Illiquidity Spirals in Coupled Over-the-Counter Markets[1]

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Harvard

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[1] The views expressed are not necessarily the views of Deutsche Bundesbank.

Overview

Essence of our model

- Each bank is simultaneously in **two** networks (over-the-counter markets), each having its own network structure.
- Each bank wants to be active (i.e. open to trade) if and only if it has at least one active counterparty in each network.
- Some banks, however, experience an exogenous shock that makes them withdraw, regardless of what else is happening.

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Preview of results

- Characterization of equilibrium response to shocks: **illiquidity spiral** of shutdown triggered by initial shock.
- Conditions under which liquidity in both markets evaporates **discontinuously** in the size of the shock (number of nodes shocked): an **abrupt market freeze**. (Two networks essential here.)
- Making at least one market **centralized** (completely connected) always has positive implications for overall liquidity: tools to quantify this.

Motivating fact: Illiquidity spiral for corporate bond and ABS repo during global financial crisis

Leading example: markets are for (i) **secured (short-term) debt** (repo) and (ii) the underlying **collateral**.

[1] Government bond collateral repo markets were stable Krishnamurthy et al. (2014).

[2] Mostly agency MBS in US. ICMA reports total size of EU repo market $\approx$ 5 tn EU and reports 6% (June 2016) and 9% (Dec. 2015) "other fixed income" collateral.

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Potential instability ...

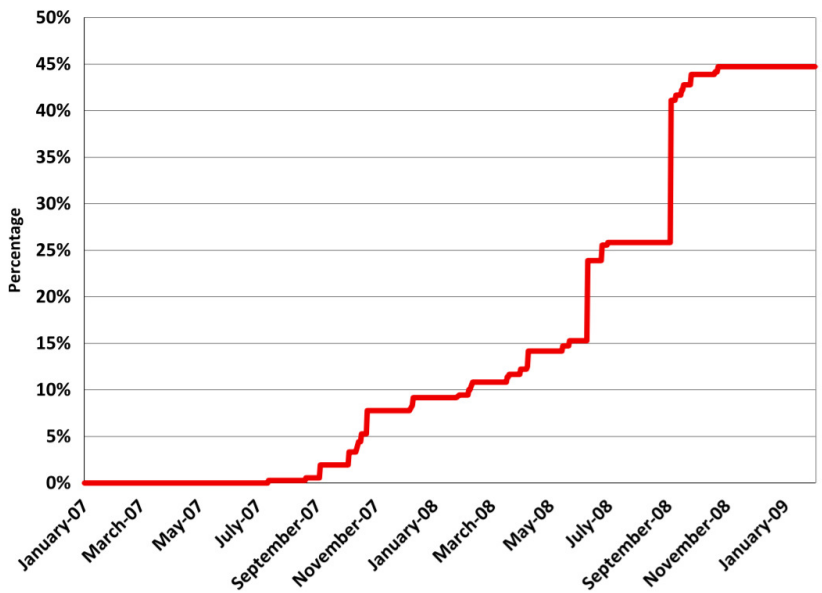

Figure: The repo-haircut index for different corporate bond and ABS repo,[2]Gorton and Metrick (2012).

... in markets of significant size

- Non-government bond repo $\approx 10\%$ in EU.
- In absolute terms:
  - non-government bond repo outstanding about 500 bn EUR (EU);
  - $+$ about 500 bn USD (US)[3], Baklanova et al. (2015) and ICMA (2016).

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Illiquidity spirals and market freezes

"[T]he complete evaporation of liquidity in certain market segments of the US securitization market has made it impossible to value certain assets fairly regardless of their quality or credit rating . . . Asset-backed securities, mortgage loans, especially sub-prime loans don't have any buyers . . . Traders are reluctant to bid on securities backed by risky mortgages because they are difficult to sell on . . . The situation is such that it is no longer possible to value fairly the underlying US ABS assets in the three above-mentioned funds."[4]

[4] Source: "BNP Paribas Freezes Funds as Loan Losses Roil Markets" (Bloomberg.com, August 9, 2007). As cited in Acharya et al. (2011).

Both non-government collateral and repo are traded OTC – what does that imply for liquidity?

