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WARWICK BUSINESS SCHOOL
THE UNIVERSITY OF WARWICK

For the Change Makers

Ram Gopal
Pro-Dean for Research and
Professor of Information
Systems & Management

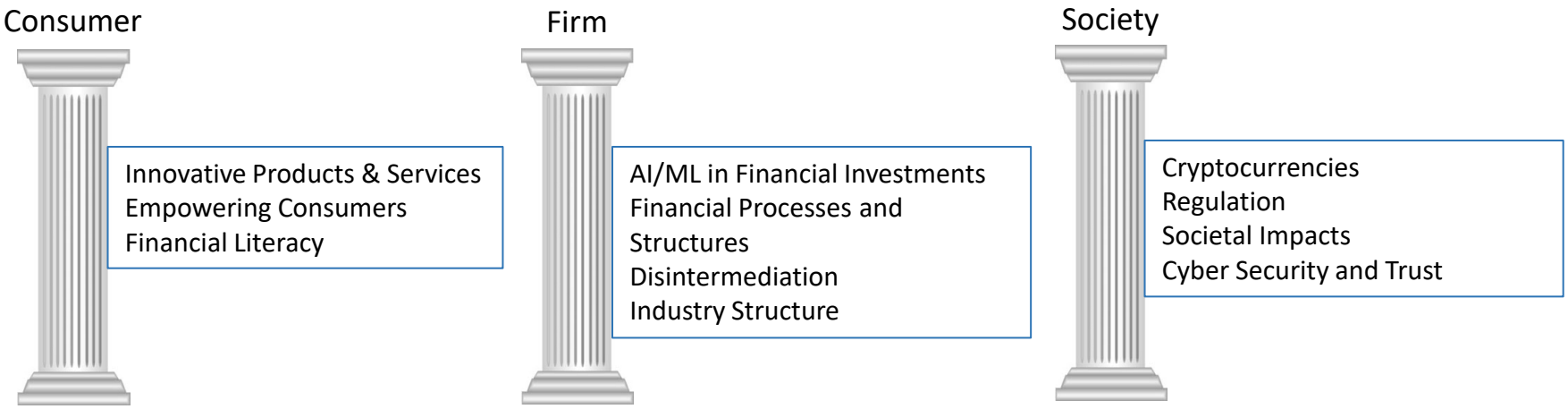
March 17, 2021

Gillmore Centre for Financial Technology Webinar

Systemic Risk in Financial Networks: Structural sources and solutions

Bazil Sansom

Gillmore Centre for Financial Technology



Recent Events

The End of Investment Management as we know it
https://warwick.ac.uk/fac/soc/wbs/subjects/ism/gillmore_centre/webinar/

Beyond the Hype: Investment-AI and Machine Learning
https://warwick.ac.uk/fac/soc/wbs/subjects/ism/gillmore_centre/

Blockchain Symposium: Financial Services and Beyond
https://warwick.ac.uk/fac/soc/wbs/subjects/ism/gillmore_centre/webinar_2/

Gillmore Centre Symposium on Central Bank Digital Currencies with Bank of England

Date: 7 May 2021: 2:00-4:00PM

Speakers:
Simon Collins, Senior Vice President of Franchise Innovation at Mastercard
Darrell Duffie, Adams Distinguished Professor of Management and Professor of Finance at Stanford University's Graduate School of Business

Central banks worldwide are in the process of developing and launching initiatives to provide their sovereign currencies in a digital form. Such central bank digital currency (CBDC) has the potential to profoundly reshape the landscape for financial and payments systems globally. Simon Collins will discuss Mastercard's learnings from managing the orchestration of multi-sided payment ecosystems and the principles that may be applied to developing CBDCs. Darrell Duffie will overview some of the motives and implications of China's Digital Currency Electronic Payment System (DC/EP).

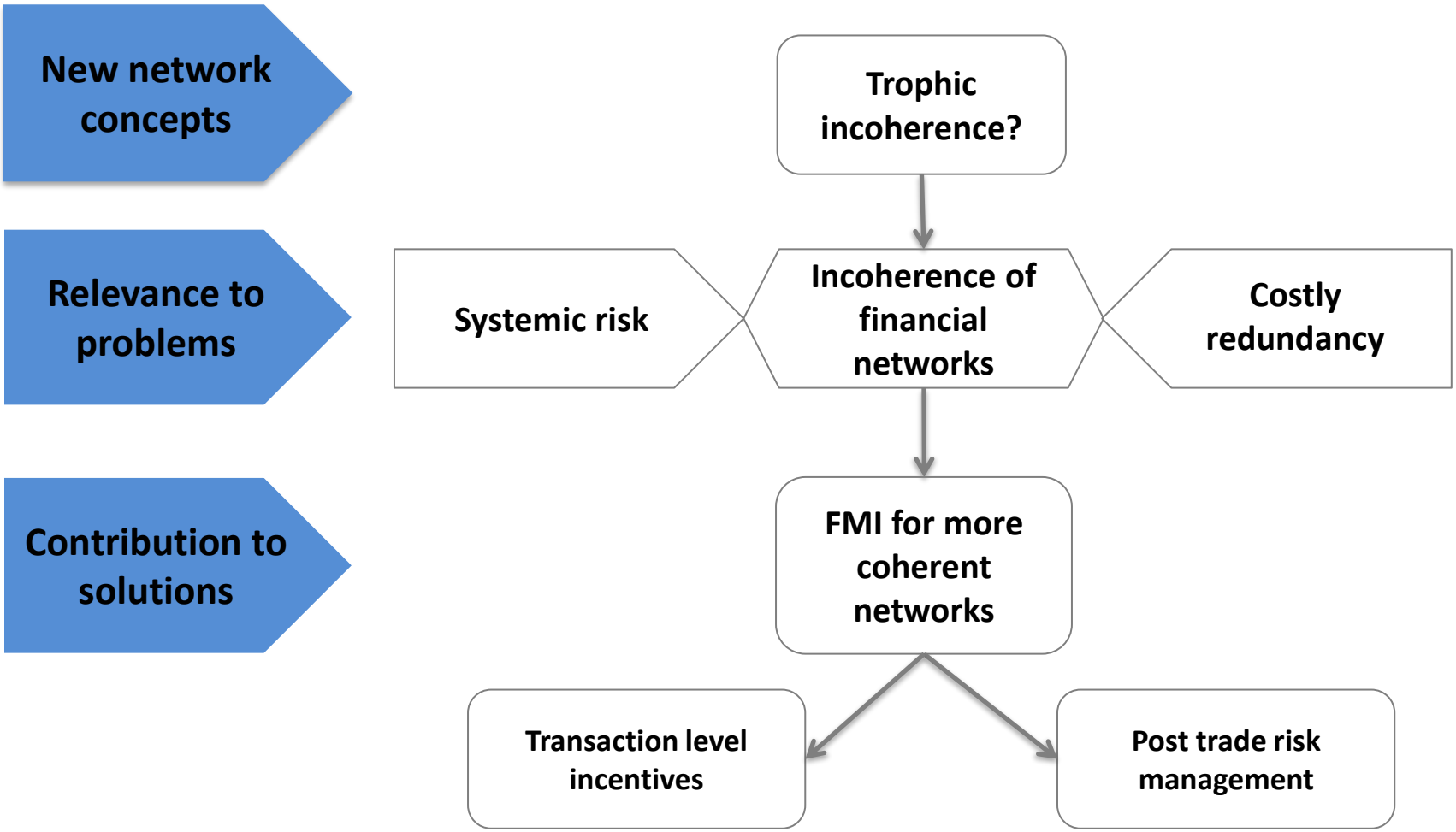
Gillmore Centre Webinar IV:

Systemic Risk in Financial Networks:
Structural sources and solutions

Bazil Sansom

University of Warwick

The plan


New network concepts
Relevance to problems
Contribution to solutions
Trophic incoherence?
Systemic risk
Incoherence of financial networks
Costly redundancy
FMI for more coherent networks
Transaction level incentives
Post trade risk management

Trophic incoherence drives systemic risk in financial exposure networks.

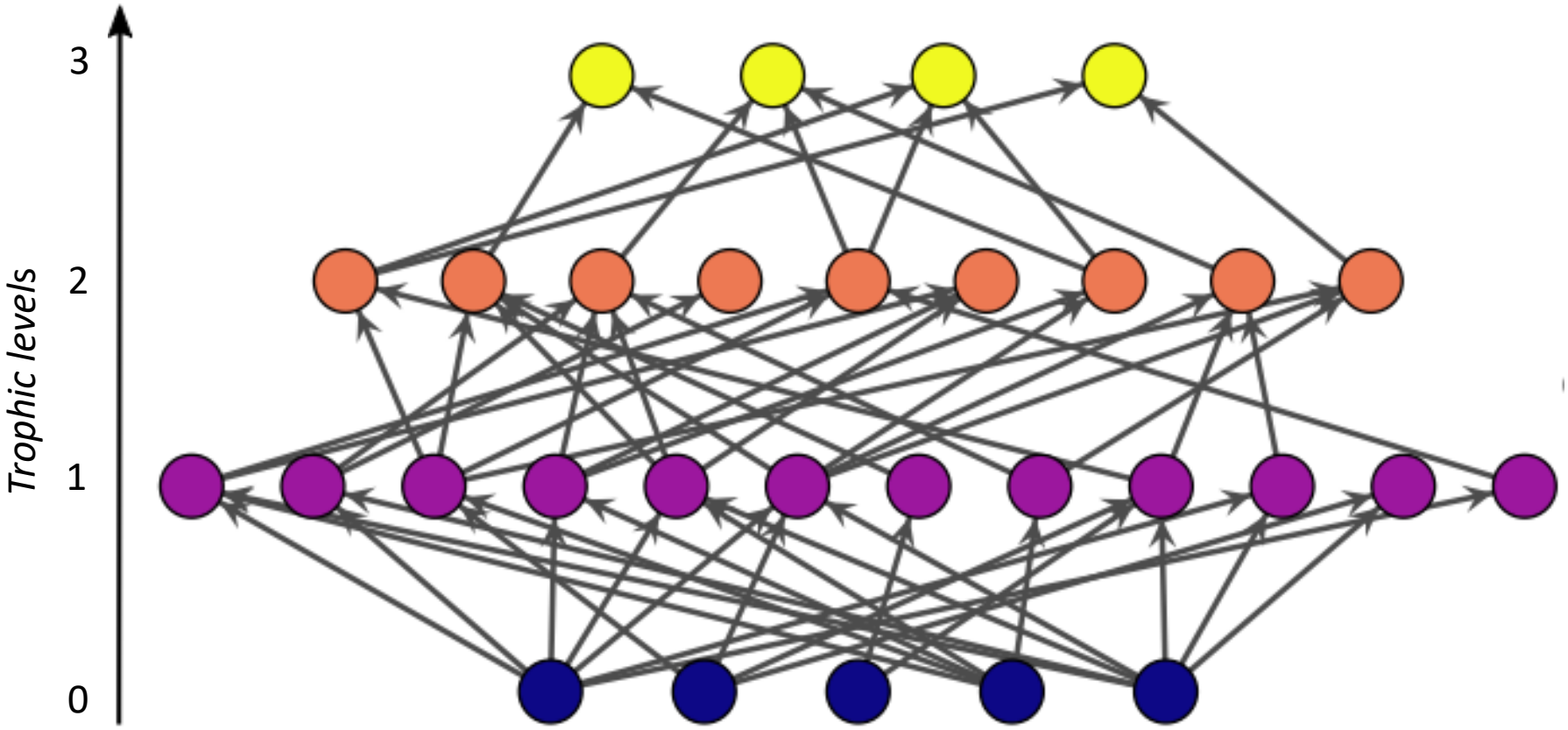
- Joint work with **Robert MacKay** (Warwick) and **Sam Johnson** (Birmingham)

- Supported by the **ESRC** via the *Instability Hub* of the **Rebuilding Macroeconomics** program at the National Institute of Social and Economic Research (NISER).

What is *trophic-coherence*?

