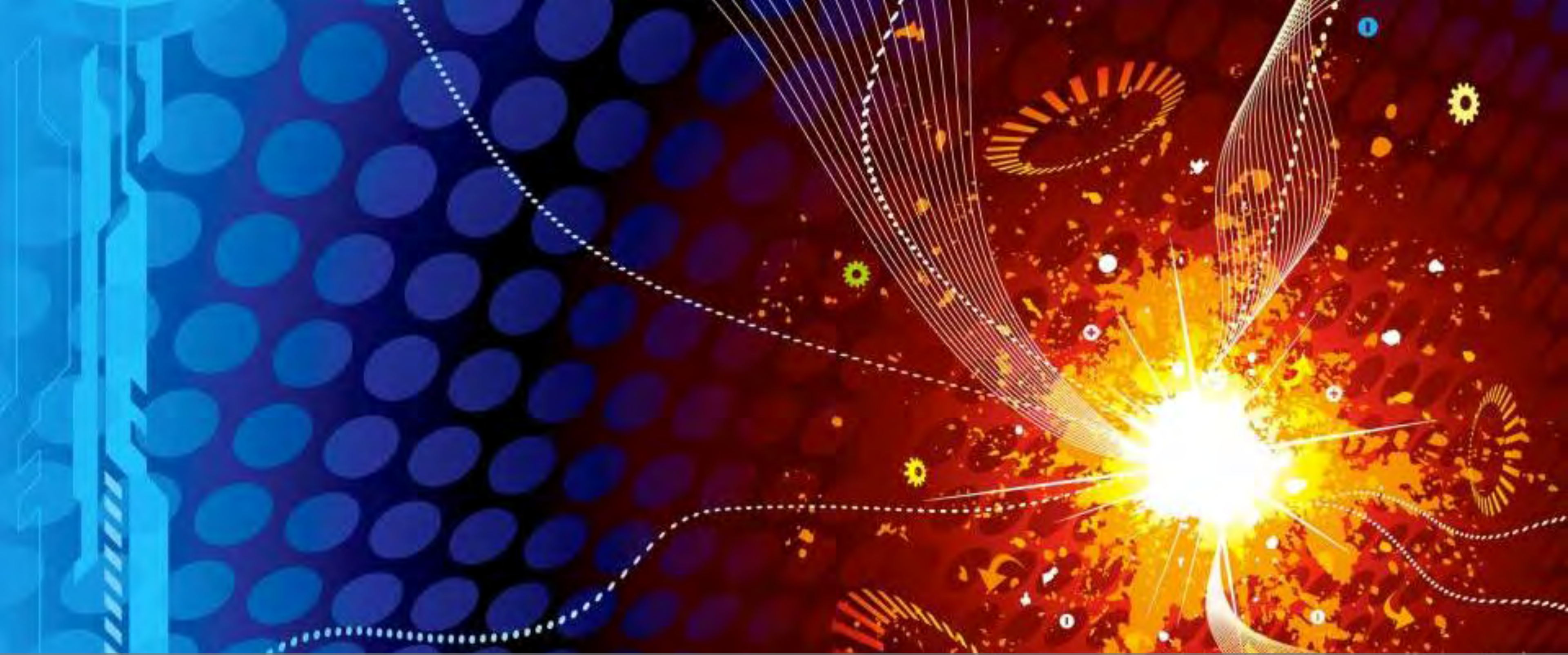

CCPs and Network Stability in OTC Derivatives Markets

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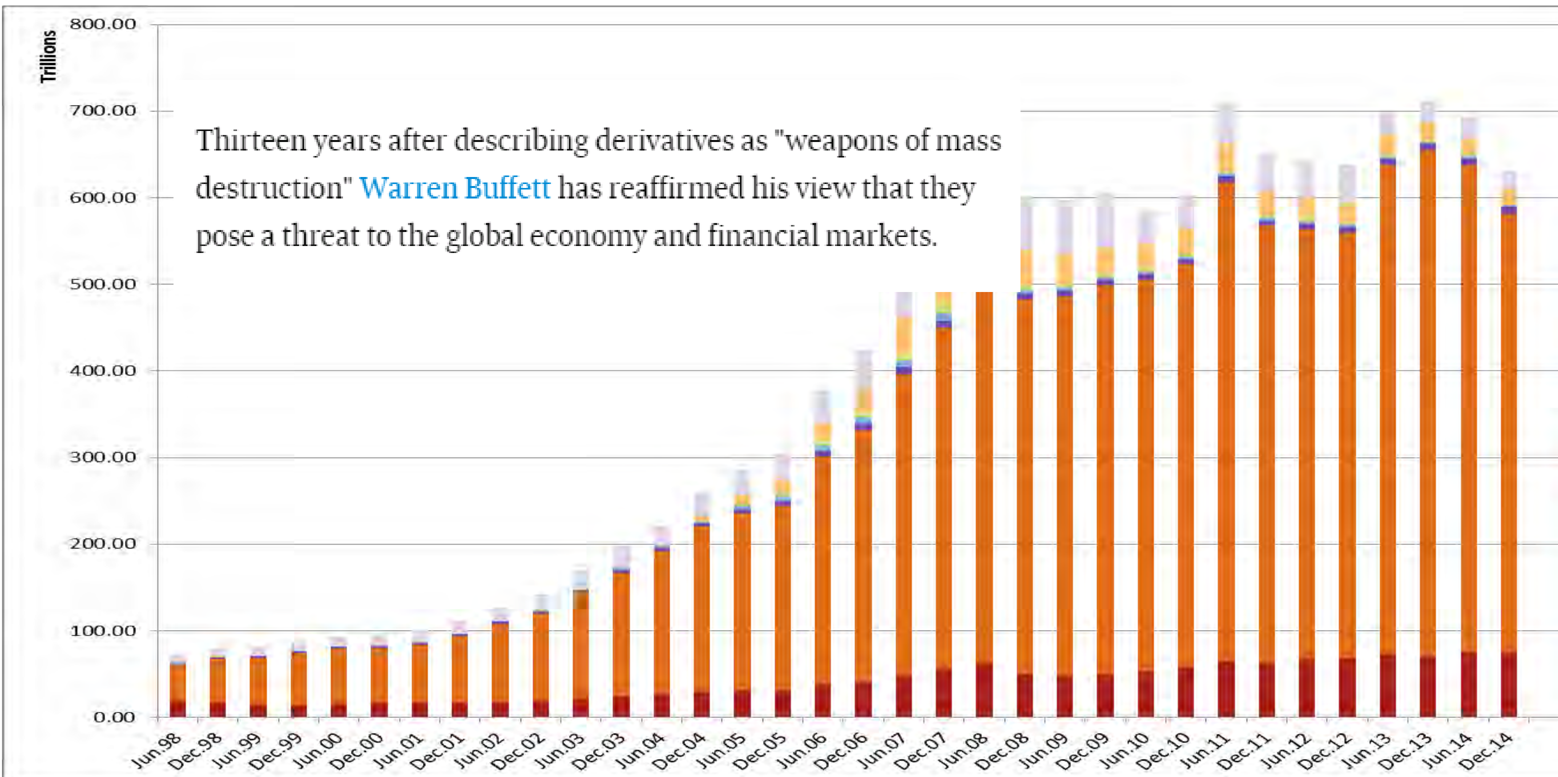
Overview

- Motivation
- The role of central counterparties
  - Collateral
  - Netting
- OTC data and network reconstruction
- Clearing scenarios
- Network stability model
- Policy messages and future work