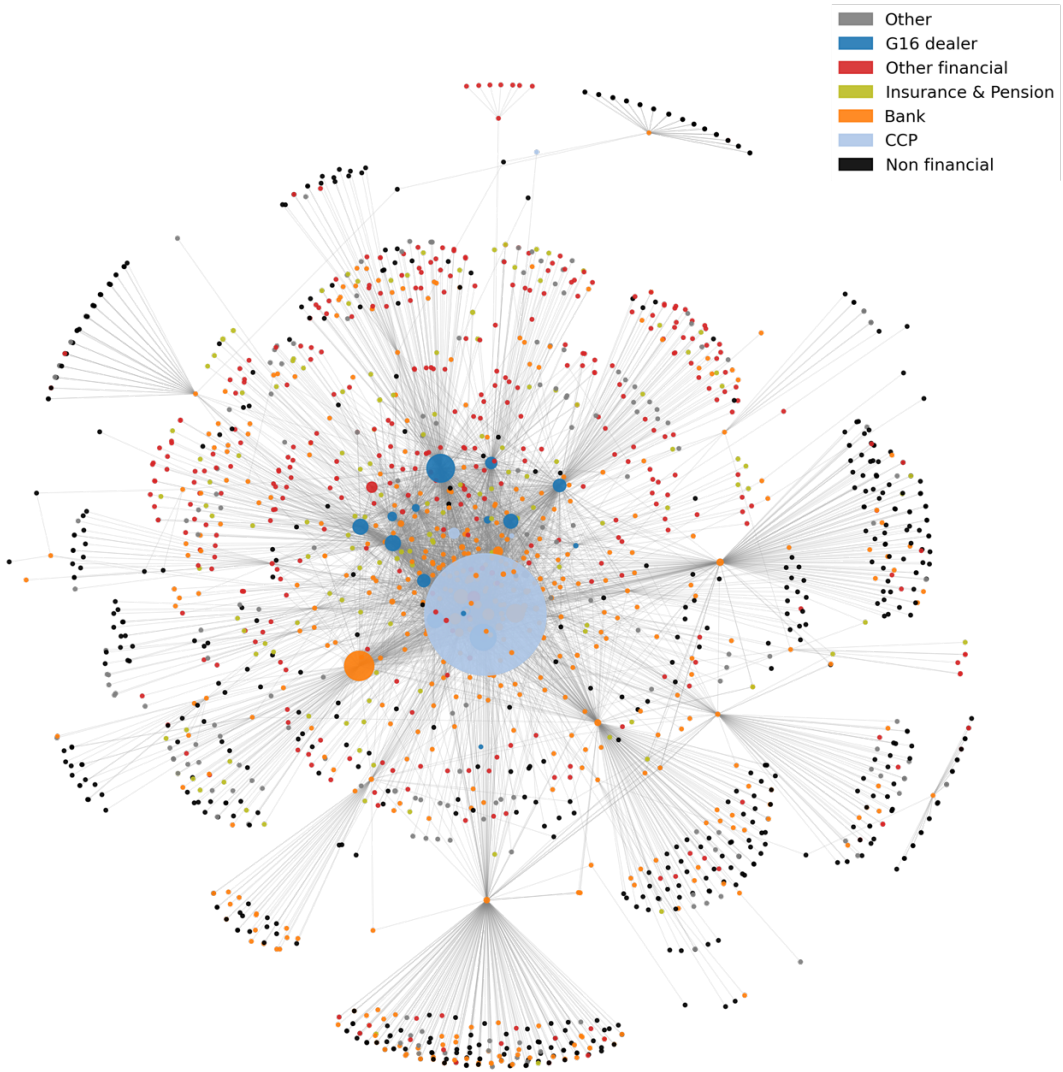

Figure: Illustrative OTC market (EURIBOR interest-rate swap) Abad et al. (2016)

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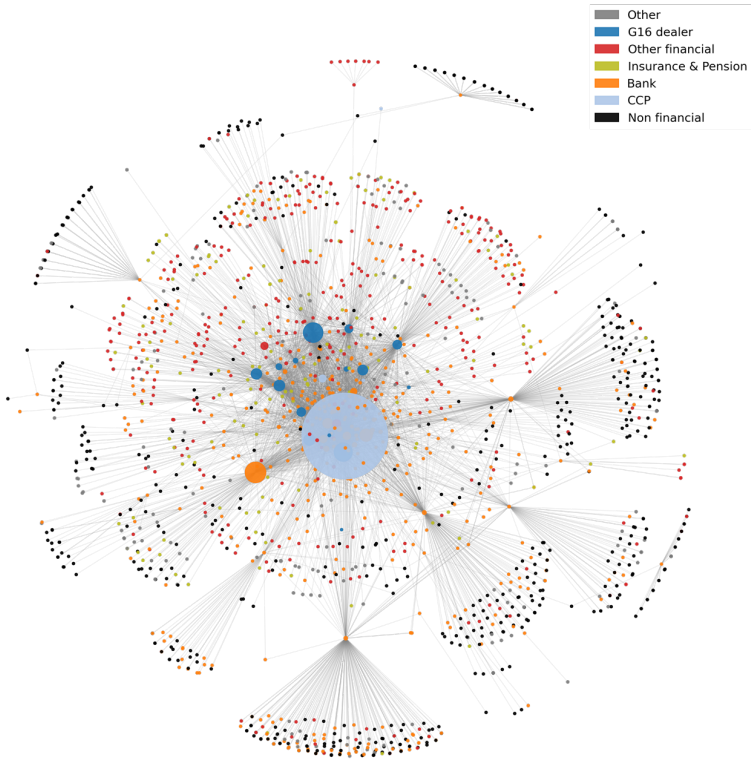

Consequences of OTC structure

- **Trading relationships**: a bank can only trade with subset of market.
- Liquidity in OTC markets is **local** and depends on a bank's counterparties' access to liquidity.
- Possibility of self-reinforcing **illiquidity spirals/cascades** in repo and collateral markets.

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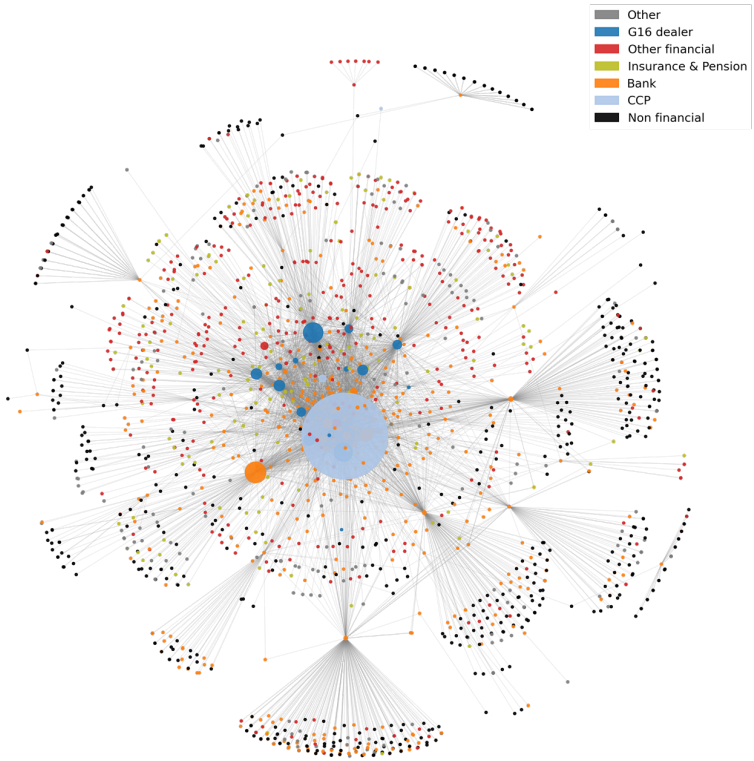

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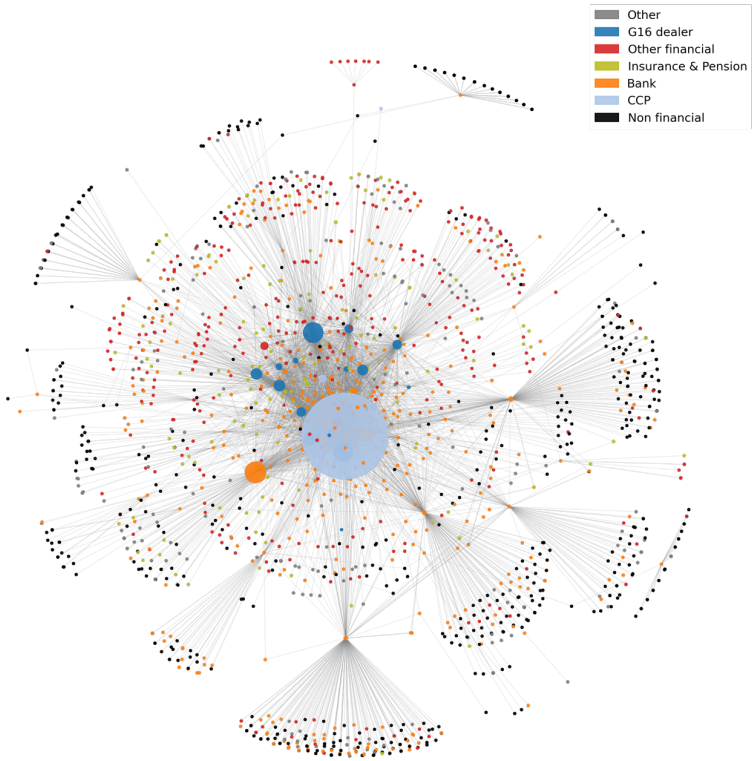

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OTC market induces feedback between market and funding liquidity.