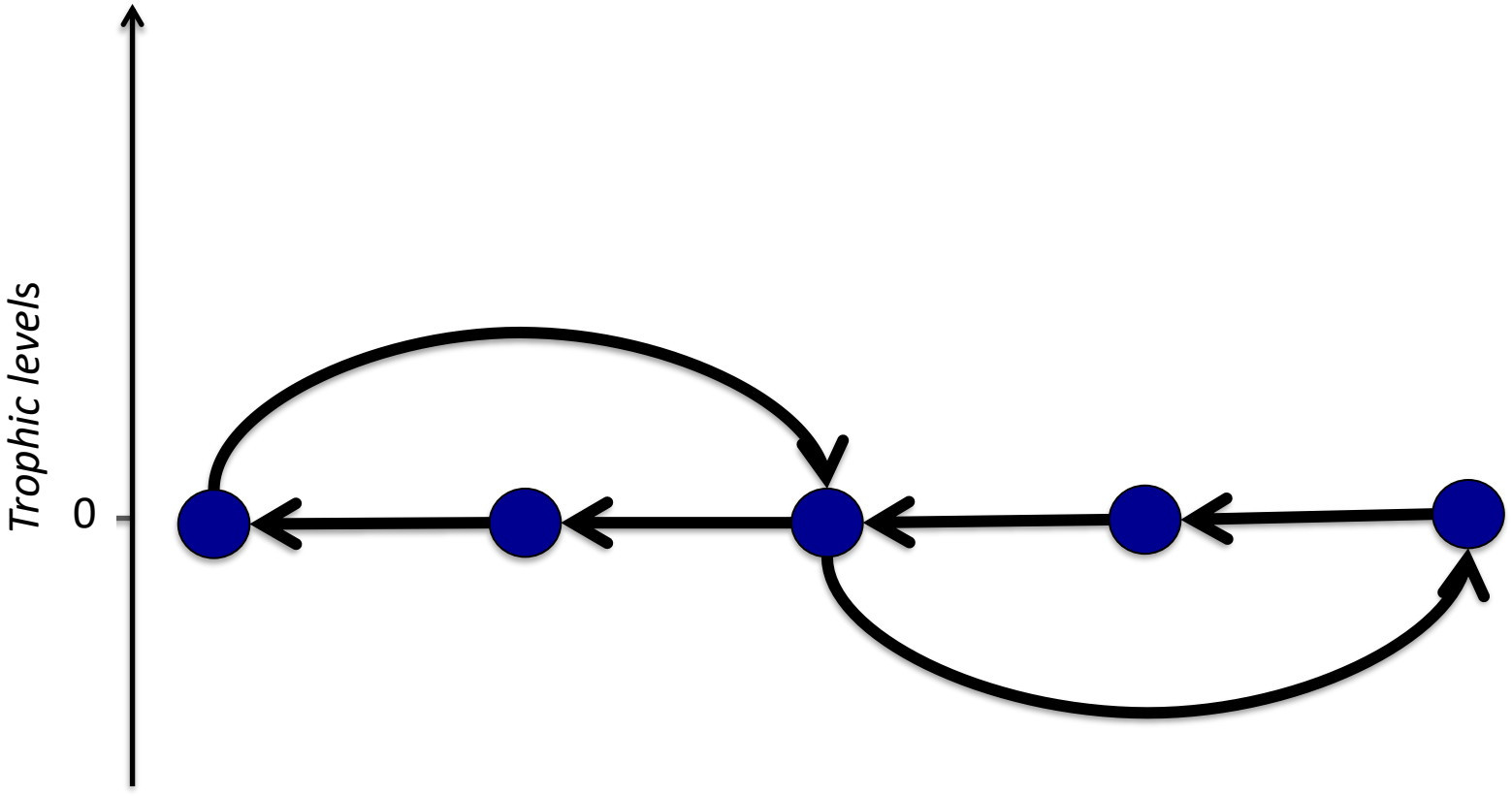
A *coherent* network: directional flow

change of *level* along each edge is +1.



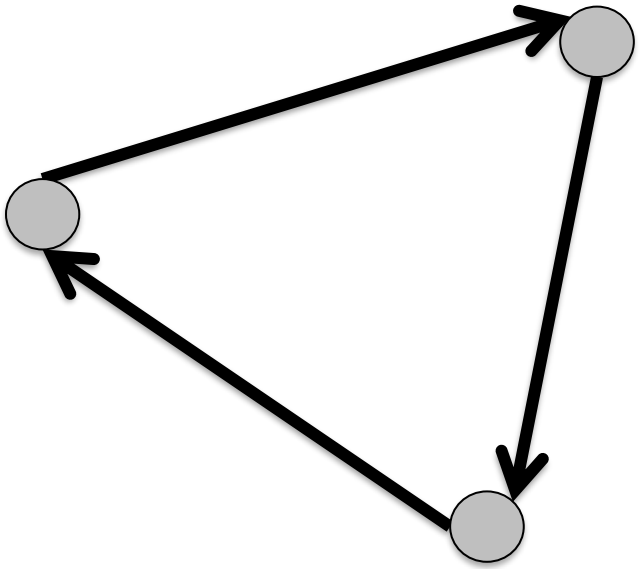
Johnson et al. (2014); MacKay et al. (2020)

An *incoherent* network: *circular* flow

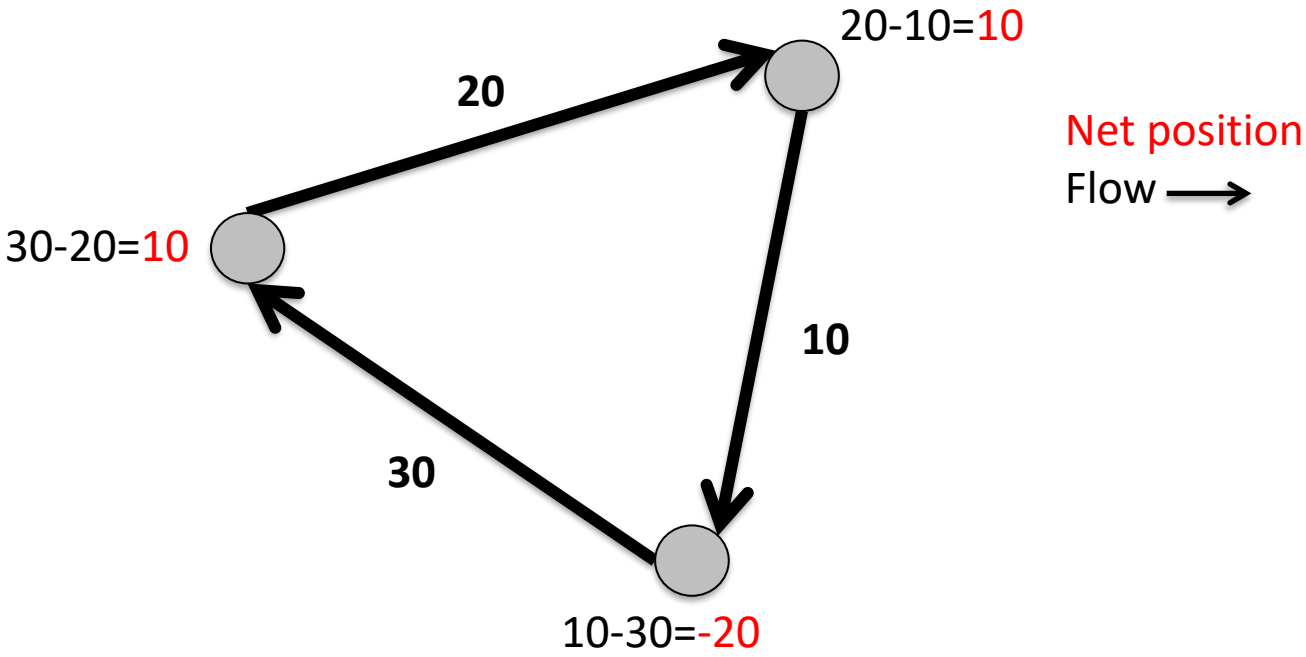


Johnson et al. (2014); MacKay et al. (2020)

Semi-coherent networks: *directional* and *circulating* flow



Semi-coherent networks: *directional* and *circulating* flow



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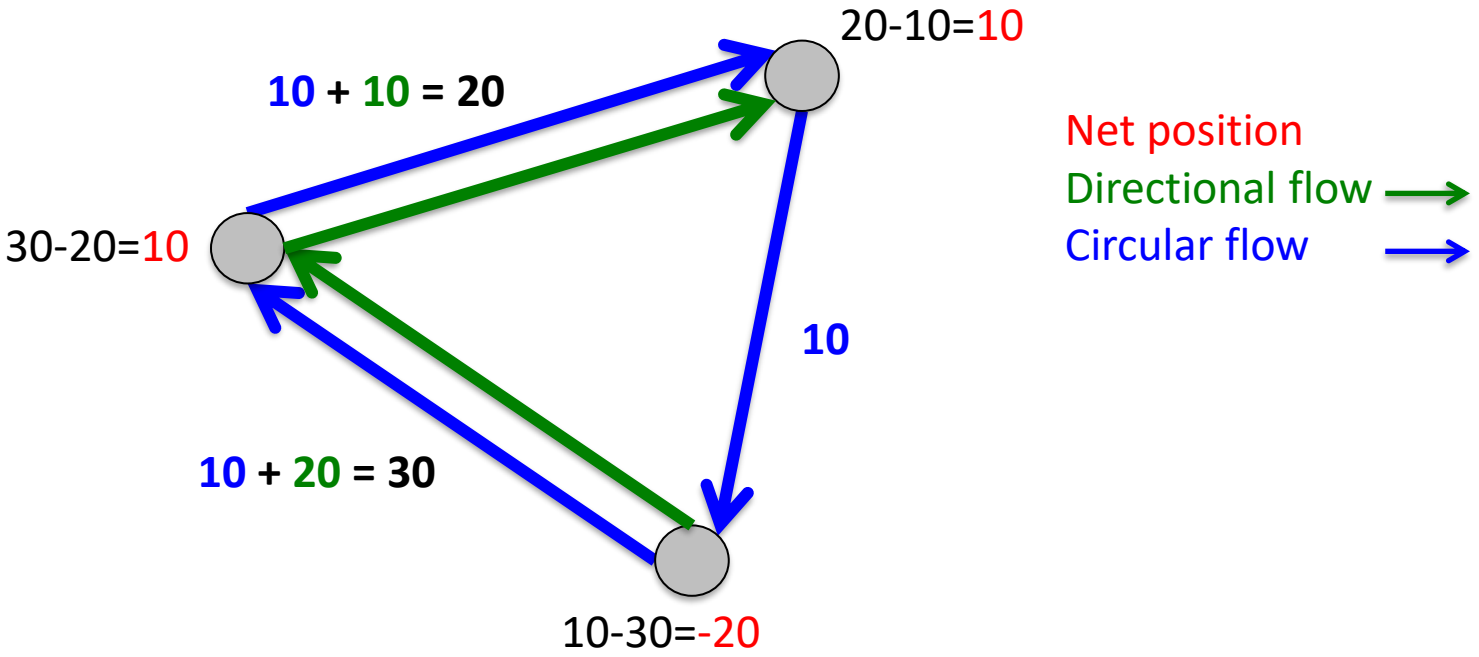
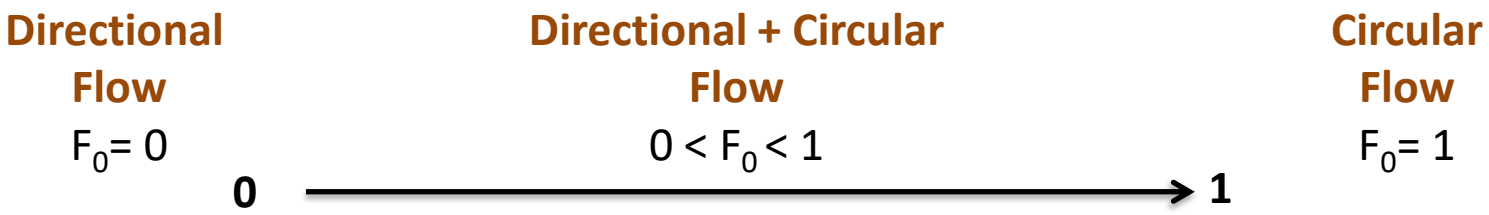


How directed is a directed network?

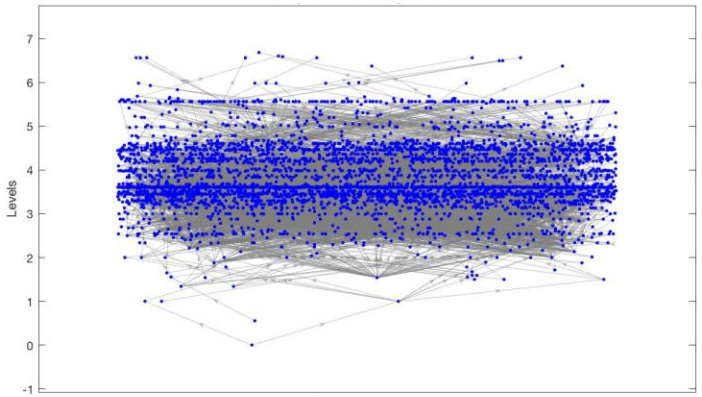
We introduce a statistic, F_0
to quantify *trophic-incoherence*
for any directed network



MacKay , Johnson, Sansom (2020) "*How directed is a directed network?*" RSOS

Some directed networks are more directed than others!