Motivation

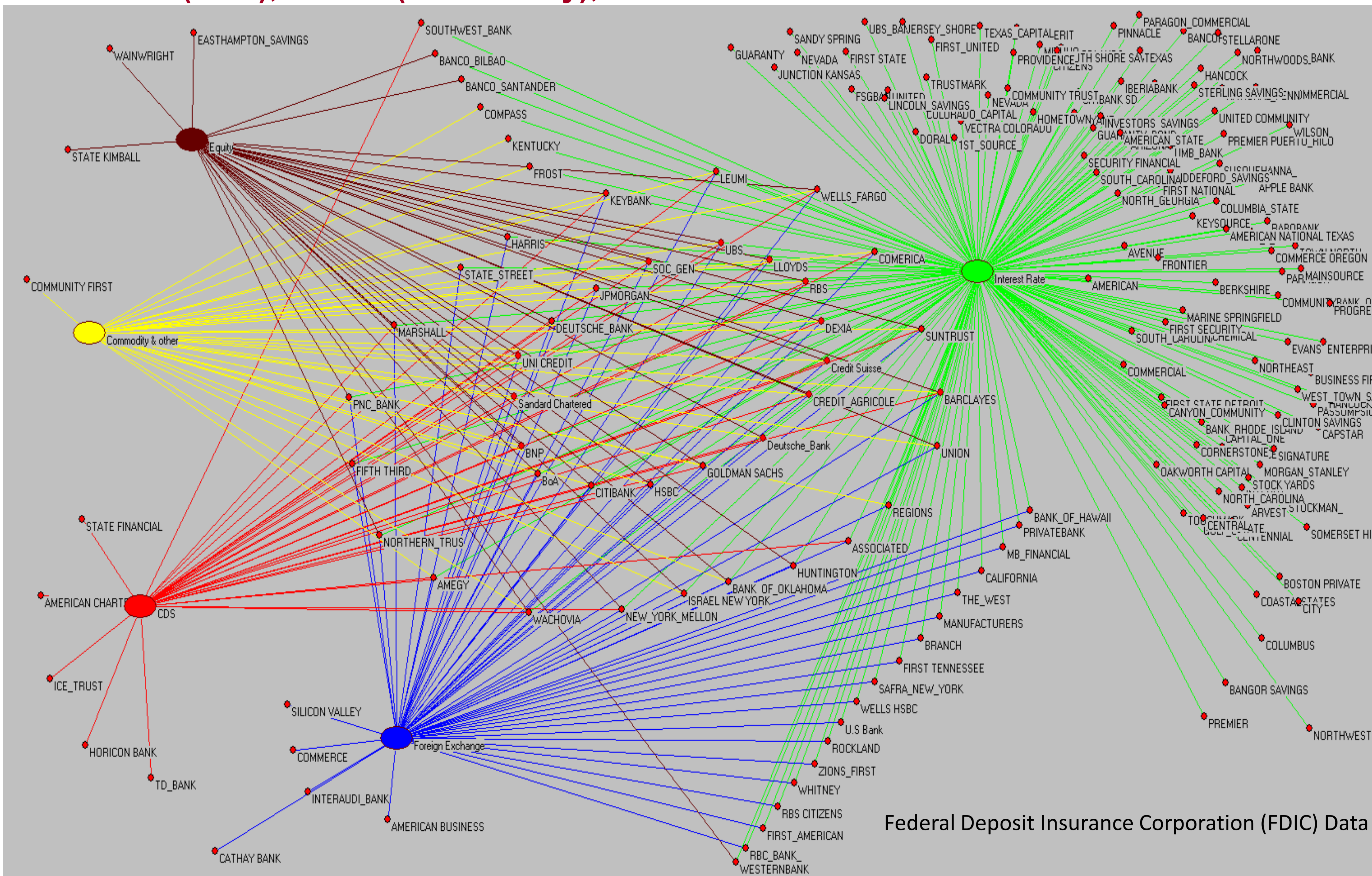
- $600+ Trillion OTC Derivatives
- G20's ambitious program to Improve market infrastructure following the 2007-2008 crisis, central counterparties (CCPs) are being put forth as the way to make over-the-counter (OTC) derivatives markets safer and sounder, and to help mitigate systemic risk.
  - Strengthen risk management; reduce interconnectedness
  - However: concentrate risk in one or a few nodes in the financial network and also increase institutions' demand for high-quality assets to meet collateral requirements
  - funding and liquidity
- Assess implications for stability



Source:
BIS Derivatives Statistics

Structure of Global Financial Derivatives Market

(2009,Q4 202 participants): Green(Interest Rate), Blue (Forex), Maroon (Equity); Red (CDS); Yellow (Commodity); Circle in centre Broker Dealers in *all* markets



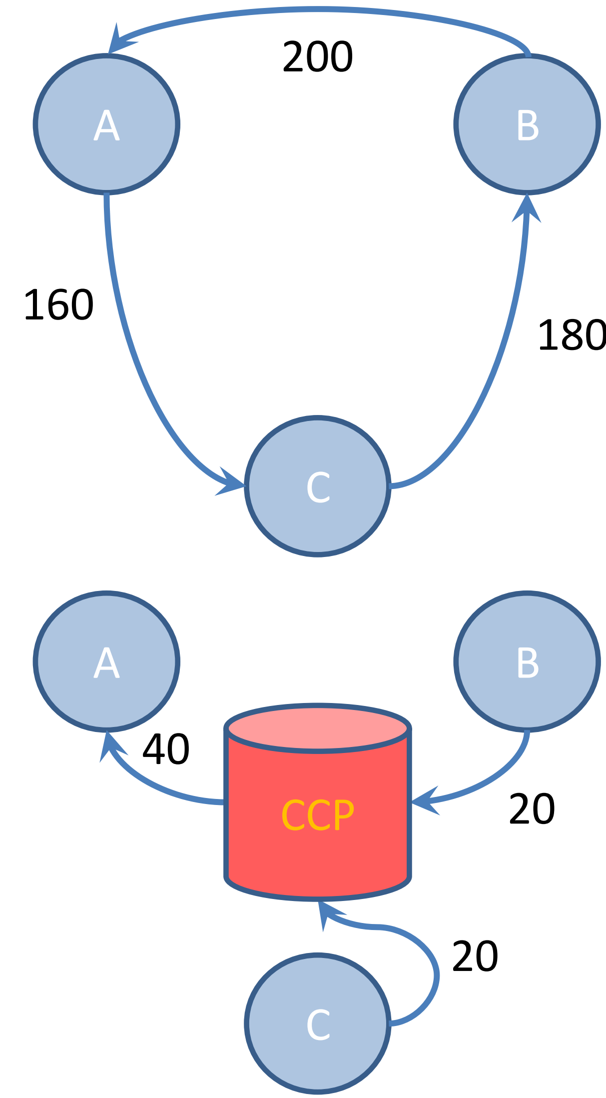
Federal Deposit Insurance Corporation (FDIC) Data