Cf. Brunnermeier and Pedersen (2009); Acharya et al. (2011) who study **price-mediated** feedback loop between market and funding liquidity. Details

Comparison: Prices induce a feedback between markets for secured debt and collateral

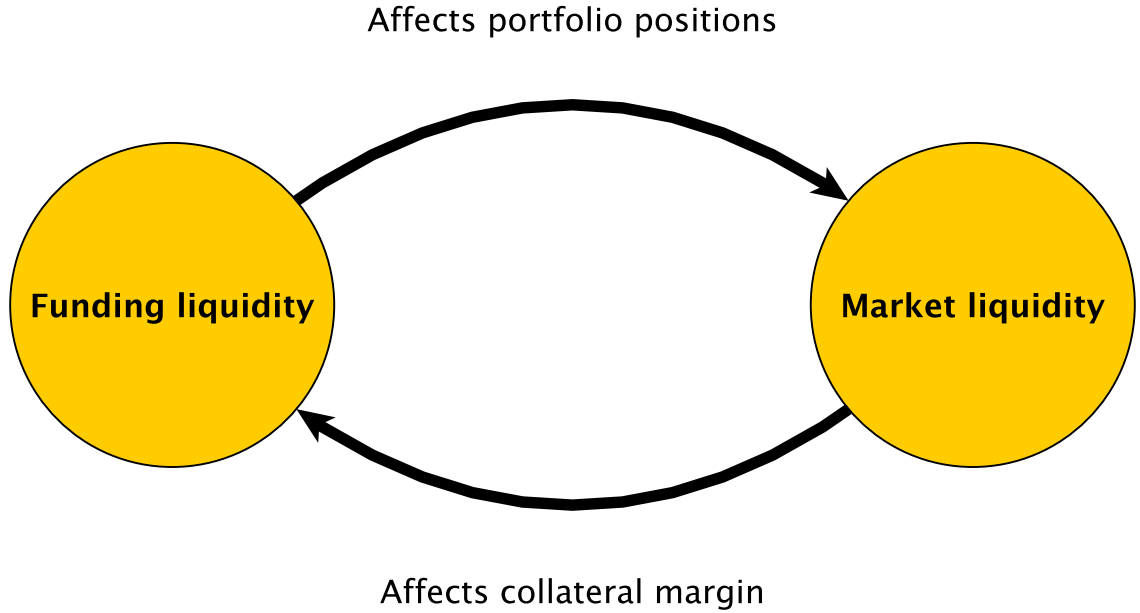
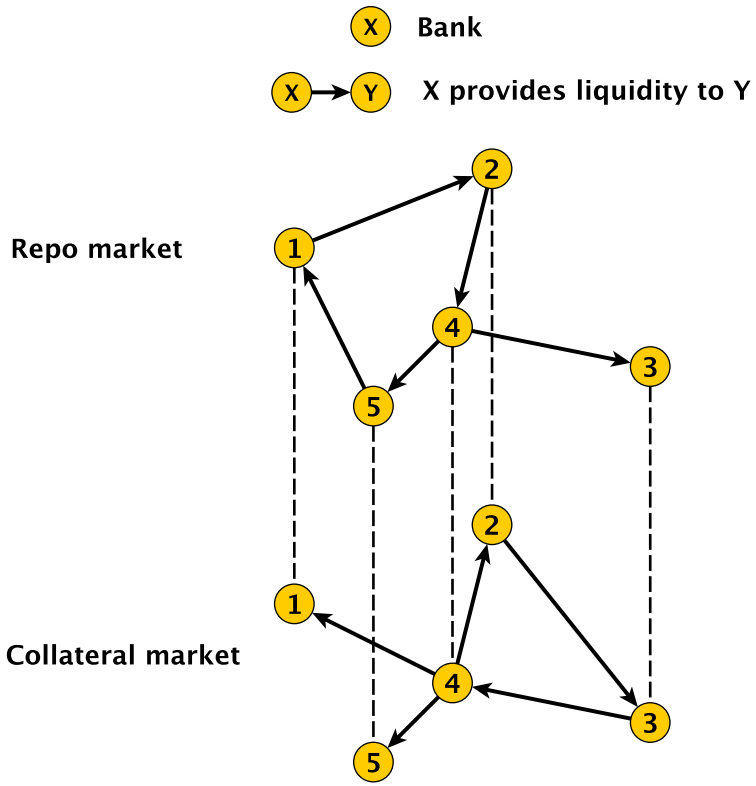


Figure: **Price-mediated** feedback between funding and market liquidity leads to evaporation of liquidity Brunnermeier and Pedersen (2009); for a quantity/debt-capacity approach see Acharya et al. (2011).

What other channels can cause feedback between market and funding liquidity? Our answer: **OTC market structure**.

Markets are modeled as directed networks of liquidity provision between intermediaries (banks)



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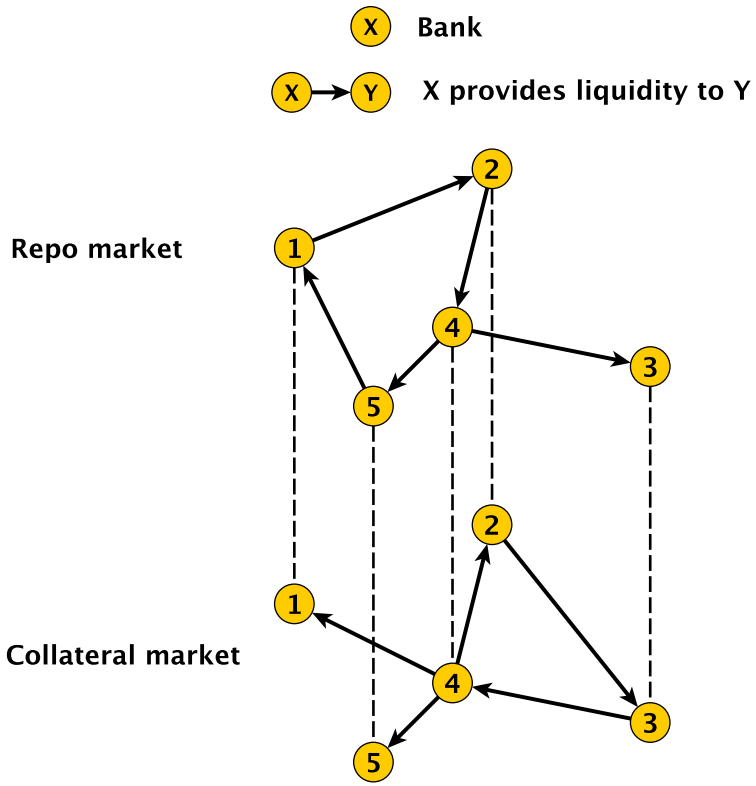

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- Two **different**, **directed** networks $\mathcal{G}_R$ (repo) and $\mathcal{G}_C$ (collateral): bilateral links of liquidity provision.