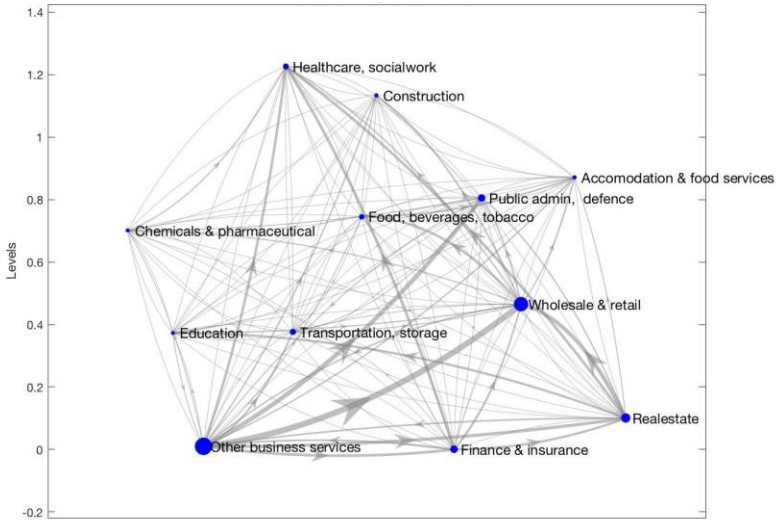
Corporate control network



Incoherence = 0.02

Very coherent

US inter-sectoral input-output network



Incoherence = 0.63

Quite incoherent

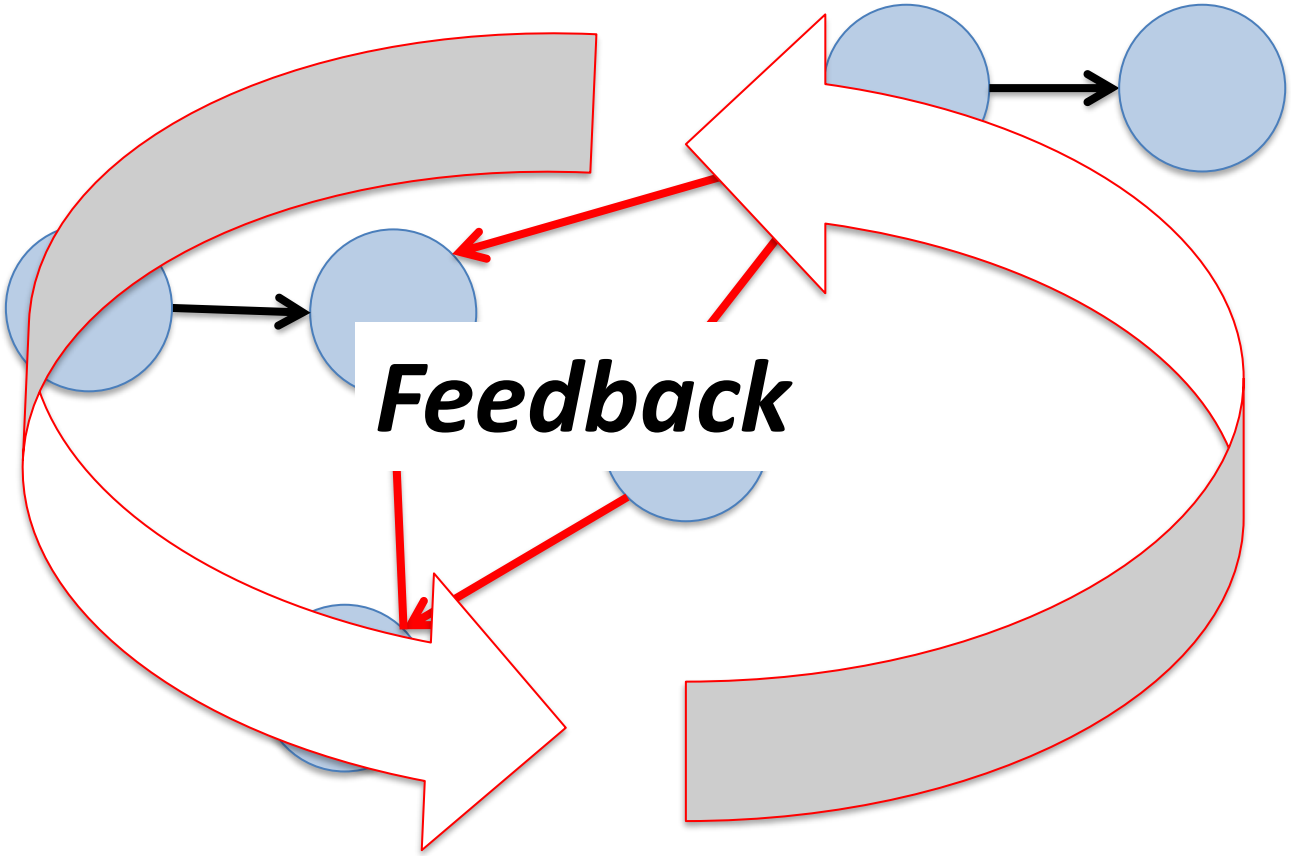
MacKay , Johnson, Sansom (2020) "*How directed is a directed network?*" RSOS

Why does *trophic-coherence* matter for systemic risk?

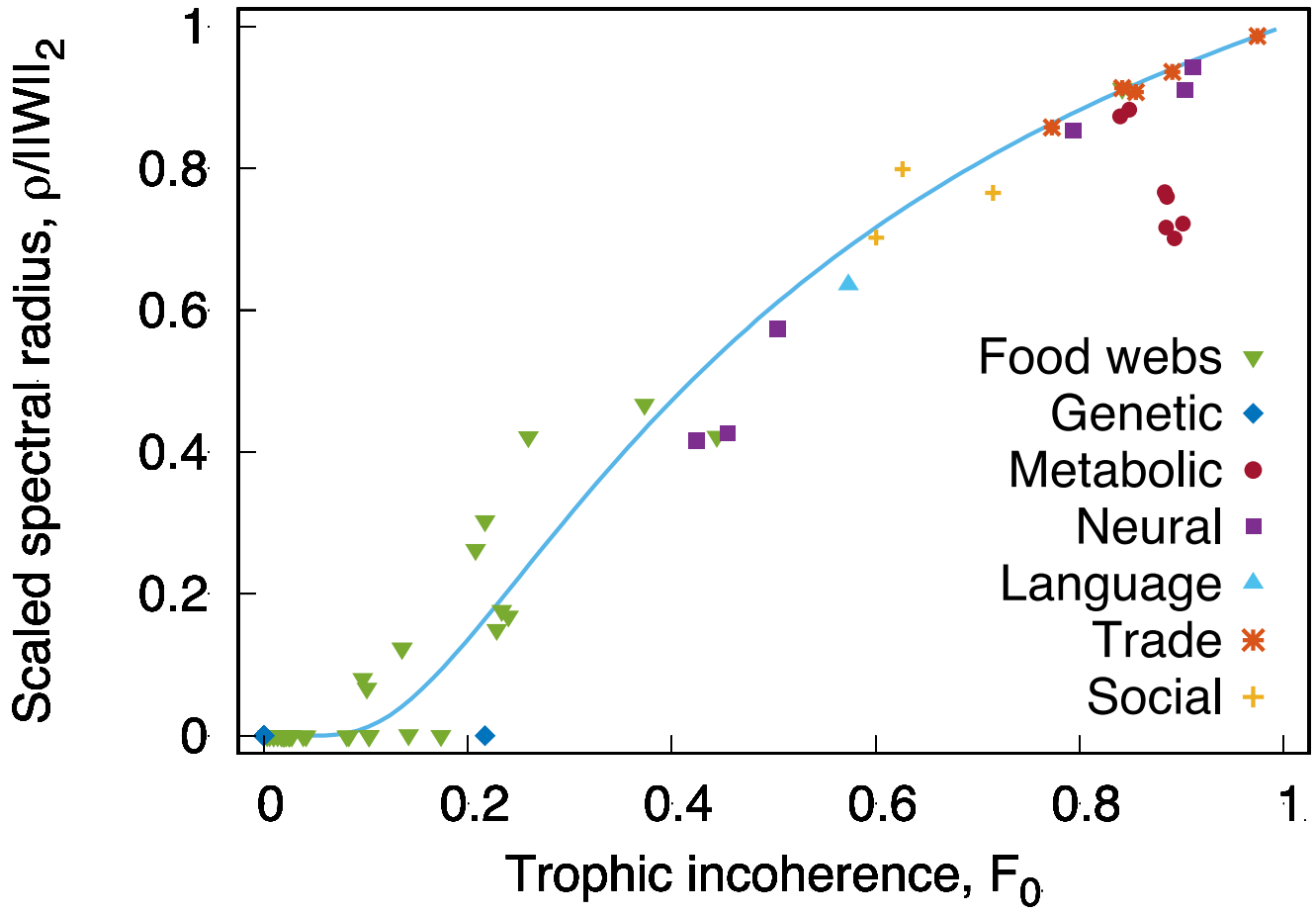
1

*In*coherence increases endogenous shock amplification

Cycles can destabilize large dynamical systems when they induce strong feedback loops

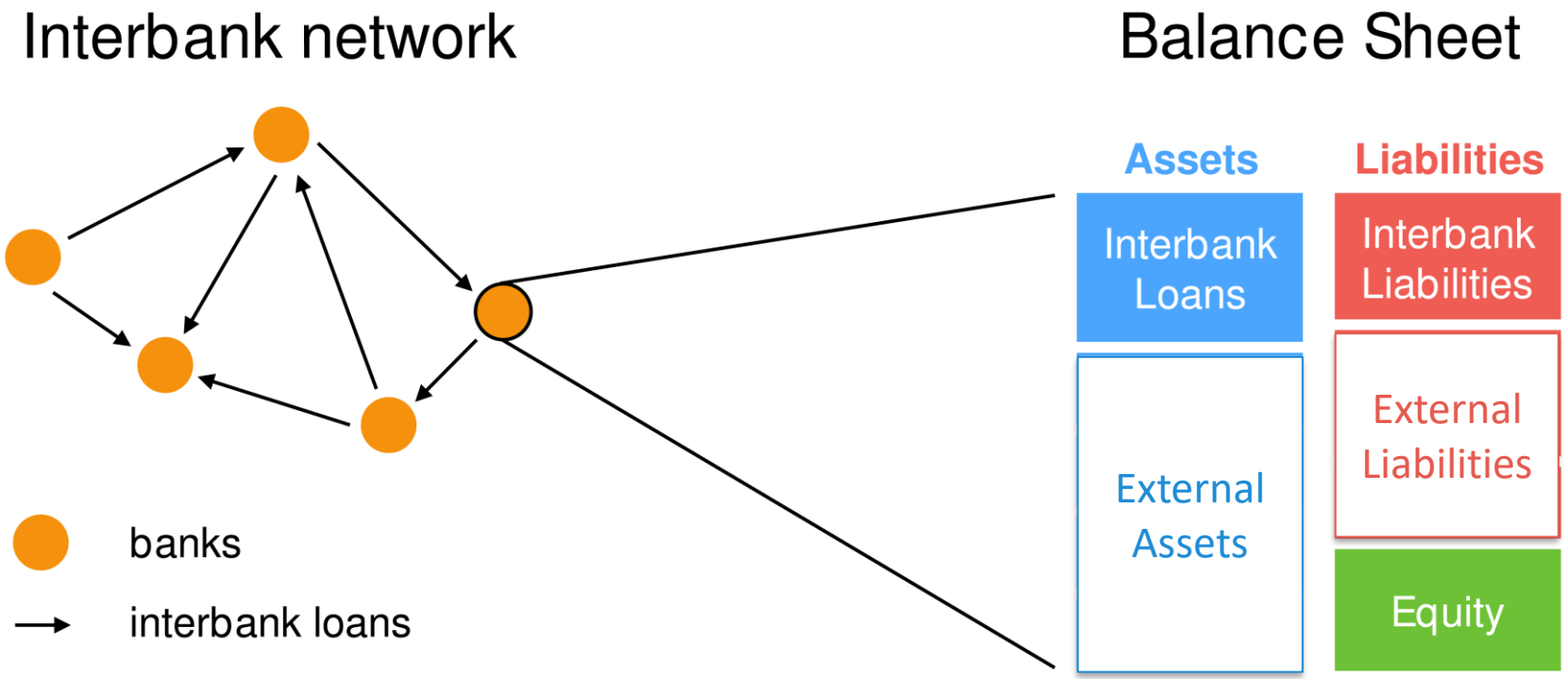


Trophic coherence correlates with leading eigenvalue of network



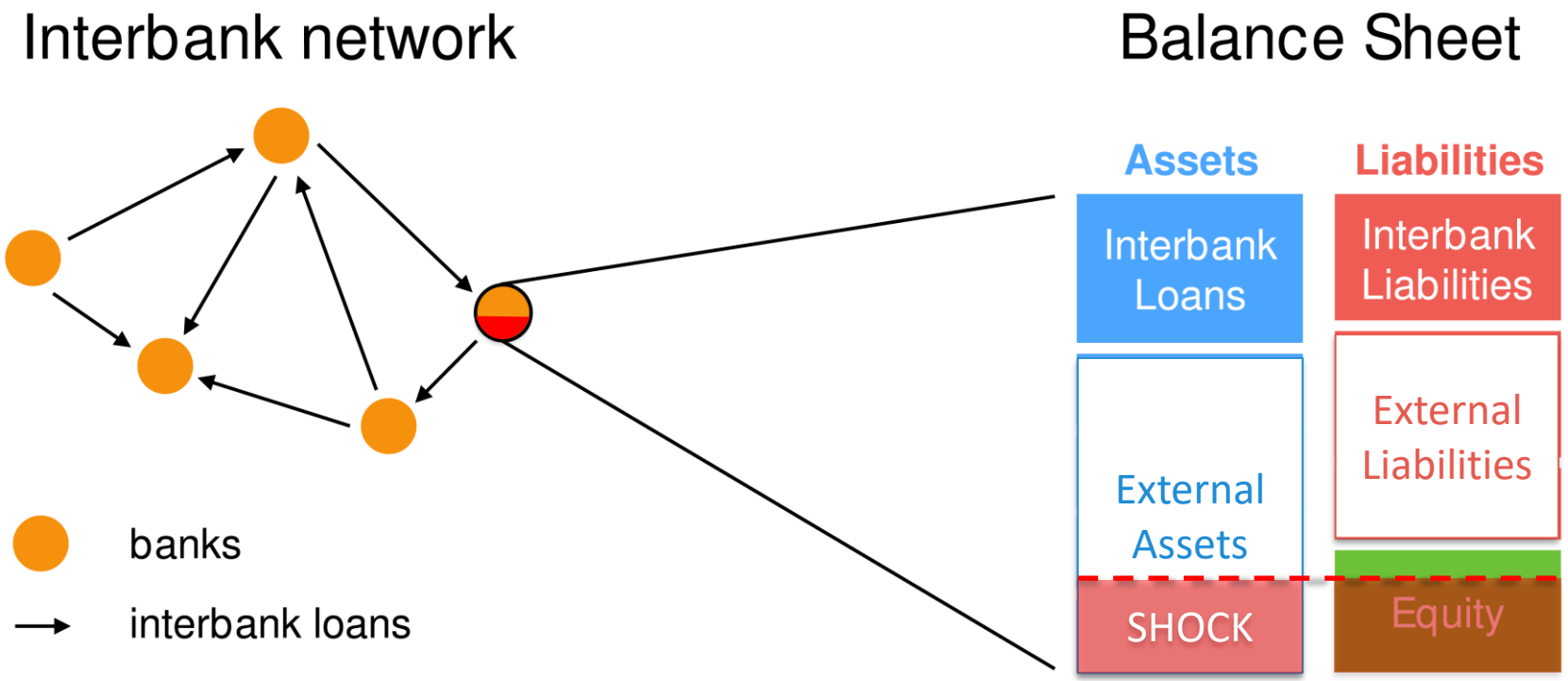
MacKay, Jonson, Sansom (2020) "*How directed is a directed network?*" Royal Society Open Science

Simulated shock and DebtRank



DebtRank: benchmark algorithm for stress propagation in lending networks.

