The Role of Visual Network Analysis in the Monitoring of Systemic Risk in Credit Default Swap Markets

Sriram Rajan, Office of Financial Research

Mark Paddrik, Office of Financial Research

Richard Haynes, U.S. Commodity Futures Trading Commission

Financial Risk & Network Theory

Cambridge Centre for Risk Studies Seminar

➢ **Background**

➢ **CDS Markets and Data**

➢ **Initial Approaches: Bipartite and Force Directed Networks**

➢ **Hive Representation**

  – Definition within CDS Markets.

  – Application.

➢ **Conclusion**

➢ **Metrics have prerequisites**

   – Risk exposures and network measures require context.

      • Net versus gross exposures.

   – Definition is important.

      • Centrality.

➢ **Network analysis hurdles**

   – Networks have sub-structures.

   – Size.

      • Participants and traded risks.

➢ **Challenge: monitor counterparty and credit risk exposures.**

  – Critical in CDS markets, but found in other OTC markets as well.

  – **Canonical example:** AIG; unknown counterparty exposures & portfolio credit risk.

  – Can systemic interconnections be observed or measured?

➢ **Contribution**

  – Application of a new way to visualize CDS networks.

  – Exploration of risk in networks.

  – Proposal of risk channels: path(s) relating participants and risks.

➢ **The Network Structure of the CDS Market and Its Determinants (Peltonen, Scheicher, and Vuilemmey, 2013)**

    – Document network properties of CDS markets and study determinants.

➢ **Financial Stability Monitoring (Adrian, Covitz, Liang, 2013)**

    – Network measures for SIFIs; focus on CCPs and margin requirements

➢ **Hive plots– rational approach to visualizing networks (Krzywinski et al 2011)**

    – Propose five requiremenrs for network representation: generality, flexibility, transparency, competence, and speed.

➢ **Integrating Statistics and Visualization: Case Studies (Schneiderman et al, 2008)**

    – Presents evidence for integration of visualization and metrics.

- **Protection Terminology**

  - Protection sellers: provide default insurance.

  - Protection buyers: pay premia.

- **Exposures**

  - Characterized by counterparty, reference entity, effective date, maturity, notional amount, contractual terms, other supplementary information.

  - Restricted to exposures on either US reference entities and/or US counterparties.

  - Weekly frequency.

Descriptive Statistics

Total Gross Notional Amount	USD 11.6 T	
Number of Dealers	30	
Number of Nondealers	1017	
Number of Sectors	16	
Largest Sectors	Max Abs Net Notional	Gross Notional
Financials	USD 6.70 B	USD 2.58 T
Government	USD 10.4 B	USD 2.23 T
Consumer Services	USD 7.08 B	USD 1.66 T
Consumer Goods	USD 5.45 B	USD 1.27 T
Industrials	USD 3.50 B	USD 922 B

➢ **Reference entity risk**

- *Underlying* credit risks in CDS contracts.

  - eg Greece, Barclays, JP Morgan.