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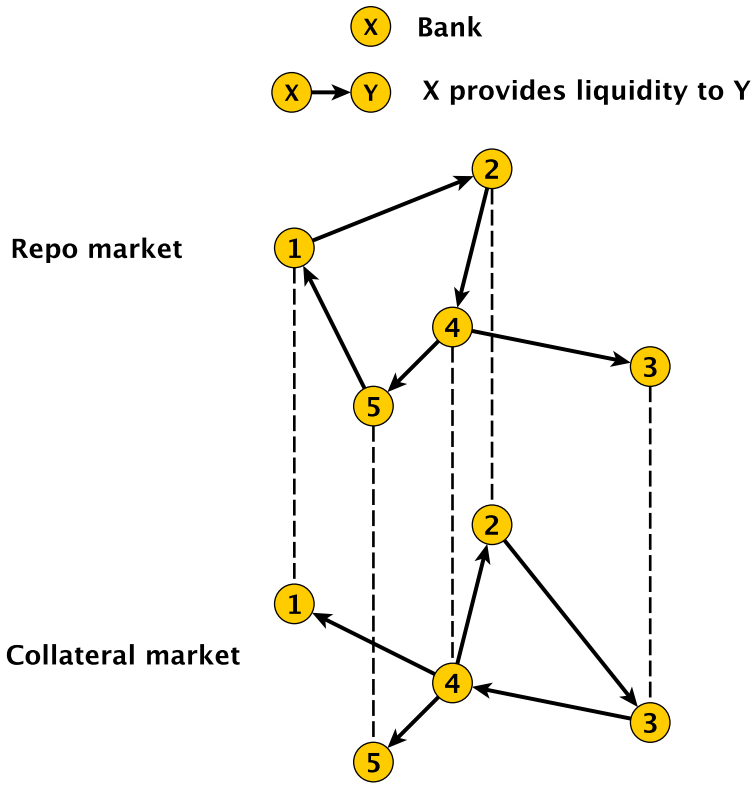

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- Binary action in each network: (a_i^R, a_i^C).
- Net utility of providing liquidity increasing in own access to liquidity.
- Best response: want to be active as long as **enough active neighbors** in **each network**.
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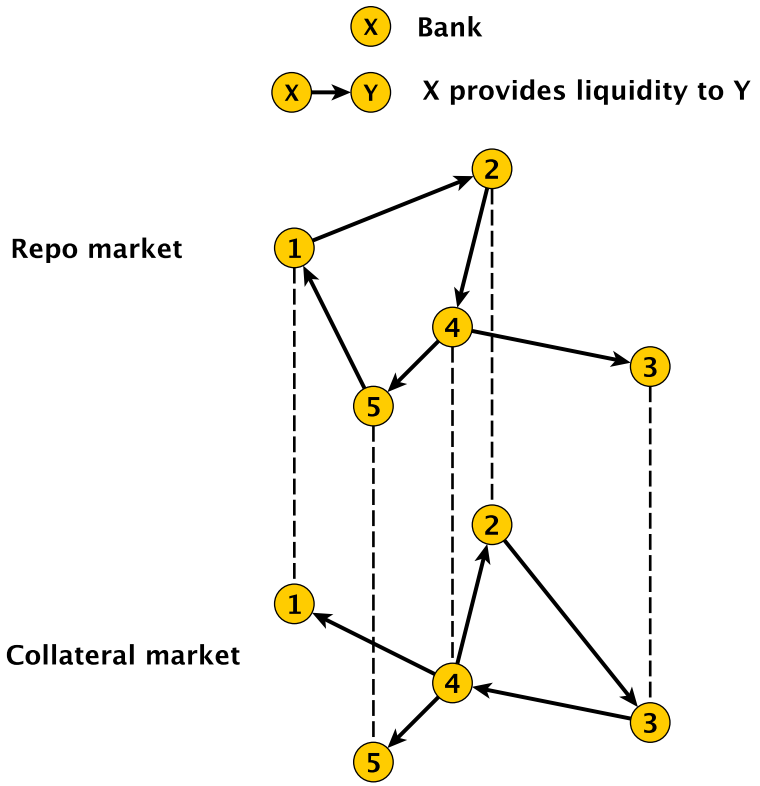

Note: By design we focus on extensive margin (**who** trades) but ignore prices and quantity of repo/collateral provided by a given bank.

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Payoffs and best responses

Let $S_i^{\mathcal{G}}$ be number of i's neighbors active in network network $\mathcal{G}$.

$$u_i(\boldsymbol{a}) = \begin{cases} \pi(S_i^R, S_i^C) - c(w_i) & \text{if } a_i^R = a_i^C = 1 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Assumption: increasing differences. BR: active if (for simplicity) at least one neighbor in each network active

Cf. [Morris, 2000], [Galeotti et al., 2010], [Golub and Morris, 2017].

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3. **Cash-in-advance constraint:**
   To purchase collateral/provide repo, banks must first obtain repo funding.
   $\implies$ $a_i^R = 1$ or $a_i^C = 1$ requires active in-neighbors in repo markets.[2]

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Key basic facts about equilibrium.

- Game is **supermodular**: i.e. best response function is weakly increasing [see Tarski, Milgrom and Roberts, 1990].
- Has a **unique maximal** equilibrium.

  Algorithm to find it: start with all banks active, repeatedly apply best response function.

  Application of BR at each step: make a bank inactive if and only if it lacks an active neighbor in at least one network.
- Liquidity measure $\mathcal{L}(\mathbf{w})$: number of banks active in the unique maximal equilibrium.