Simulated shock and DebtRank



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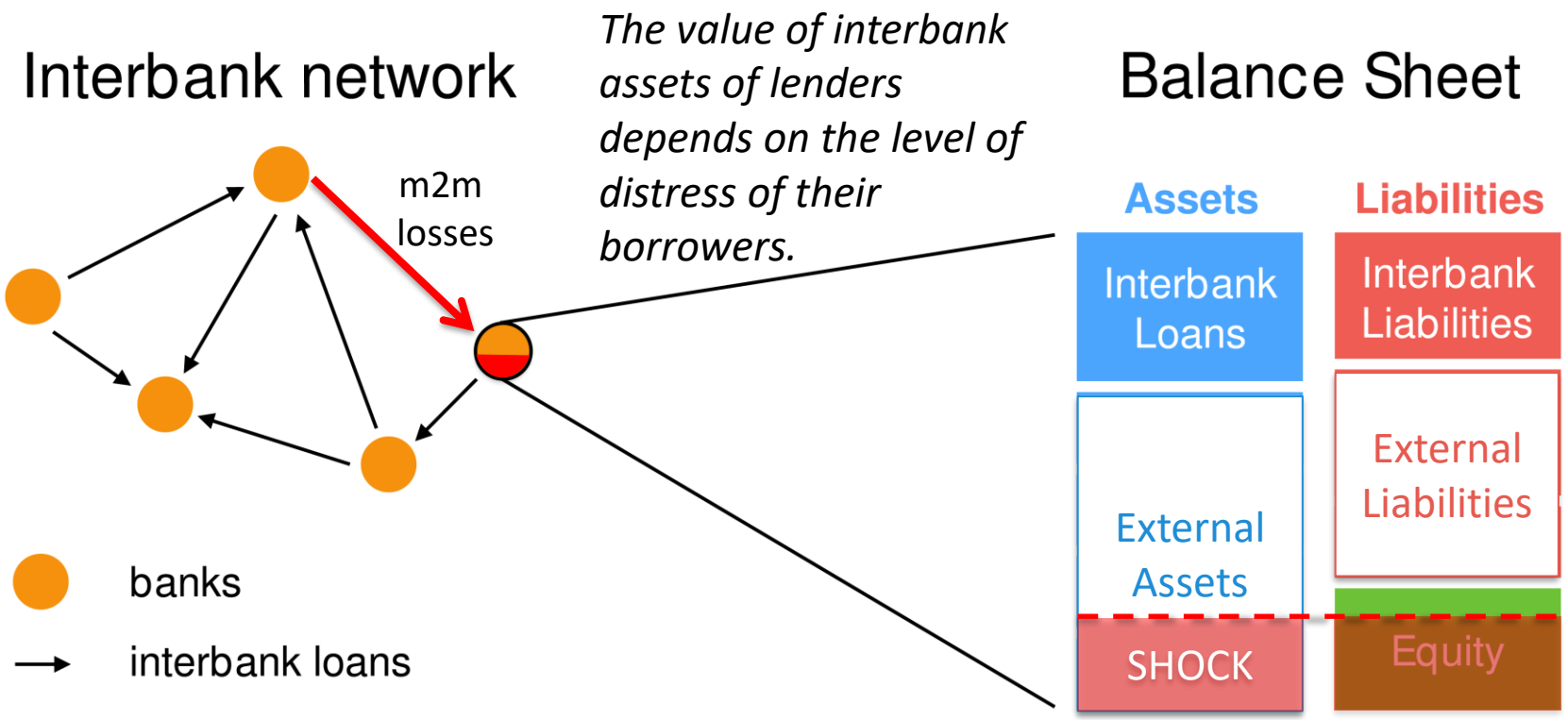

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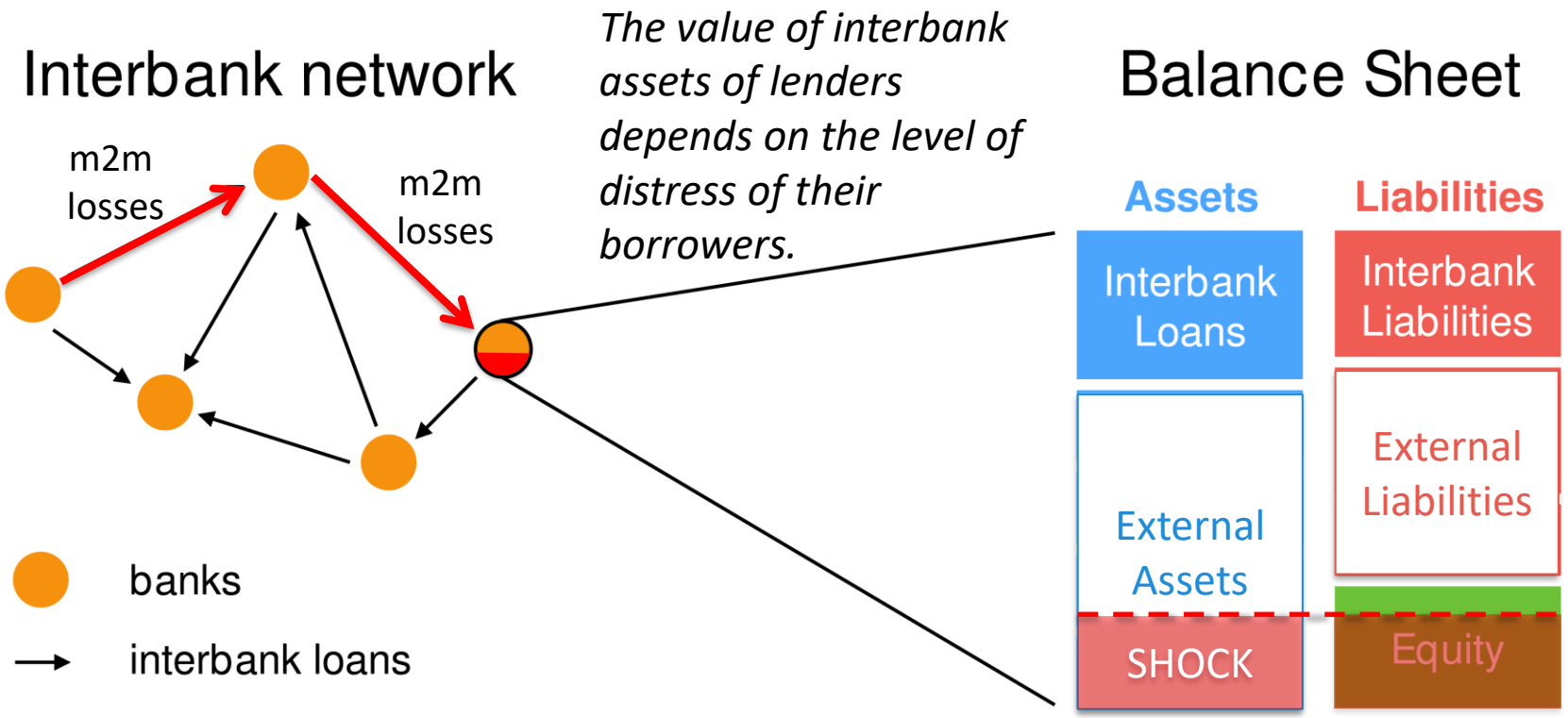

DebtRank: benchmark algorithm for stress propagation in lending networks.

Reduced endogenous amplification of losses in more coherent financial networks

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A stress test exercise

- Vary *trophic incoherence* and *leverage* (equity/assets).

Reduced endogenous amplification of losses in more coherent financial networks

A stress test exercise

- Vary *trophic incoherence* and *leverage* (equity/assets).
- Apply uniform -1% shock to banks' external assets.

Reduced endogenous amplification of losses in more coherent financial networks

A stress test exercise

- Vary *trophic incoherence* and *leverage* (equity/assets).
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- Run DebtRank algorithm for stress propagation in interbank lending networks.

Reduced endogenous amplification of losses in more coherent financial networks

A stress test exercise

- Vary *trophic incoherence* and *leverage* (equity/assets).
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- Obtain "*Total Relative Equity Loss*" (i.e. the fraction of equity lost in the system, once dynamics converge).

Reduced endogenous amplification of losses in more coherent financial networks

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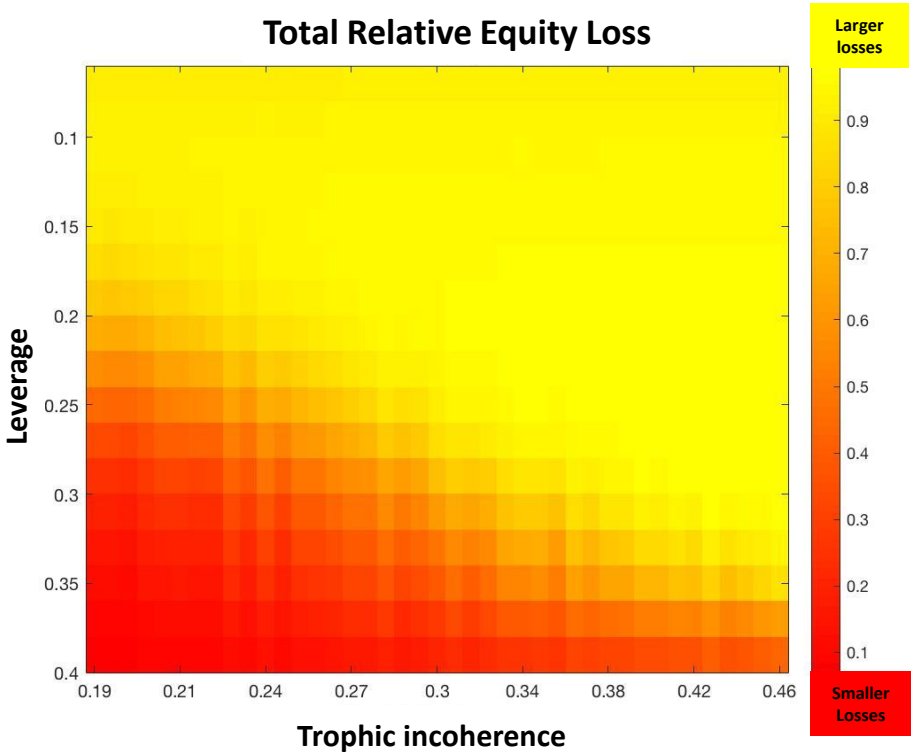

Sansom, Johnson, MacKay (2021) "*Trophic incoherence drives systemic risk in financial exposure networks ?*" Rebuilding Macroeconomics Working Paper No.39

Reduced endogenous amplification of losses in more coherent financial networks

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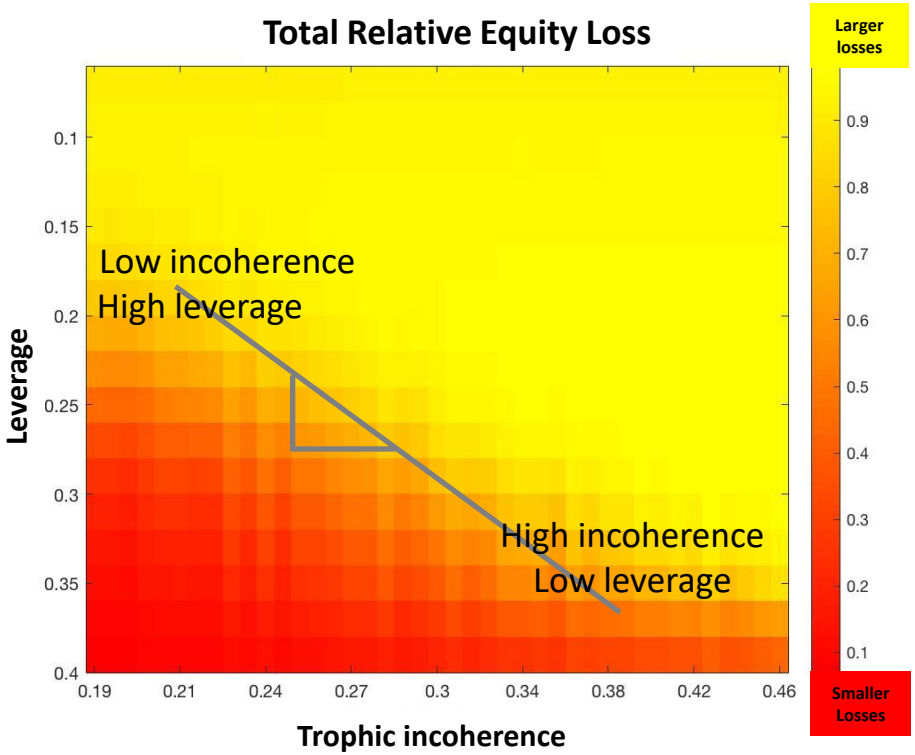

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Policy implications

Systemic risk

- Buffers not necessarily enough -> need to consider interconnectedness
  - to assess fragility the system
  - to control stability

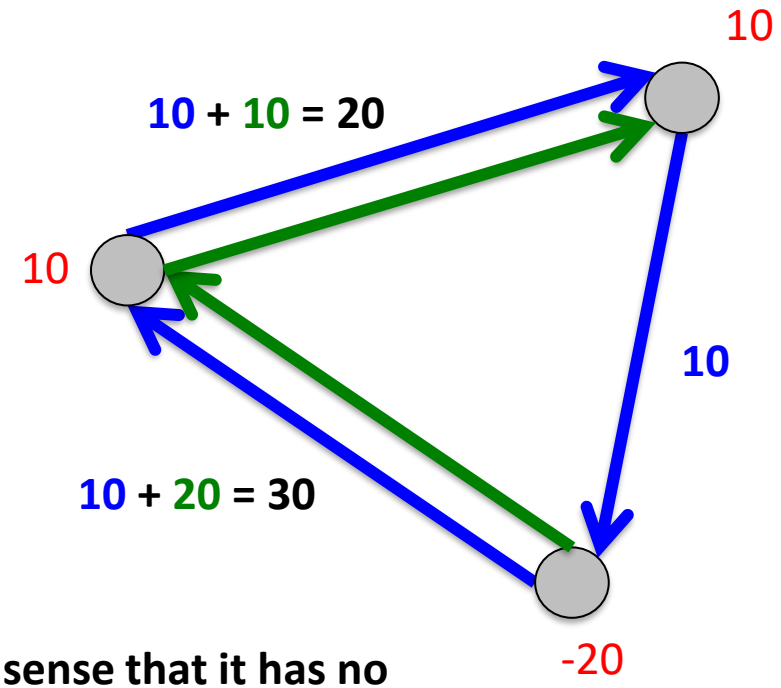
System level solutions?