The Role of Central Counterparties

- A **CCP** assists institutions in the management of counterparty credit risk by interposing itself between counterparties to become the buyer to every seller, and the seller to every buyer. These arrangements support anonymous trading, deepen market liquidity, and generally maximize the netting of exposures across participants.

- 1) clearinghouses are better able to manage risk than dealer banks in the over-the-counter derivatives market, and (2) clearinghouses are better able to absorb risk than dealer banks. Adam J. Levitin

- Policymakers acknowledge that confidence in underlying markets could be severely tested if a CCP's activities were disrupted, leaving market participants unable to establish new positions or manage existing exposures.



Collateral

- Replacement cost risk managed through
  - Variation margin: exchanged daily usually in cash – to reflect mark-to-market price changes on participants' outstanding positions.
  - Initial margin: to cover, with typically 99% Confidence level, potential future exposure arising between the last variation margin payment and the closeout or replacement of a defaulted counterparty's trades
- A CCPs initial margin is supplemented with a pool of resources from all participants known as the default fund
- For systemically important CCPs these fund is calibrated to withstand the default of its largest two participants (cover 2)

OTC Derivatives Data

- The MAGD (Macroeconomic Assessment Group on Derivatives) data on OTC derivatives consist of reported balance sheet data on derivative assets and liabilities for 41 banks that are involved in OTC derivative trading. (2012 Financial reports)
- Tier 1 capital and liquid resources (which we define here as the sum of cash and cash equivalents and available-for-sale assets)

($US trillion)	Total	Core (16 Banks)	Periphery (25 Banks)
Derivative Liabilities	14.34	12.16	2.18
Derivative Assets	14.48	12.35	2.13
Cash and Cash Equivalents	2.44	1.20	1.25
Available for Sale Assets	5.57	2.83	2.74
Tier 1 Capital	2.39	1.34	1.05

Network Reconstruction

- The OTC derivative obligations owed by bank *i* to bank *j* in product-class *k* → X_{ij}^{k}
- Bank *i*'s total derivative liabilities in product-class *k* will be given by the sum of its obligations → $\sum_{j=1}^{B} X_{ij}^{k}$,
- connectivity priors: 16 core banks 100 % probability peripheral banks to core banks 50%, peripheral → peripheral 25%
- Genetic Algorithm that distributes the aggregate gross market asset and liability values across bilateral relationships (Rais Shaghaghi and Markose (2012))
- The bilateral gross notional positions are estimated by multiplying the values in each row of the product matrices by the ratio of gross notional liabilities to gross market value liabilities. $\mathbf{G}^{k}$
- The matrix of bilateral net notional OTC derivative positions is then given by $\mathbf{N}^{k} = \mathbf{G}^{k} - \mathbf{G}^{k'}$

Clearing scenarios and netting

- $W_{ij}^{k} = (1 - s^{k})N_{ij}^{k}$,
- with CCP c → $W_{i(B+c)}^{k} = \sum_{j=1}^{B} s^{k} N_{ij}^{k}$.
- $s^{k} = 1$ in extreme scenario 3 and 4

Scenario	CCP Service	Per cent centrally cleared, by product class
Scenario 1	Product specific	75 per cent interest rate; 50 per cent credit; 20 per cent commodity; 15 per cent equity; 15 per cent currency
Scenario 2	Single	As in Scenario 1
Scenario 3	Product specific	100 per cent of each product class
Scenario 4	Single	100 per cent of each product class

Netting

- Netting efficiency depends on the product and counterparty scope of a given clearing arrangement, the profile of positions, and the margining methodology applied:

Initial Margin at 99 Percent Coverage

	Total	Bank-to-bank	Bank-to-CCP	CCP-to-bank
Scenario 1	942.10	892.88	49.22	0.00
Scenario 2	930.25	892.88	37.37	0.00
Scenario 3	121.82	0.00	121.82	0.00
Scenario 4	80.76	0.00	80.76	0.00

Default Fund Size

- In the case of the CCP, the relevant metric is not capital, but rather the pooled financial resources in the CCP's default fund
- Table below sets out the size of each CCP's default fund in each scenario.