Equilibrium: Illustration of iterative algorithm and characterization in terms of network

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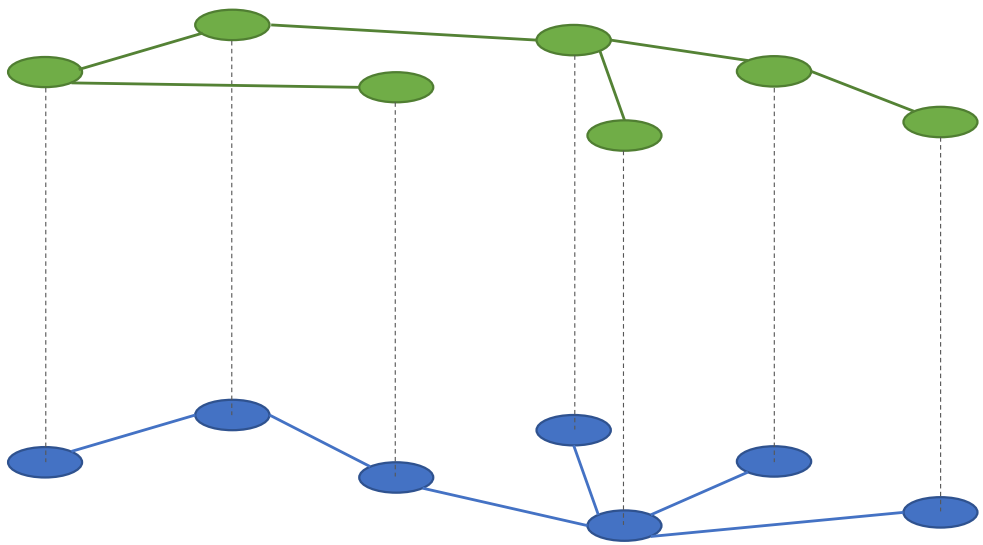
Coupled network contagion: (undirected simplification)



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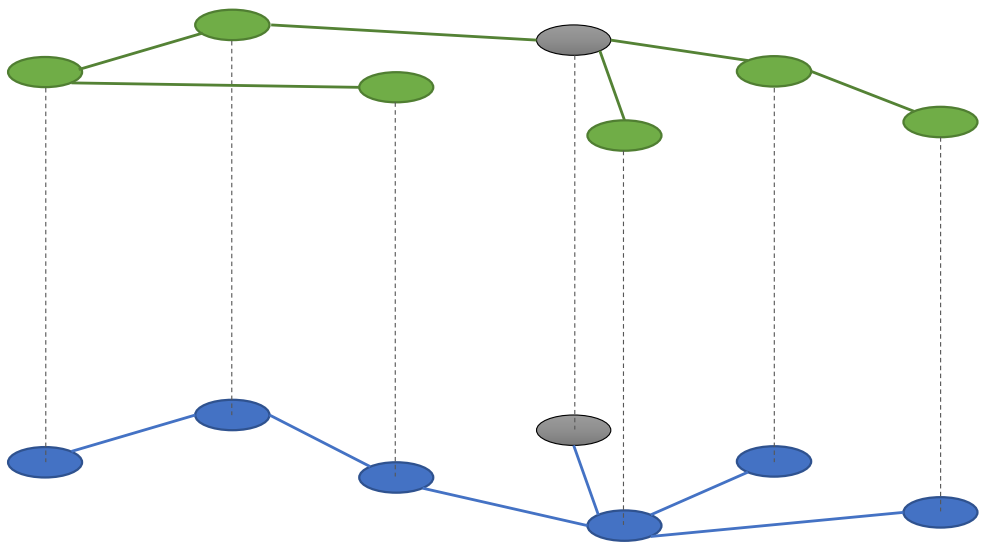

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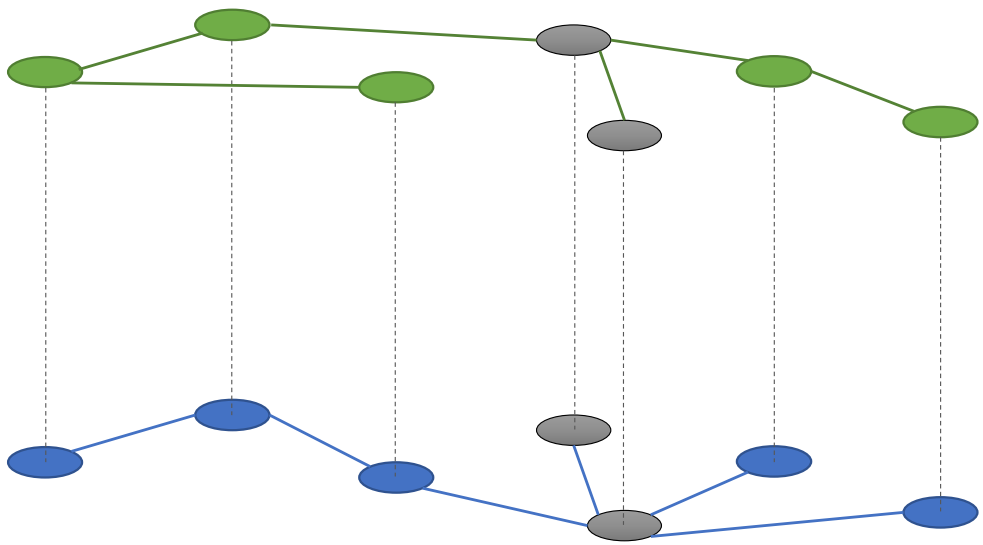

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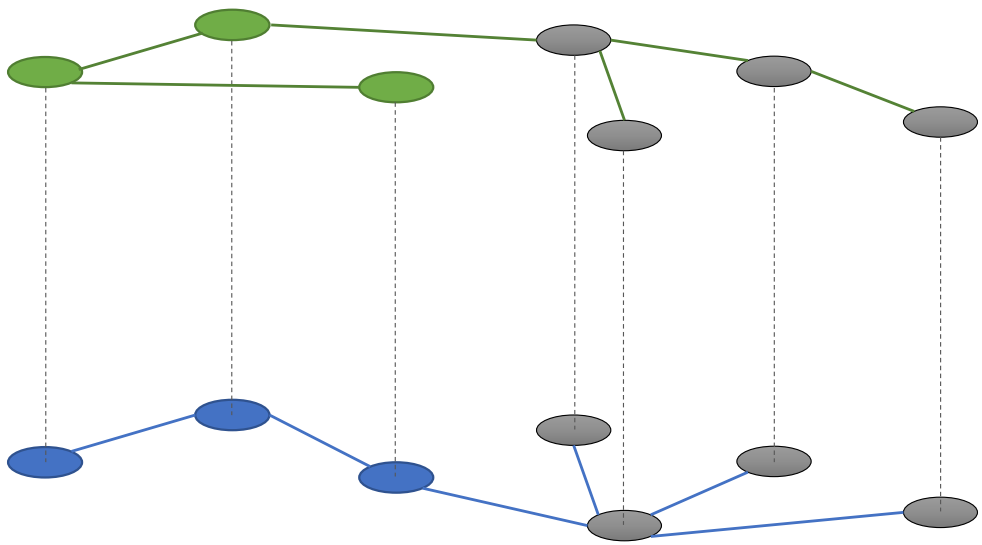