- Systemic risk could be reduced by rewiring network to achieve more coherent structure.
  - Preserve connectedness
  - Remove destabilizing feedback from the system
  - ..whilst preserving *net-equivalence*

2

Incoherence implies redundant exposures (market excess)

Circulating flow is redundant



Net position
Directional flow
Circular flow

- **Redundant: in the sense that it has no impact on net positions.**
- **Important: since contributes to contagion and counterparty risk.**

… so *incoherence* provides a measure of redundancy in a financial network.

$$\text{Total flow} = \text{Circular flow} + \text{Directional flow}$$

$$\text{Incoherence} = \frac{\text{Circular flow}}{\text{Total flow}}$$

Incoherence quantifies how much of total counterparty exposure balanced without contributing to net positions.

Policy implications

- Rewiring to achieve more coherent structure could achieve both:
  - More resilient topology
  - Significant portfolio compression

- The compression benefits would help reduce:
  - Total counterparty risk (thus systemic risk)
  - Required regulatory capital (where calculated on gross notional)
  - Collateral requirements (so demand for HQLA).

Achieving more coherent financial networks?

Three strategies for achieving more coherent financial networks:

1. Transaction level incentives → endogenous tendency to more coherent structure

1. Post-trade optimisation → network optimisation without change of counterparties

(1) Transaction level incentives?

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(1) Ask for quotes on potential transactions with several counterparties.

Central counterparty

Bank

(1) Transaction level incentives?

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(2) Add charge proportional to trophic-level difference from 1 to quote for each transaction.

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(3) Provide list of quotes

(1) Transaction level incentives?

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Central counterparty

Bank

(2) Add charge proportional to trophic-level difference from 1 to quote for each transaction.

(3) Provide list of quotes

(4) Choose transaction based on list of quotes provided

(2) Post-trade operations?

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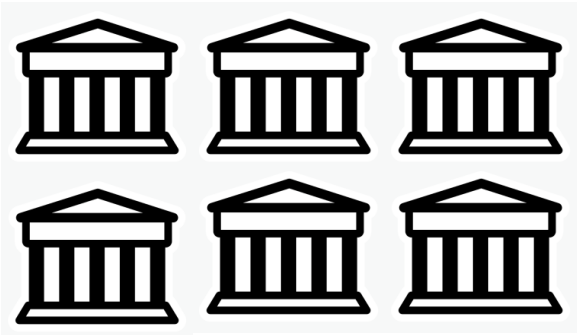
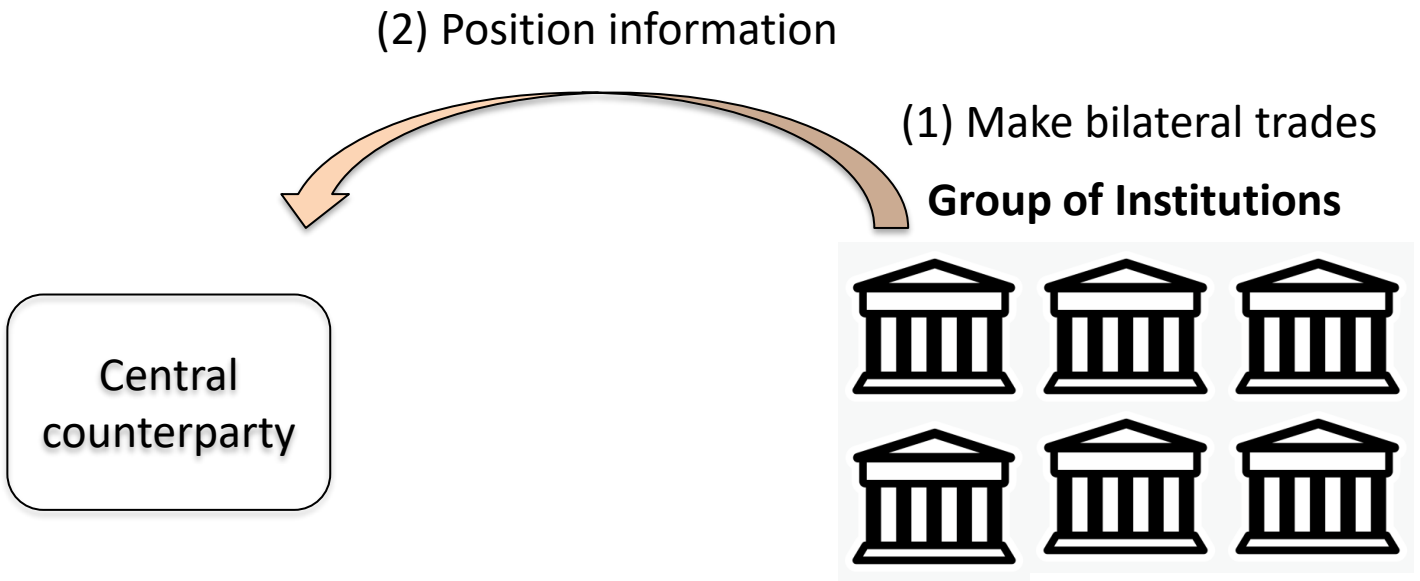
(1) Make bilateral trades

Group of Institutions



(2) Post-trade operations?



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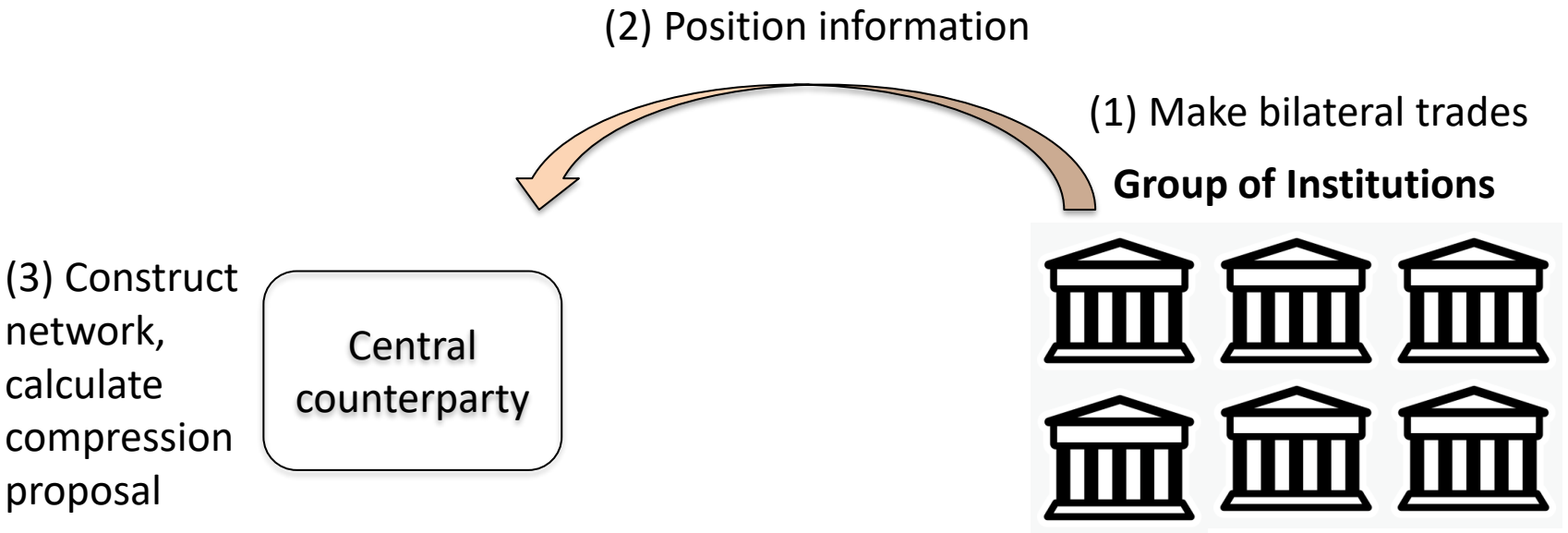

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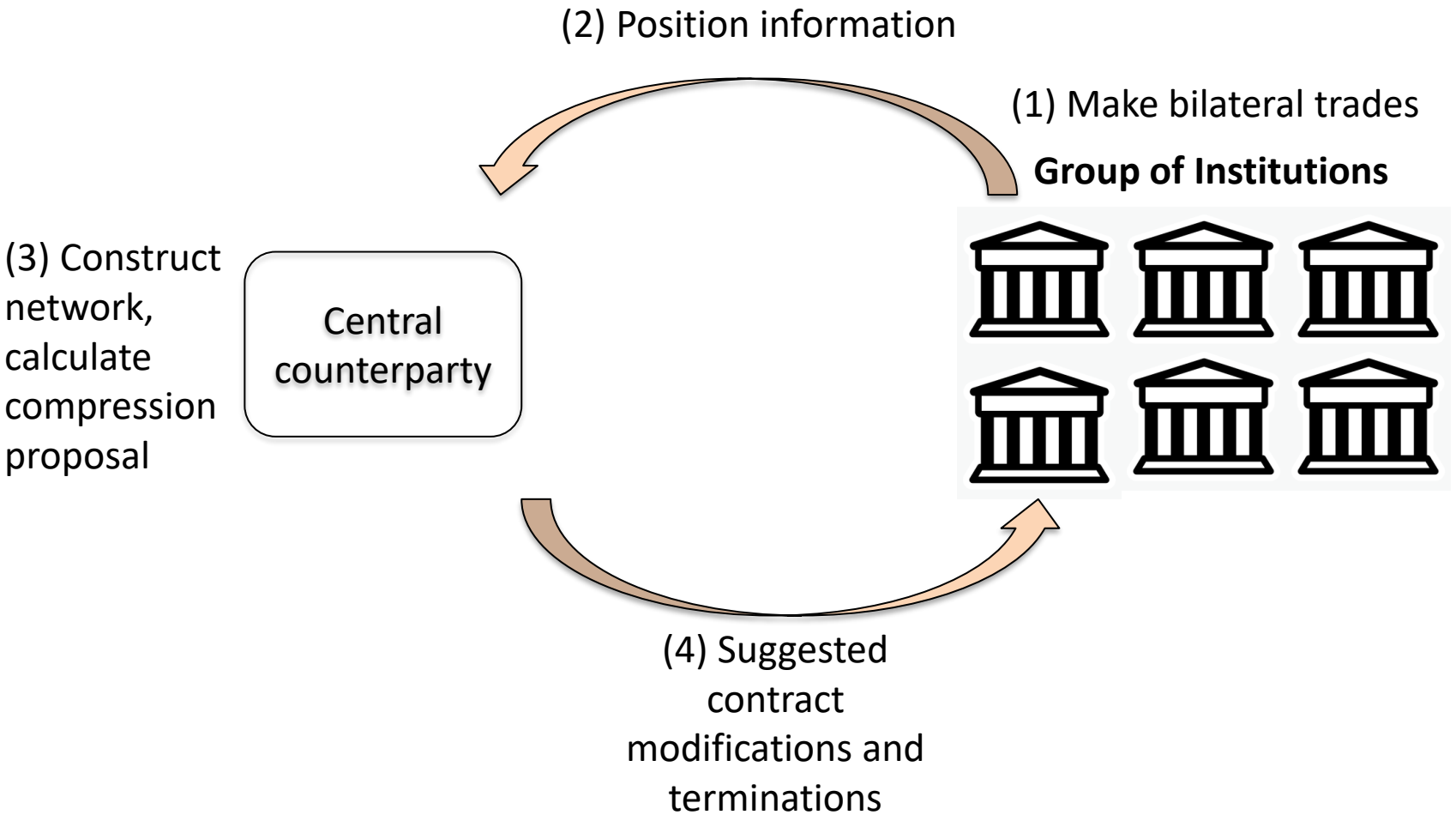