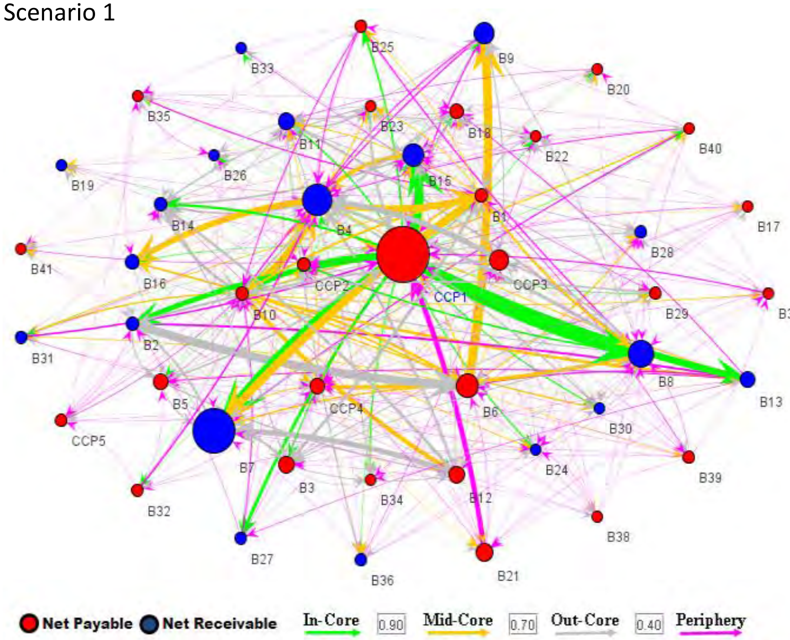
($US billion)	Scenario 1	Scenario 3
CCP1 (Interest Rates)	3.86	5.14
CCP2 (Foreign Exchange)	0.45	3.00
CCP3 (Equity)	1.63	10.83
CCP4 (Credit)	0.84	1.63
CCP5 (Commodity)	0.17	0.87
Total	6.95	21.47
Total encumbrance (default fund and initial margin)	949.05	143.29
	Scenario 2	**Scenario 4**
CCP (Combined)	4.14	11.86
Total encumbrance (default fund and initial margin)	934.39	92.62

Network Stability

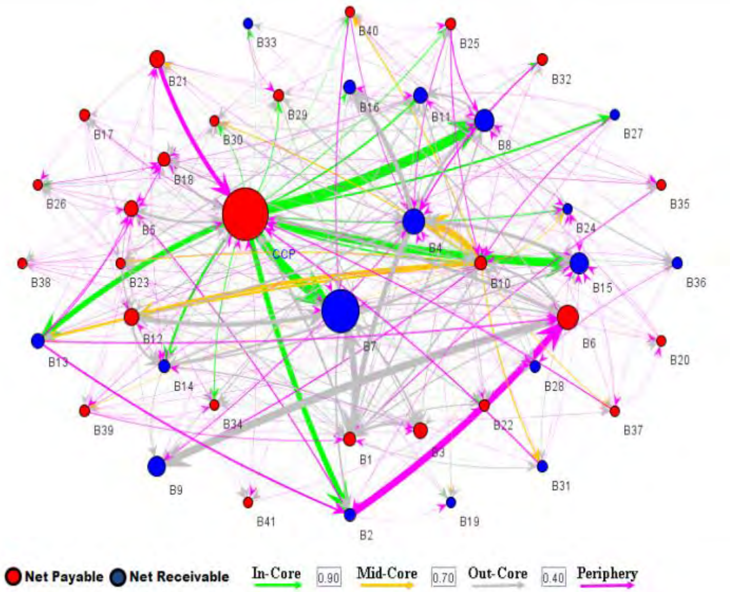
- Understanding the vulnerability of the system to failure
- Quantify the stability of a network system
- Adapt *(Markose 2013)(Markose, Giansante, Rais Shaghaghi 2012)* eigen-pair method
- which simultaneously determines the maximum eigenvalue of the network of liabilities (adjusted for Tier 1 capital), to indicate the stability of the overall system, along with eigenvector centrality measures.