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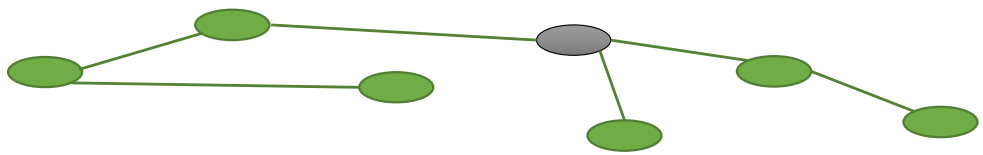
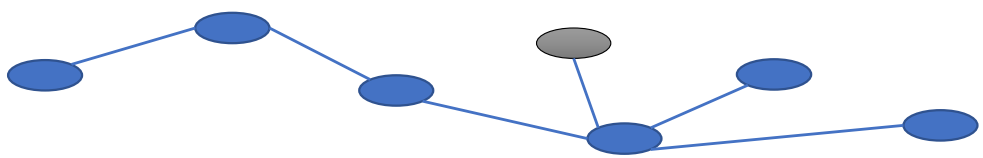


Repo network



Collateral network

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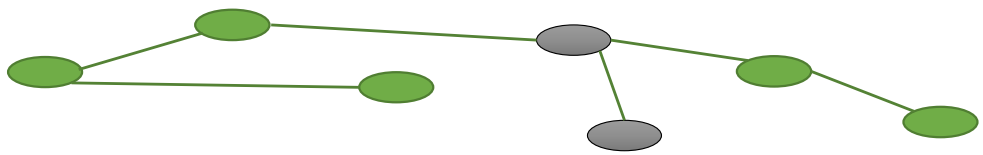

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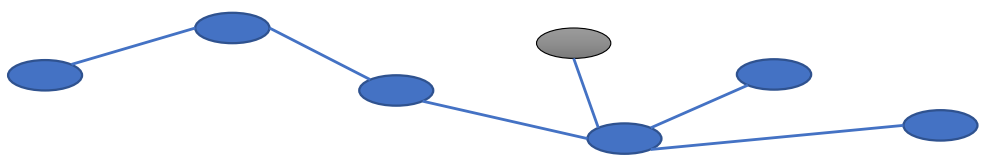

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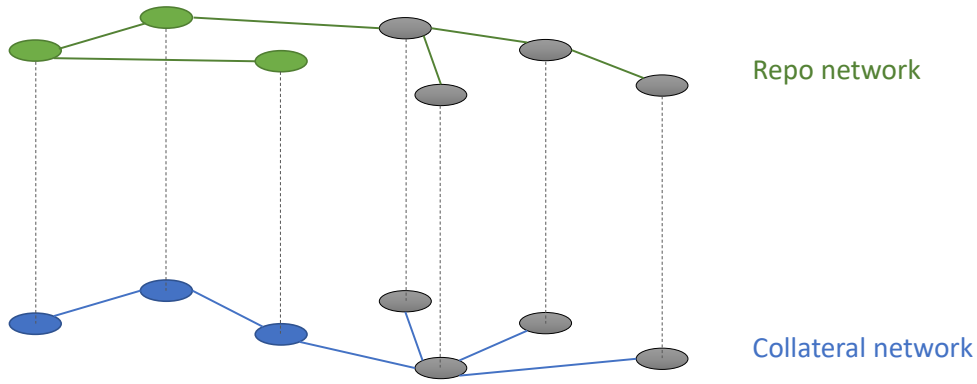


Reducing to a network notion

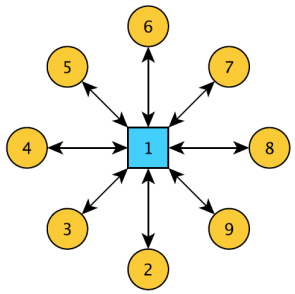
The liquidity measure is equal to the number of banks in a nontrivial mutual strong component.

Strong **component**: there is a path connecting any node to any other.

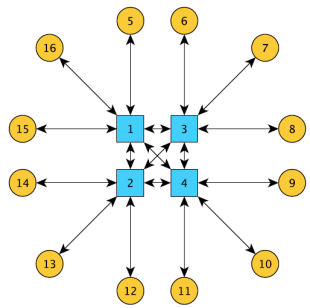
Mutual strong component: intersection of two strong components.

Nontrivial: larger than one node.

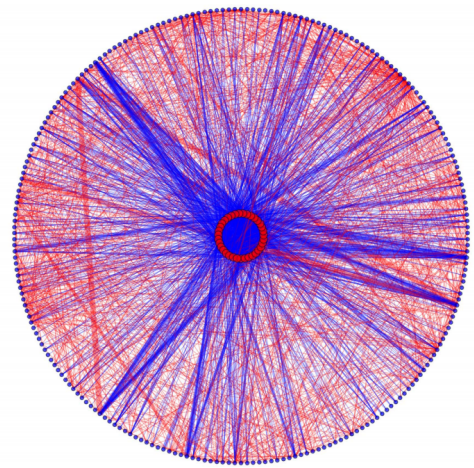
Similar results apply to core-periphery networks.



(a) Star network



(b) Core-periphery network.



