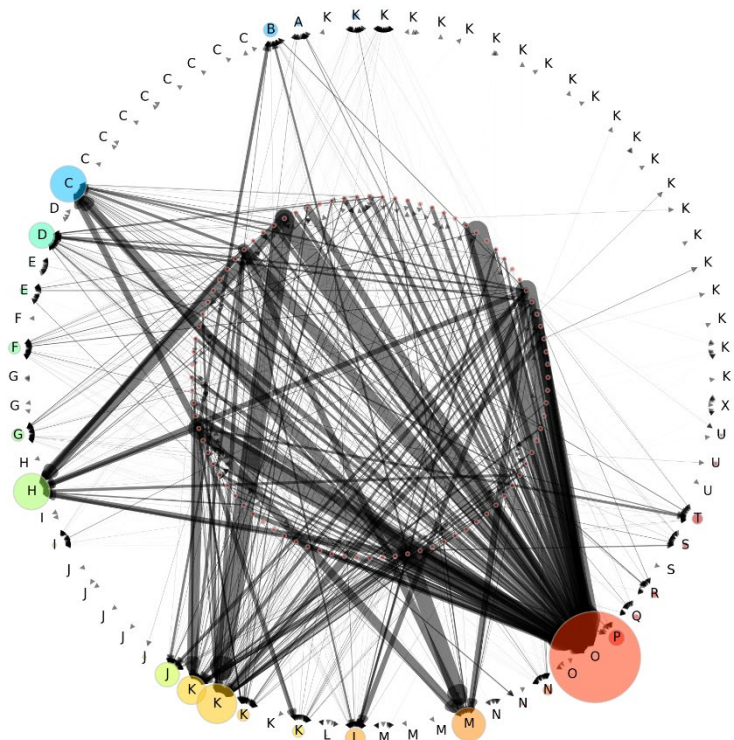
Exposure to sectors



- Inner circle: reporting banks
- Outer circle: external counterparties, colours indicating countries
- Another dimension to capture concentration – exposure to economic sectors, showing unweighted graph (a link if there is an exposure, with undifferentiated width)...

Source: COREP 27, 28 and FINREP 20.04

Exposure to sectors



Source: COREP 27, 28 and FINREP 20.04

- Inner circle: reporting banks
- Outer circle: external counterparties, colours indicating countries
- ...And with leverage exposure metric (i.e., width proportional to exposure/capital)

What have we learned?

- ❖ **What is systemic risk?**
- ❖ **How to use graphs to represent the financial system...**
- ❖ **...such that we have a model to be explored to measure systemic risk**