Network Topology

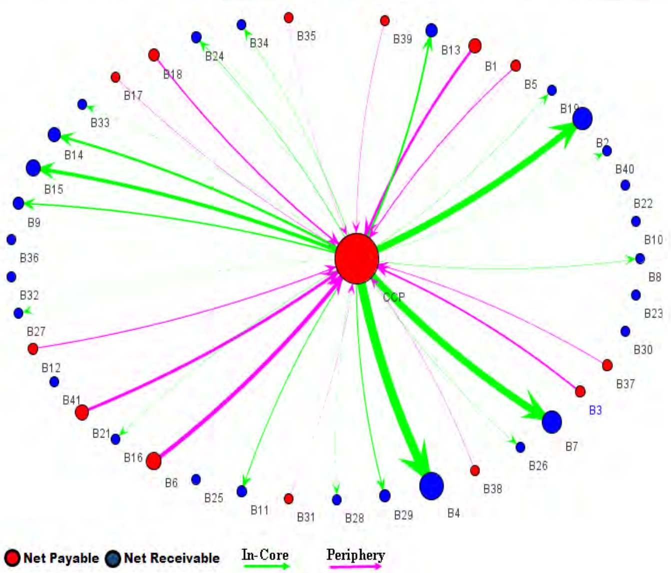
Scenario 1



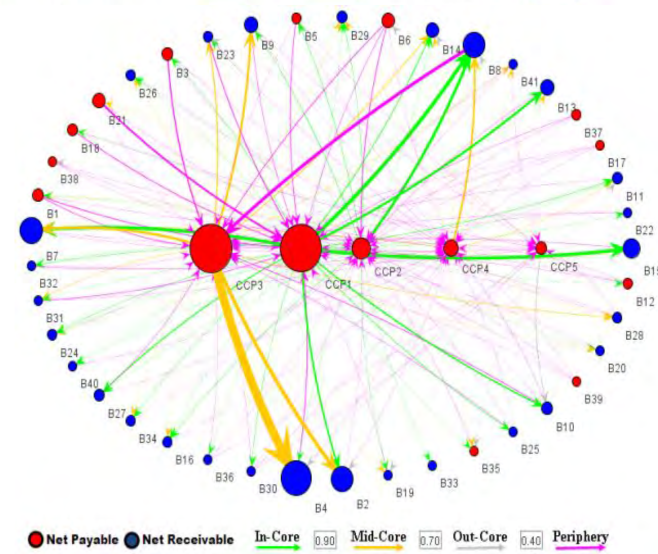
Scenario 2



Scenario 4



Scenario 3



The colours of the nodes denote whether the financial institution is a net payer (red) or a net receiver (blue) of variation margin, while the size of the arrows linking the nodes is proportional to the size of the exposure between them

Model
Populating the stability matrix

- $B + c$ financial institutions B Number of banks and c number of CCPs
- $\mathbf{\Theta}$ is a $(B + c) \times (B + c)$ matrix
  - where the (i, j)-th element represents the positive residual obligation M_{ij} from participant i to participant j as a share of participant j's resources
- Bank *j*'s resources, K_j, include bank j's Tier 1 capital adjusted for bank *j*'s contributions to any CCP default funds. In the case of a CCP, K_j represents the CCP's default fund.

Stability Matrix

- In hybrid case with separate CCPs the matrix $\boldsymbol{\Theta}$ is given as follows:

- $$\boldsymbol{\Theta} = \begin{bmatrix} 0 & \frac{M_{12}}{K_2} & \cdots & \frac{M_{1B}}{K_B} & \frac{M_{1CCP_1}}{K_{CCP_1}} & \cdots & \frac{M_{1CCP_5}}{K_{CCP_5}} \\ \frac{M_{21}}{K_1} & 0 & \cdots & \frac{M_{2B}}{K_B} & \frac{M_{2CCP_1}}{K_{CCP_1}} & \cdots & \frac{M_{2CCP_5}}{K_{CCP_5}} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \frac{M_{B1}}{K_1} & \frac{M_{B2}}{K_2} & \cdots & 0 & \frac{M_{BCCP_1}}{K_{CCP_1}} & \cdots & \frac{M_{BCCP_5}}{K_{CCP_5}} \\ \frac{M_{CCP_1 1}}{K_1} & \frac{M_{CCP_1 2}}{K_2} & \cdots & \frac{M_{CCP_1 B}}{K_B} & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \frac{M_{CCP_5 1}}{K_1} & \frac{M_{CCP_5 2}}{K_2} & \cdots & \frac{M_{CCP_5 B}}{K_B} & 0 & \cdots & 0 \end{bmatrix}$$

Systemic Stress

- **Liquidity stress**
  - can arise at each point in time from the encumbrance of banks' liquid assets to fund initial margin and default fund contributions.
    - Let L_i denote bank i's liquid assets
    - C_i be bank i's total initial margin
    - F_i be bank i's contributions to the default fund
  - proportion of encumbered liquid assets, given by $\frac{C_i+F_i}{L_i}$, is a metric for each bank's vulnerability to liquidity stress
- **Solvency**: From Epidemiology : Failure of i at q+1 determined by the criteria that losses exceed a predetermined buffer ratio, r, of Tier 1 capital
  - is defined in terms of a threshold, $1 \leq \rho^i \leq 0$
    - For a bank, we assume that only 10 per cent of Tier 1 capital ($\rho^{Bank} = 0.1$) can be absorbed to deal with potential derivative losses before the bank is deemed to be in stress. Since a CCP can use all of its default fund to protect against losses, $\rho^{CCP}=1$.
- **Interconnectedness** with counterparties can transmit stress to an institution, $\sum_j \frac{M_{ji}}{K_i} = \sum_j \theta_{ji}$
- Incorporating the factors above, the dynamics characterizing the transmission of contagion in a financial network for a bank can be given by
  - $u_{iq+1} = \left[\frac{(C_i+F_i)}{L_i} - \rho^{Bank}\right] u_{iq} + \sum_j \frac{M_{ji}}{K_{i0}} u_{jq} \quad u_{iq} = \left(1 - K_{iq}/K_{i0}\right)$ for q>0