- Examples of a star network (left) and a core-periphery network (center)
- The Euroarea interbank market. Source: Colliard, Foucault, Hoffmann (2017)

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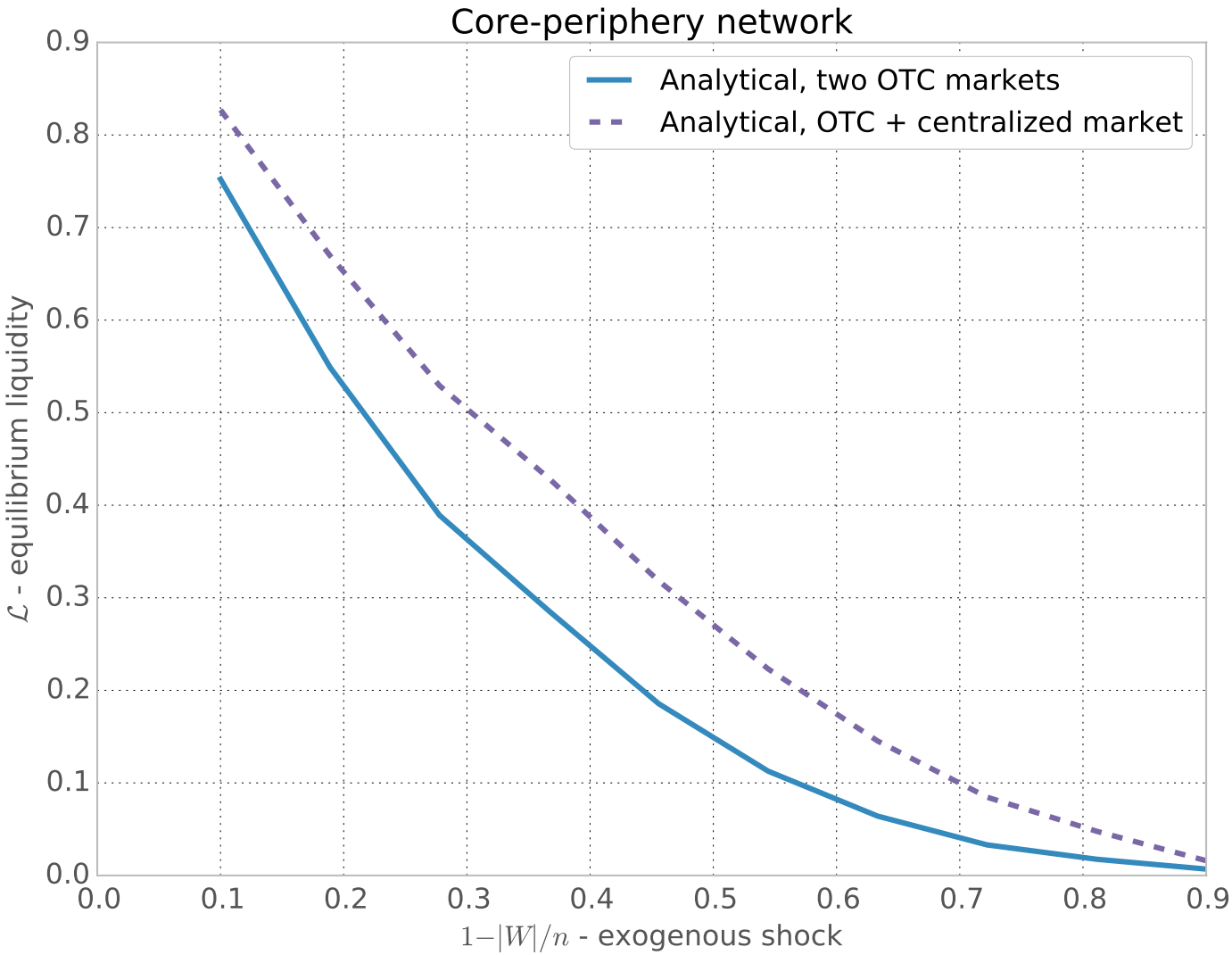

[4] (ncc = 0,ncp = 2,npc = 2,npp = 50)

General Fact

Adding trading opportunities in either network *always* weakly improves post-shock liquidity.

To study more interesting networks, we focus on a class of random networks determined by distribution of number of counterparties -

Constructing constrained random market structures...

- Each bank i has a given number of counterparties:
  - Number of banks i provides liquidity to: $d^{+}_{i,\mu}$.
  - Number of banks i receives liquidity from: $d^{-}_{i,\mu}$.

[1] Degree distribution need to satisfy certain other regularity conditions, e.g. finite variance in the limit as $n \to \infty$.

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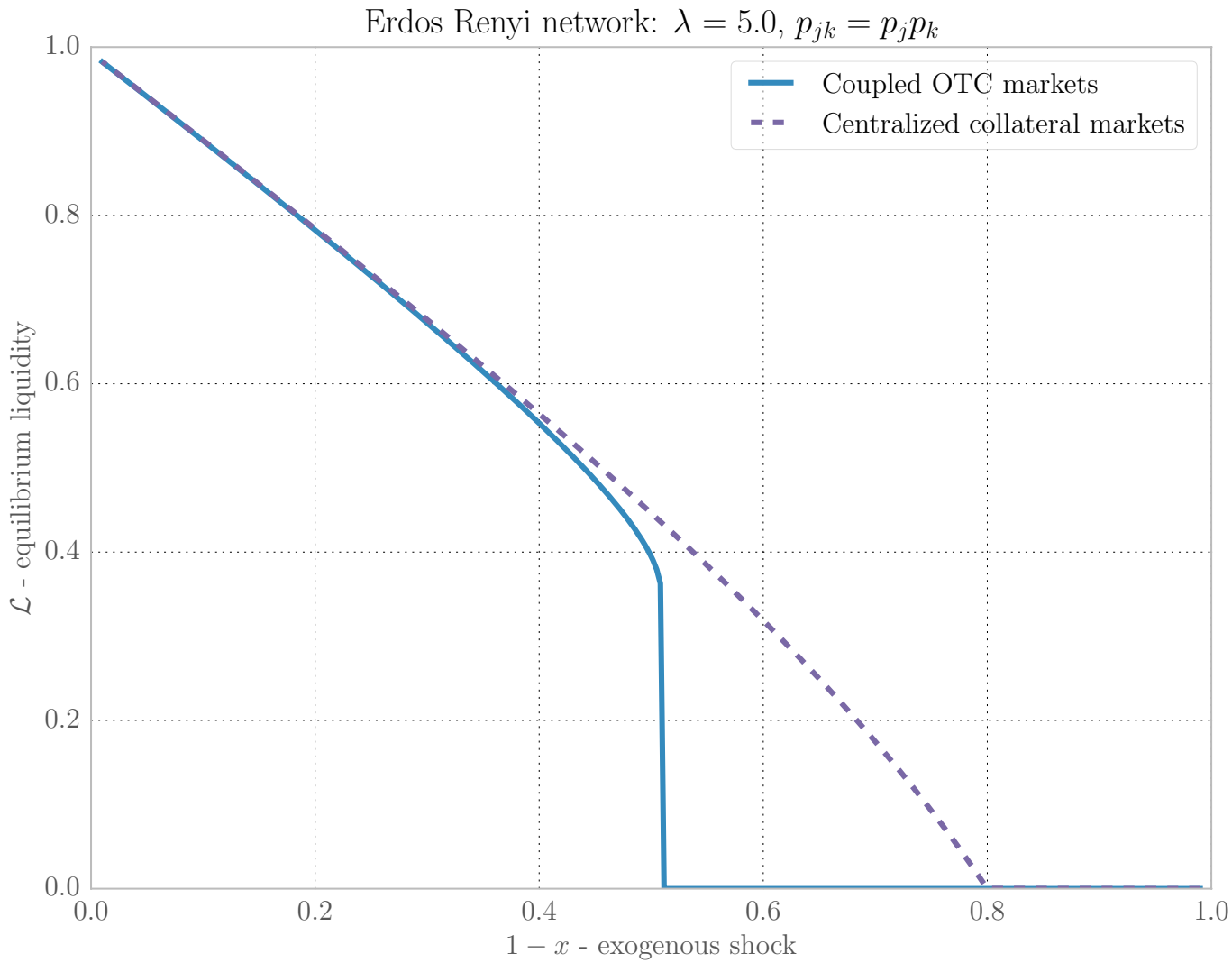
- Rather than working with fixed vectors of degrees, specify a *degree distribution*:

$$P_\mu(d^+ = j \text{ and } d^- = k) = p_{jk,\mu}$$

In this context, what can we say about equilibria and the corresponding liquidity measure?

[1] Degree distribution need to satisfy certain other regularity conditions, e.g. finite variance in the limit as $n \to \infty$.

Example for a graph with binomial degree distribution (Erdős-Rényi): Abrupt market freeze



Market freezes in OTC vs centralized markets

Proposition (Market freezes)

- *Repo and collateral are OTC: There exists a critical shock* x^* *such that* $\mathcal{L}^*(x)$ *vanishes* **discontinuously** *in* x*.*
- *Repo OTC and collateral centralized: There exists a critical shock* w^* *such that* $\mathcal{L}^*(w)$ *vanishes* **continuously** *in* w*.*
- *We always have* $x^* < w^*$*.*

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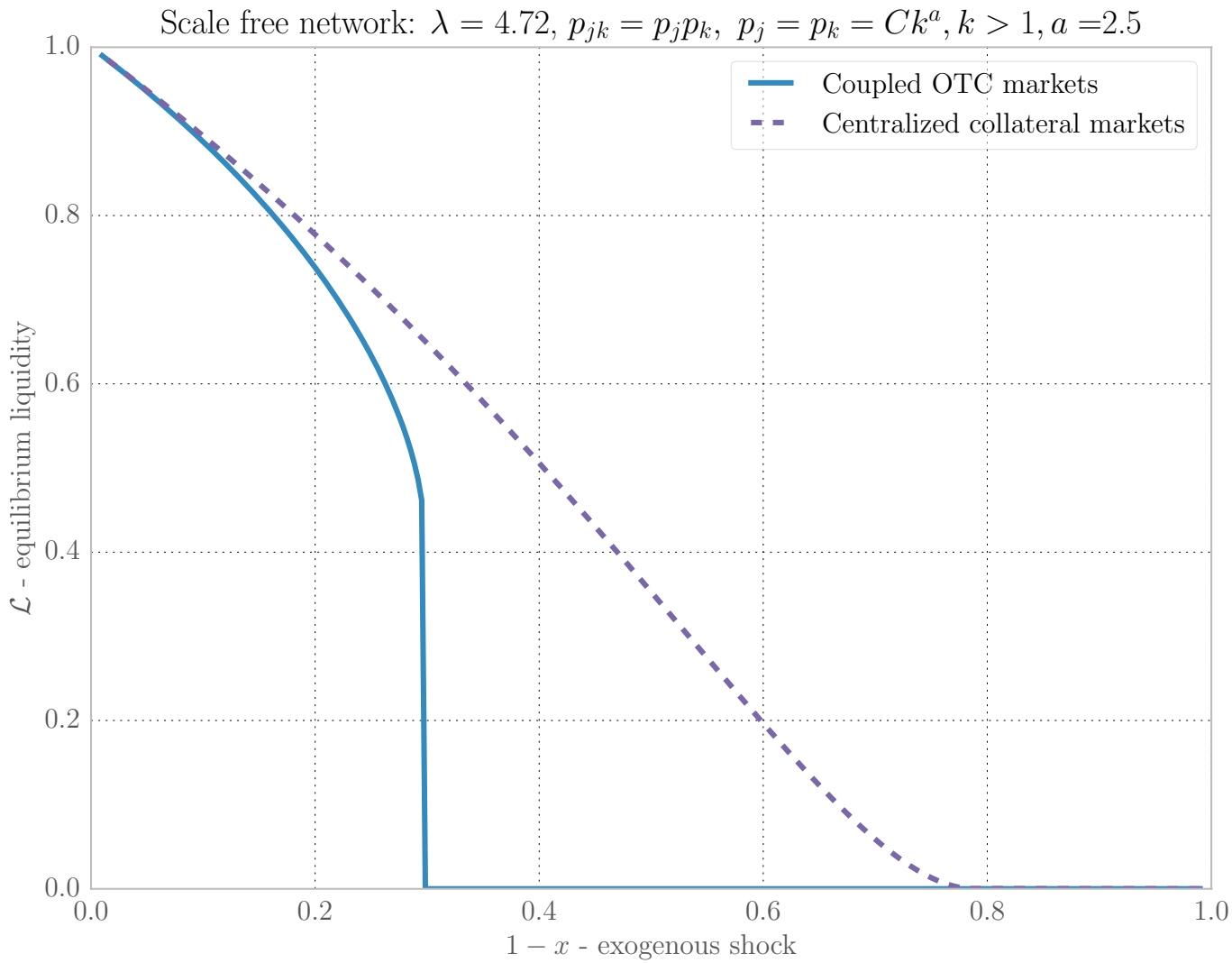
Proposition (Market freezes)

- *Repo and collateral are OTC: There exists a critical shock* x^* *such that* $\mathcal{L}^*(x)$ *vanishes* **discontinuously** *in* x*.*
- *Repo OTC and collateral centralized: There exists a critical shock* w^* *such that* $\mathcal{L}^*(w)$ *vanishes* **continuously** *in* w*.*
- *We always have* $x^* < w^*$*.*

Introduction of centralized collateral market makes joint system more stable.

Another example for a graph with power-law degree distribution



Take-home messages

When repo and collateral markets jointly OTC. . .

1. Significant illiquidity spirals occur for **different network topologies**: star, core-periphery, Erdős-Rényi , etc.
2. Coupling between OTC repo and collateral markets can lead to **sudden evaporation** of liquidity and **increased susceptibility** to random shocks to intermediaries.
3. Some randomness in structure of networks critical to sharp evaporation.
4. Introduction of centralized collateral markets improves liquidity resilience substantially.

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$\Rightarrow$ Thank you!