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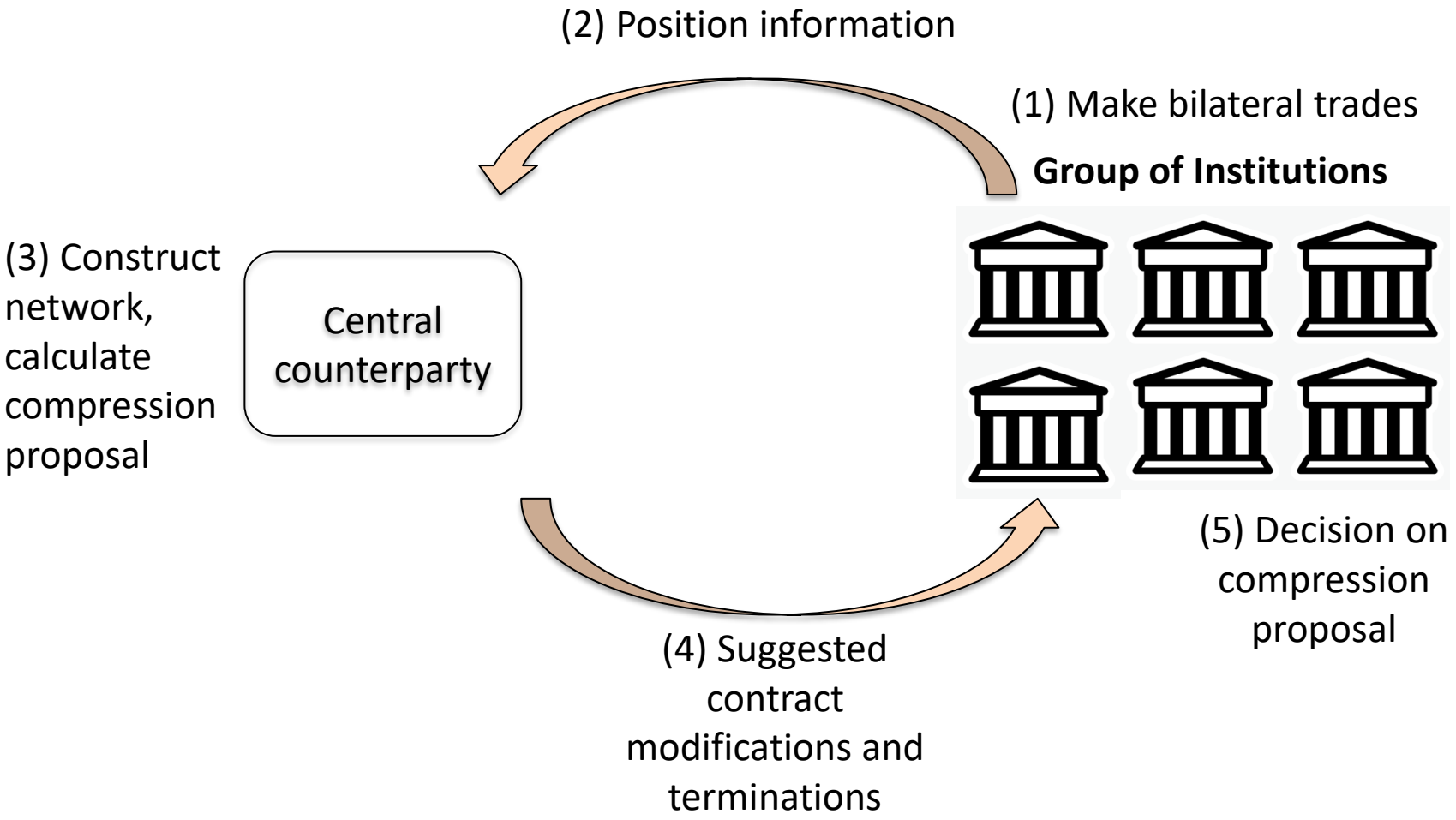

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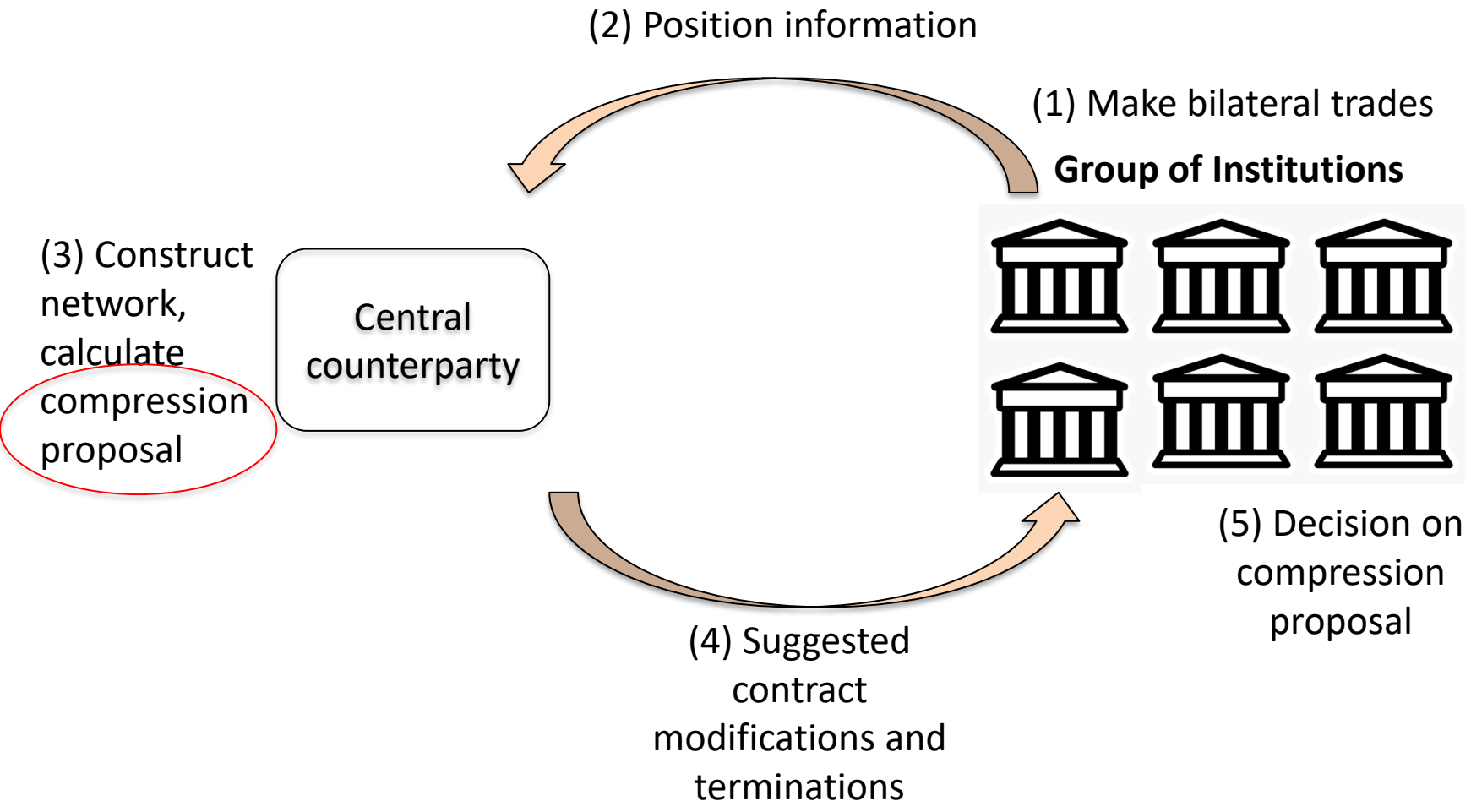
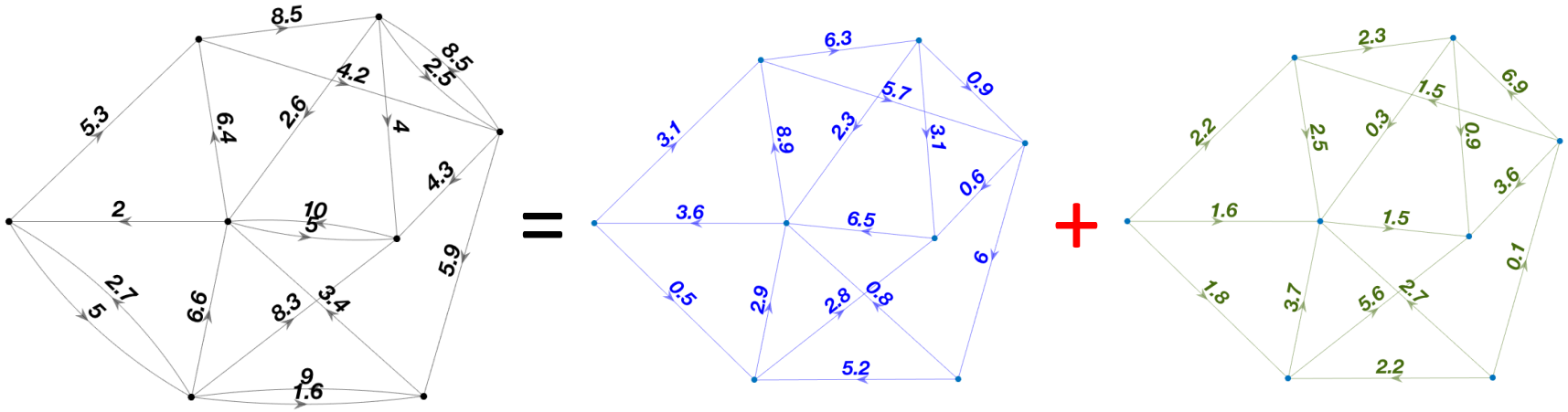


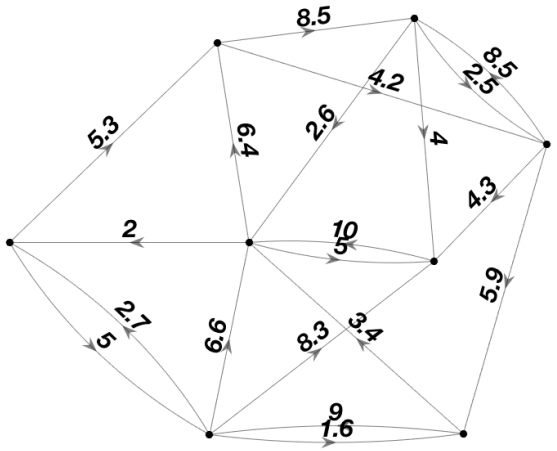
Decomposition of total flow into circular + directional components provides one solution



Total flow = **Circular flow** + **Directional flow**

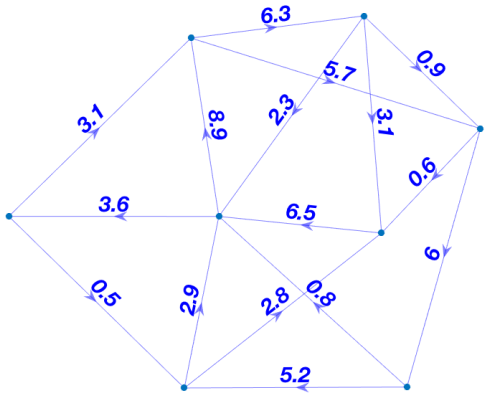
Compression proposal
(Required adjustments to positions)

Decomposition of total flow into circular + directional components provides one solution



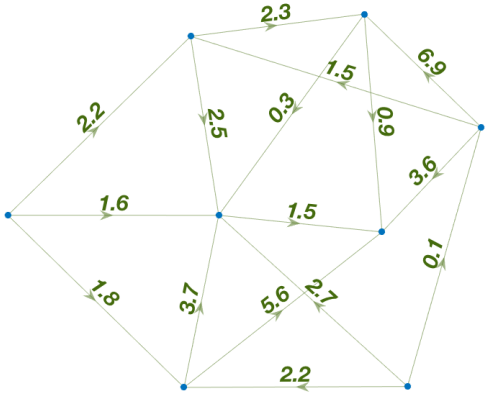
Total flow

\-



Circular flow

=



Directional flow

Compression proposal
(Required adjustments to positions)

Optimized network

Respects:
- Net-equivalence
- Existing counterparties

Achieves:
- Significantly more coherent topology
- Significant portfolio compression

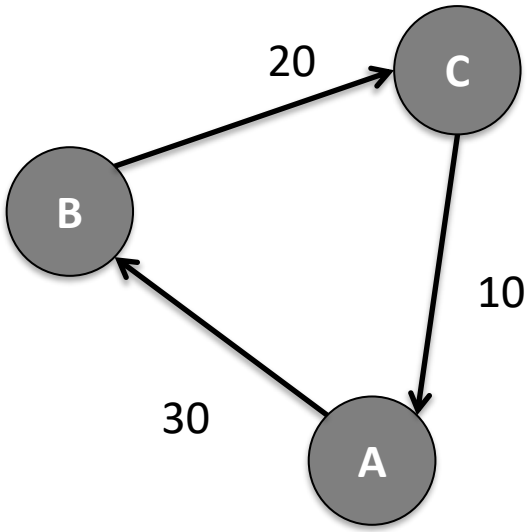
Post-trade compression services

Might also find application in analogous payment system problem(s)…?