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- In matrix notation, the dynamics of the system can be characterized in the following way:
  - $\mathbf{U}_{q+1} = \left[\mathbf{D}^{\mathbf{Liq}} - \ \boldsymbol{D}^{\boldsymbol{Sol}} + \boldsymbol{\Theta}'\right]\mathbf{U}_q = \mathbf{Q}\mathbf{U}_q$
  - $\mathbf{U}_q$ is a vector where each element is the rate of failure u_{iq}
  - system stability will be evaluated on the basis of the power iteration:

$$\mathbf{U}_{\boldsymbol{q}} = \mathbf{Q}^{\boldsymbol{q}}\mathbf{U}_{\mathbf{1}}$$

- The following condition can also be seen to be the tipping point for the system:
  - $\lambda_{max}\,(\mathbf{Q}) = \lambda_{max}\left(\mathbf{D}^{\mathbf{Liq}}\right) - \lambda_{max}\,(\mathbf{D}^{\mathbf{Sol})} \ + \lambda_{max}\,(\boldsymbol{\Theta}') < 1.$
- Right Eigenvector Centrality : Systemic Risk Index Left Eigenvector centrality Leads to vulnerability Index

Results of stability analysis

- Assuming CCPs hold prefunded resources to *Cover 2* and manage realized uncovered losses

- The risk of a systemic problem arising from a liquidity event in our system, as summarized by the Liquidity Systemic Risk Index
  - (LSRI, $\boldsymbol{\lambda_{max}}\left(\mathbf{D}^{\mathbf{Liq}}\right)$)
- and the probability of a solvency problem arising from second-round stress, as summarized by the Solvency Systemic Risk Index (SSRI, $\boldsymbol{\lambda_{max}}\,(\boldsymbol{\Theta}')$). *LSRI + SSRI < 1 + ρ = 1.1.*

Systemic Risk Indices

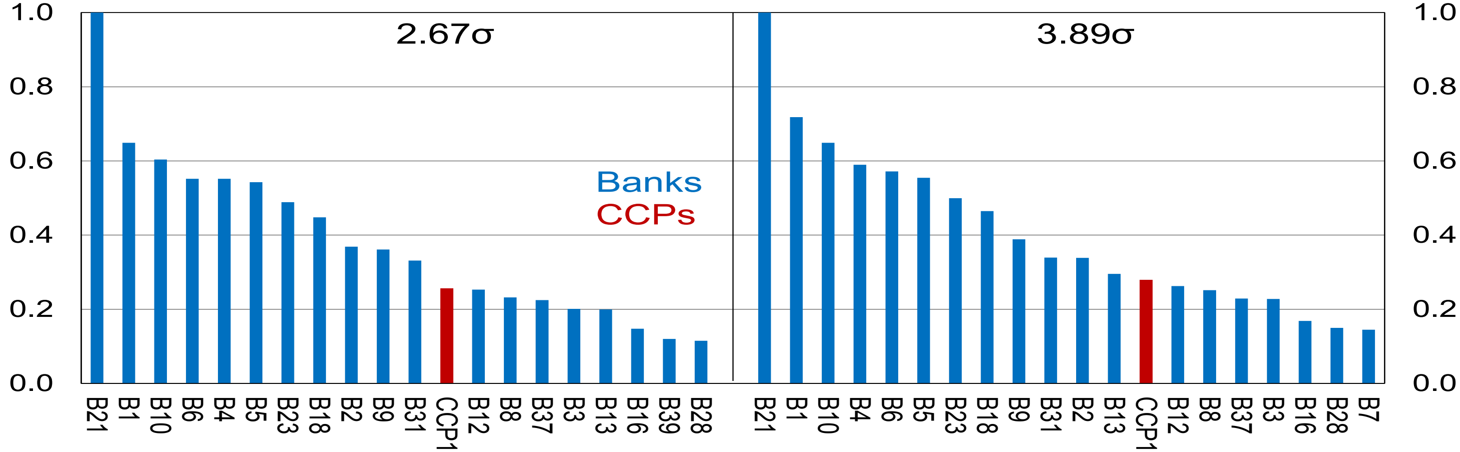
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Liquidity Systemic Risk Index (LSRI)				
	0.83	0.83	0.27	0.15
Solvency Systemic Risk Index (SSRI)				
Realized 2.67 Volatility	0.16	0.12	0.21	0.30
Realized 3.89 Volatility	0.39	0.31	0.45	0.58
Total Systemic Risk (SSRI+LSRI)				
Realized 2.67 Volatility	0.99	0.95	0.48	0.45
Realized 3.89 Volatility	1.22	1.14	0.72	0.73

- In Scenarios 1 and 2, in which a significant portion of positions remain non-centrally cleared, the limited scope for netting combined with the need to prefund initial margin gives rise to high encumbrance levels, hence the LSRI is very high
- For Scenarios 3 and 4, positions cleared via a CCP netting efficiency higher, liquidity risk is significantly reduced.
- In S1 and S2 SSRIs relatively low observed trade-off between liquidity risk and solvency risk in Heath, Kelly and Manning (2013) →high encumbrance reflects collateralization, the risk of solvency stress declines as liquidity risk increases.

Systemic Importance and Vulnerability

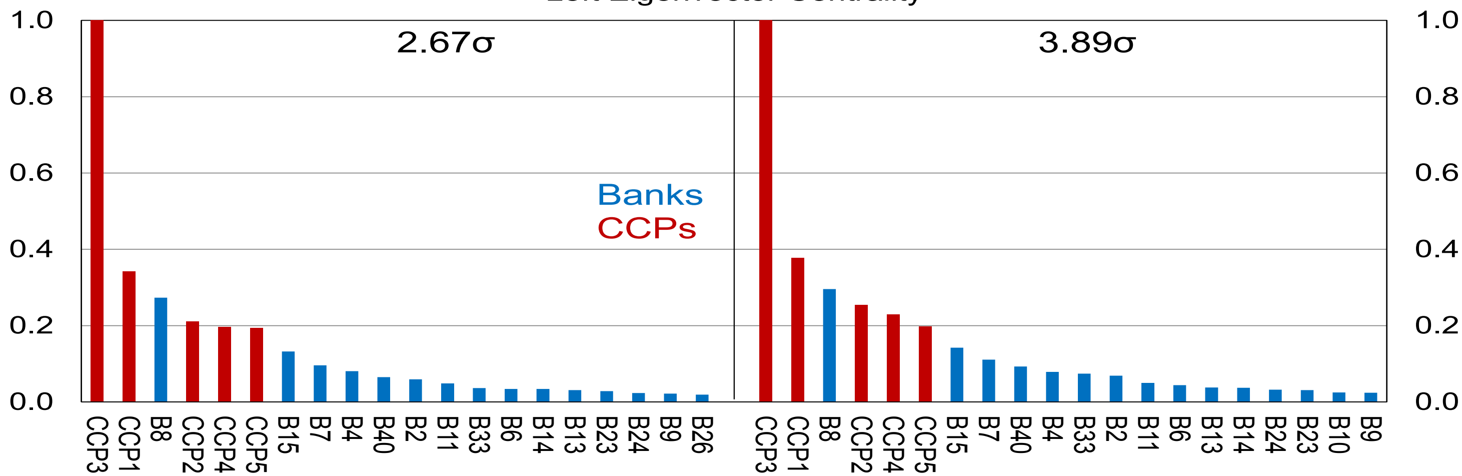
Systemic Importance

Right Eigenvector Centrality



Systemic Vulnerability

Left Eigenvector Centrality



Ranking of institutions can differ in the respective 2.67 and 3.89 price volatility cases; for example, in Figure 5(a), B6 is ranked fourth for the 2.67 standard deviation case, while B4 is ranked fourth for the 3.89 standard deviation case. Eigenvectors normalized to equate highest centrality rank to 1.

Conclusions

- Large exposures of CCPs and their extensive interconnections make them among the most vulnerable institutions in the system
- However, given their role and the design of their risk frameworks, CCPs would not be expected to transmit stress widely through the system in the event of a shock.
- Using real data on banks' OTC derivatives positions, the analysis in this work confirms the finding in Heath, Kelly and Manning (2013) that there is a trade-off between liquidity risk and solvency risk.
- Given that Scenario 1 most closely describes the topology that is likely to be observed in the near term, our analysis underscores the importance of understanding the stability of networks in which central clearing and non-central clearing co-exist. We have demonstrated that in such a scenario, the interaction between liquidity and solvency risks is particularly important.
- We leave to future research, the continued refinement of analytical techniques to deepen the analysis of how CCPs could transmit stress under alternative loss allocation mechanisms once prefunded resources have been depleted.

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