Payment system ‘gridlock’ – toy example

Balance = 5 + 10

Starting balance
Net flow



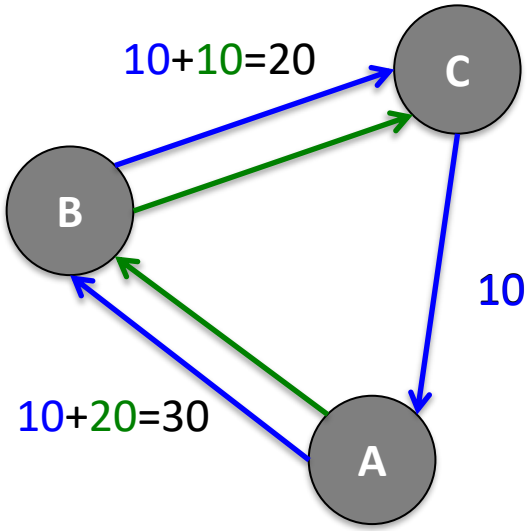
Balance = 15 + 10

Balance = 20 - 20

Total=60

Payment system ‘gridlock’ – toy example

Balance = 5 + 10



Starting balance
Net flow
Directional flow ->
Circular flow ->

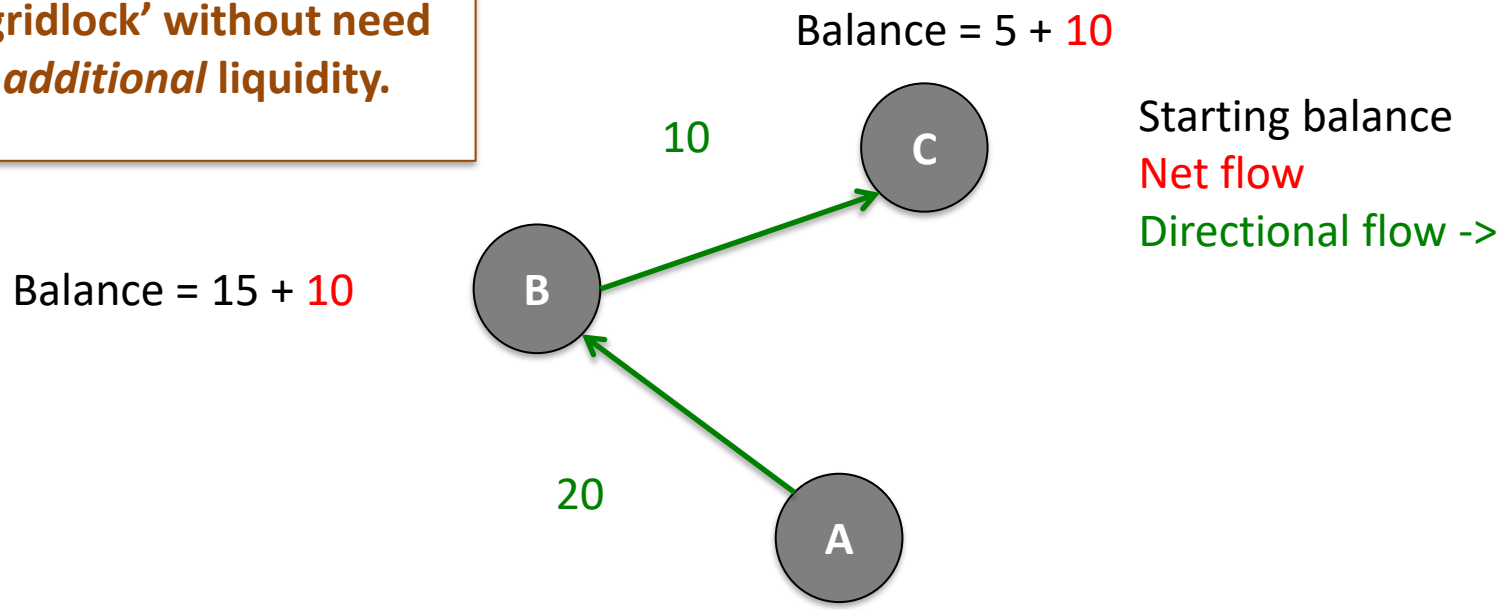
Balance = 15 + 10

Balance = 20 - 20

Total=60=30+30

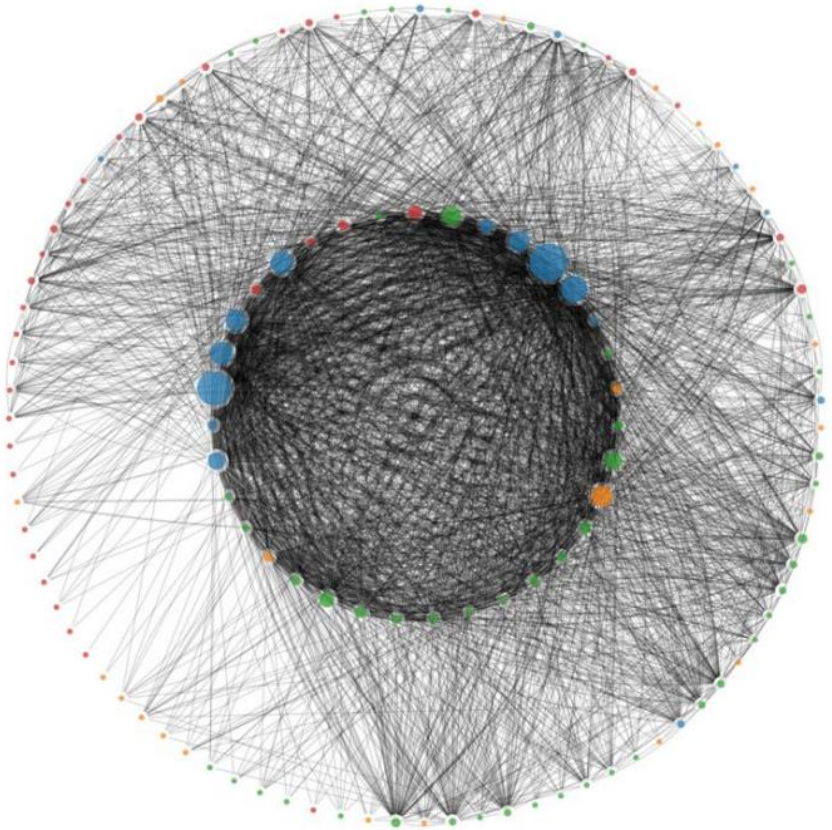
Payment system ‘gridlock’ – toy example

Multilateral netting resolves the ‘gridlock’ without need for *additional* liquidity.



Total= **30**

Complexity of real payment networks means optimal netting proposal non-trivial problem…



BoK-Wire+

Baek, Soramäki and Yoon (2014).
J. of Financial Market Infrastructure

Decomposition of total flow into circular + directional components provides one solution

(Just the solution to a linear system of equations)

Total flow = Circular flow + Directional flow

A balanced obligation network
(i.e. it can be settled all at once! Without need for liquidity).

Residual network satisfying net-equivalence.

- Requires less liquidity for settlement.
- Trophic levels provide ordering of payments! (nodes are perfectly ranked)

Summary

- Shock amplification is larger for more trophic-incoherent networks.
- Redundancies are larger in more trophic-incoherent networks.
- The tools of trophic analysis can be used to design and operate FMI able to achieve:
  - Significantly more coherent (resilient) topology
  - Significant compression/netting efficiencies

Thank you

bazil.sansom@warwick.ac.uk

For further details see:

- Sansom, Johnson, MacKay (2021) "*Trophic incoherence drives systemic risk in financial exposure networks ?*" Rebuilding Macroeconomics Working Paper No.39

- MacKay , Johnson, Sansom (2020) "*How directed is a directed network?*" Royal Society Open Science, 7, 201138.

(3) Central clearing

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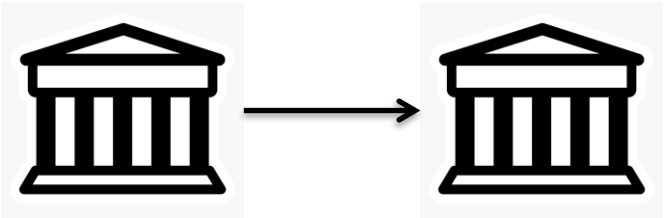
(1) Agree a trade

Banks



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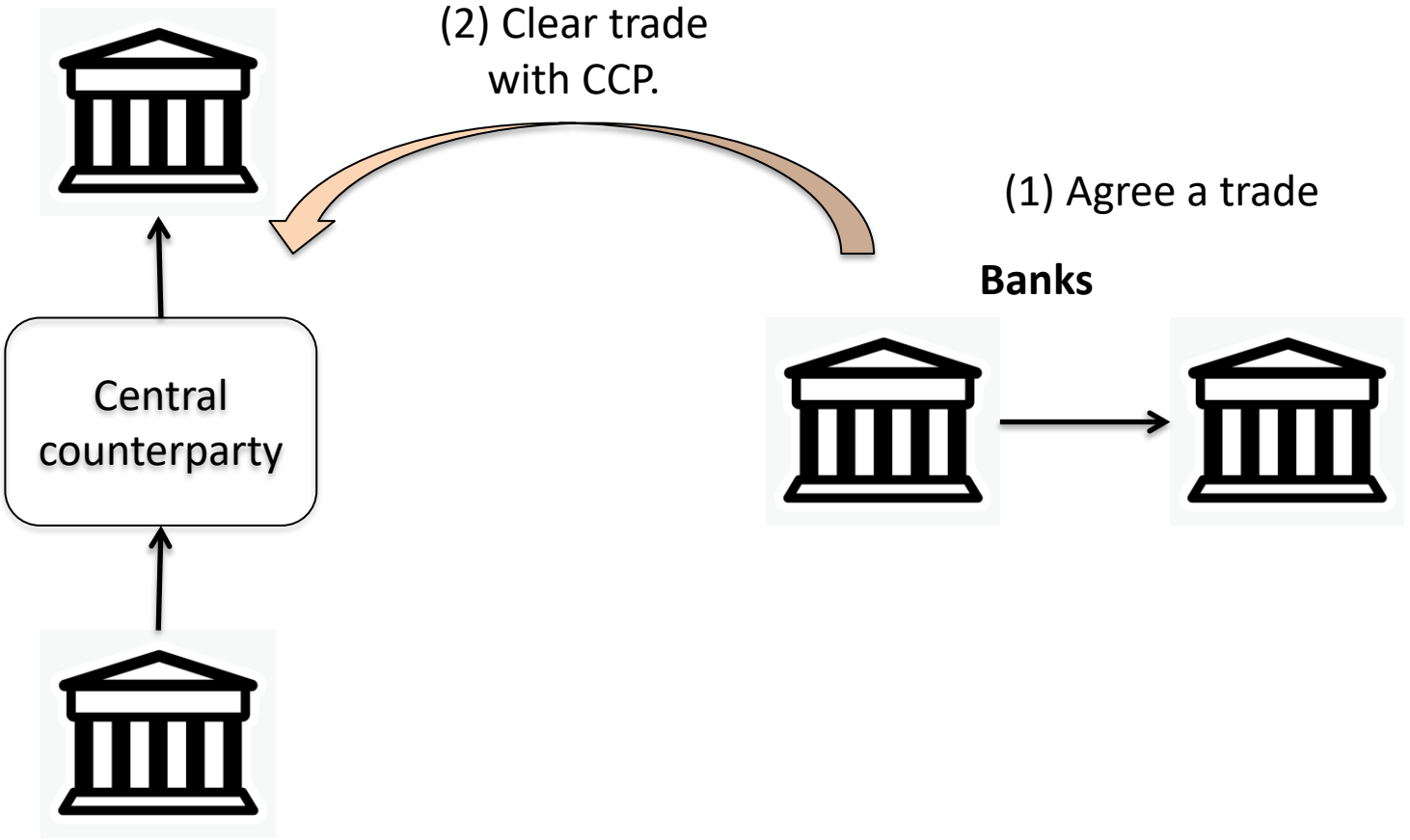

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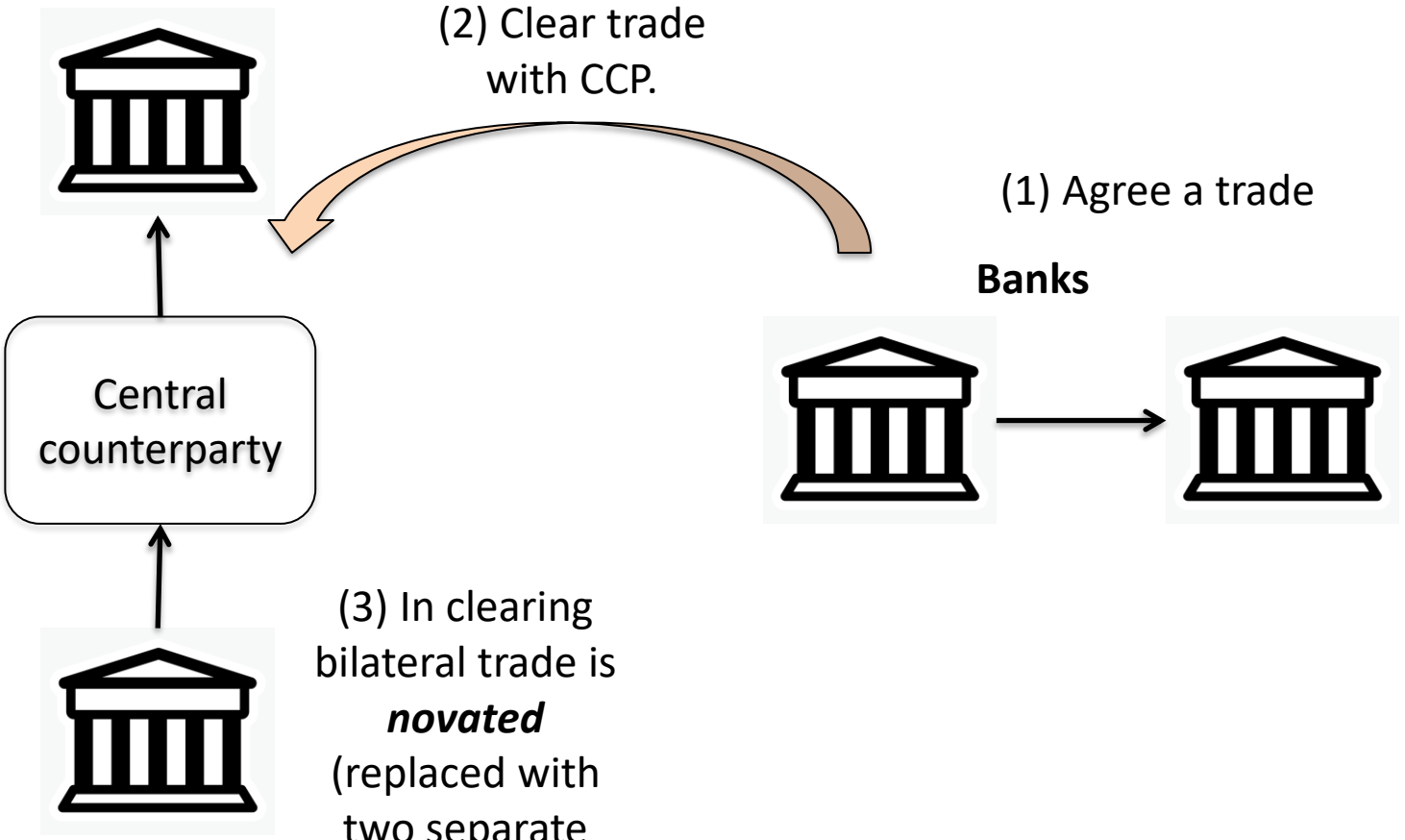
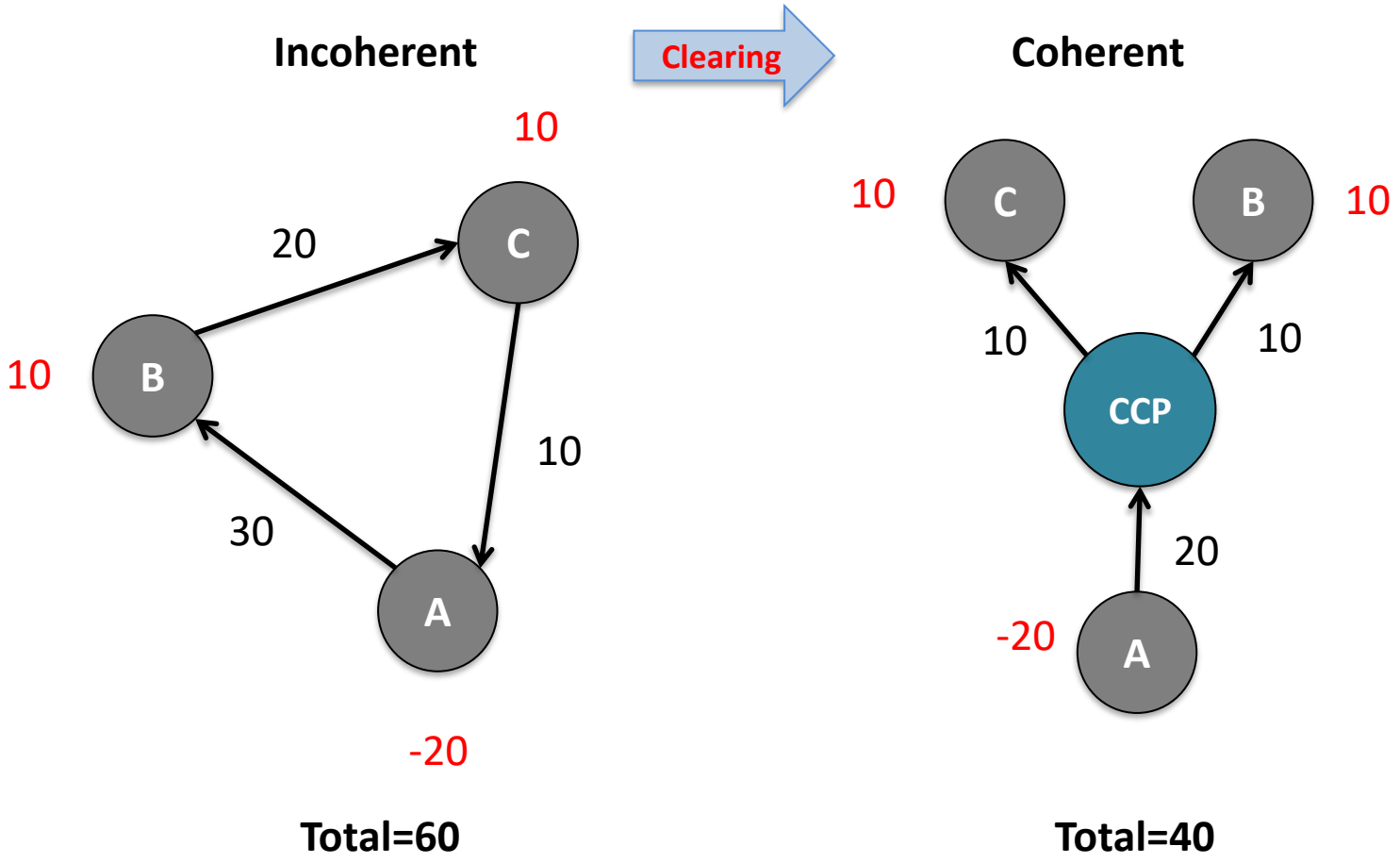
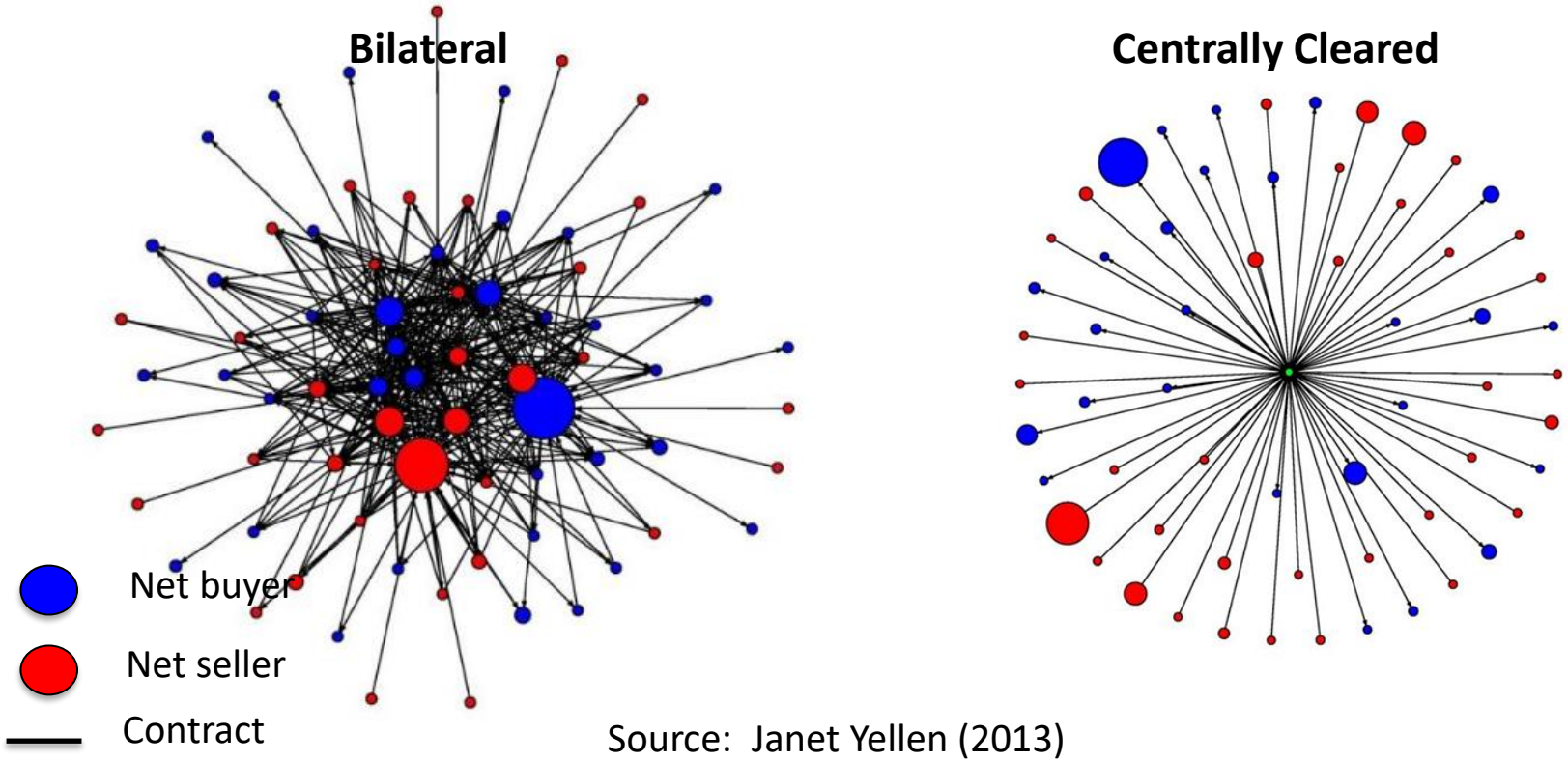


Central Clearing = ‘star transformation’



Central Clearing = ‘star transformation’

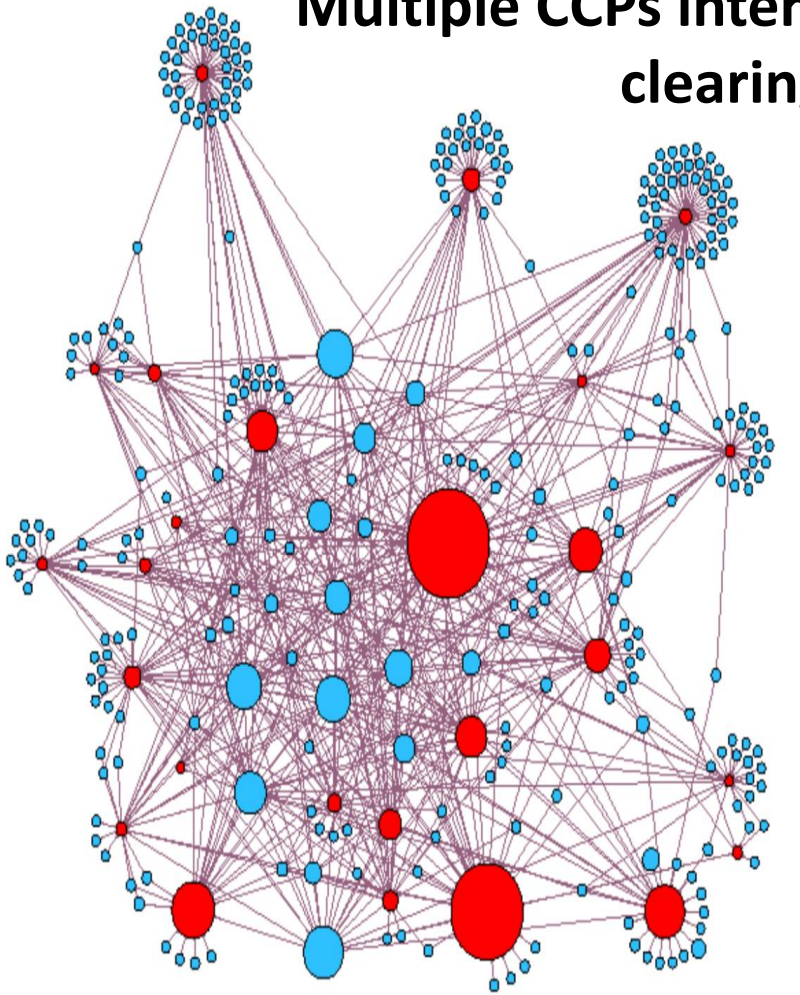
Network of Counterparty Relationships
A single and highly traded CDS contract



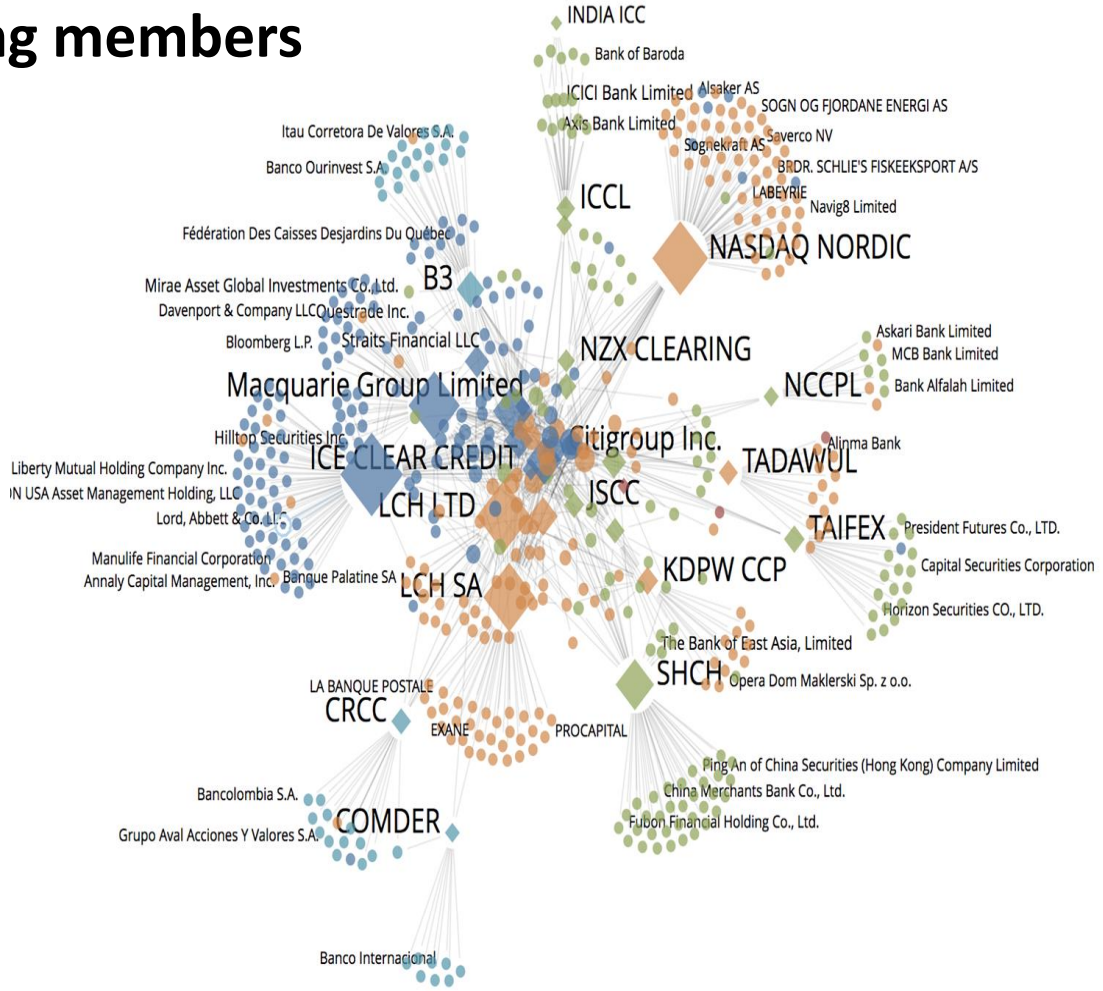
Source: Janet Yellen (2013)

Interconnectedness remains an issue

Multiple CCPs interconnected via common clearing members



BIS (2018)



FNA (2018)