- Can inlcude indices, single names, and/or tranches.
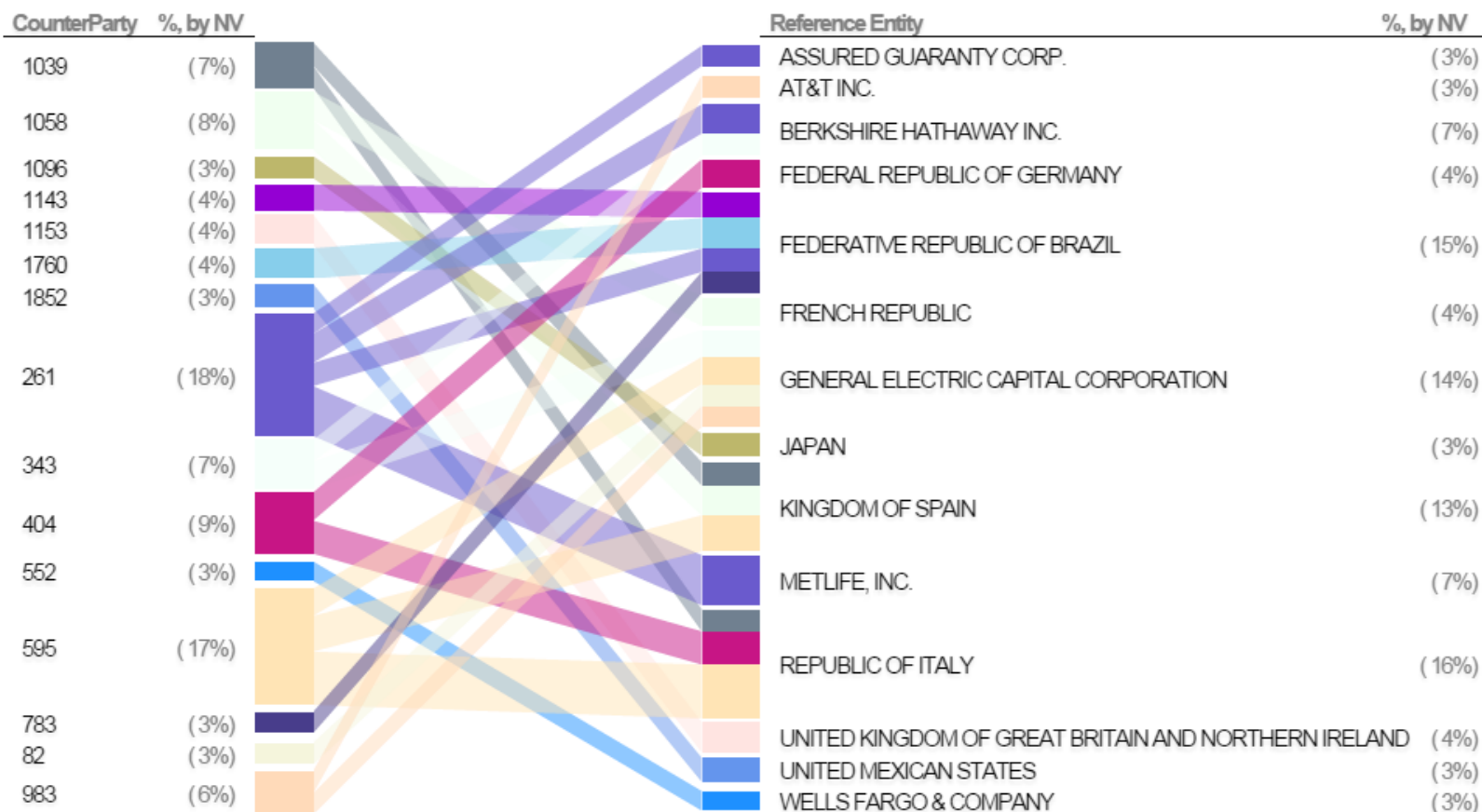
➢ **Counterparty risk**

- *Contractual* risks of CDS counterparties to each other:

  - Dealers: (eg. Goldman Sachs, RBS).

  - Nondealers: hedge funds, insurance companies, asset managers, etc.

- Failures to pay premia or on default payment obligations. Why important?

  - Interconnectedness.

  - Exposure.

➢ *What are the largest risk exposures in the CDS market?*

 – Enumerate top positions by reference entity and counterparty.

 – Enable policymakers to arrive at conclusions through exploration:

  • Identify reference entities which share counterparties.

  • Identify counterparties which share reference entities.

 – Requirements:

  • Identification of concern: protection sale or purchase.

  • Knowledge of counterparty interrelationships.

  • Construction of reference entity concentrations.

➢ Critiques

– Systemic importance not demonstrated or measured.

– Does not develop a story for explaining risk paths.

## Top Reference Entity Positions held by Nondealer Counterparties

CounterParty	%, by NV	Reference Entity	%, by NV
1039	(7%)	ASSURED GUARANTY CORP.	(3%)
		AT&T INC.	(3%)
1058	(8%)	BERKSHIRE HATHAWAY INC.	(7%)
1096	(3%)	FEDERAL REPUBLIC OF GERMANY	(4%)
1143	(4%)		
1153	(4%)	FEDERATIVE REPUBLIC OF BRAZIL	(15%)
1760	(4%)		
1852	(3%)	FRENCH REPUBLIC	(4%)
261	(18%)	GENERAL ELECTRIC CAPITAL CORPORATION	(14%)
343	(7%)	JAPAN	(3%)
404	(9%)	KINGDOM OF SPAIN	(13%)
552	(3%)	METLIFE, INC.	(7%)
595	(17%)	REPUBLIC OF ITALY	(16%)
783	(3%)	UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND	(4%)
82	(3%)	UNITED MEXICAN STATES	(3%)
983	(6%)	WELLS FARGO & COMPANY	(3%)

➢ Critiques

– Reproducibility.

– Comparability.
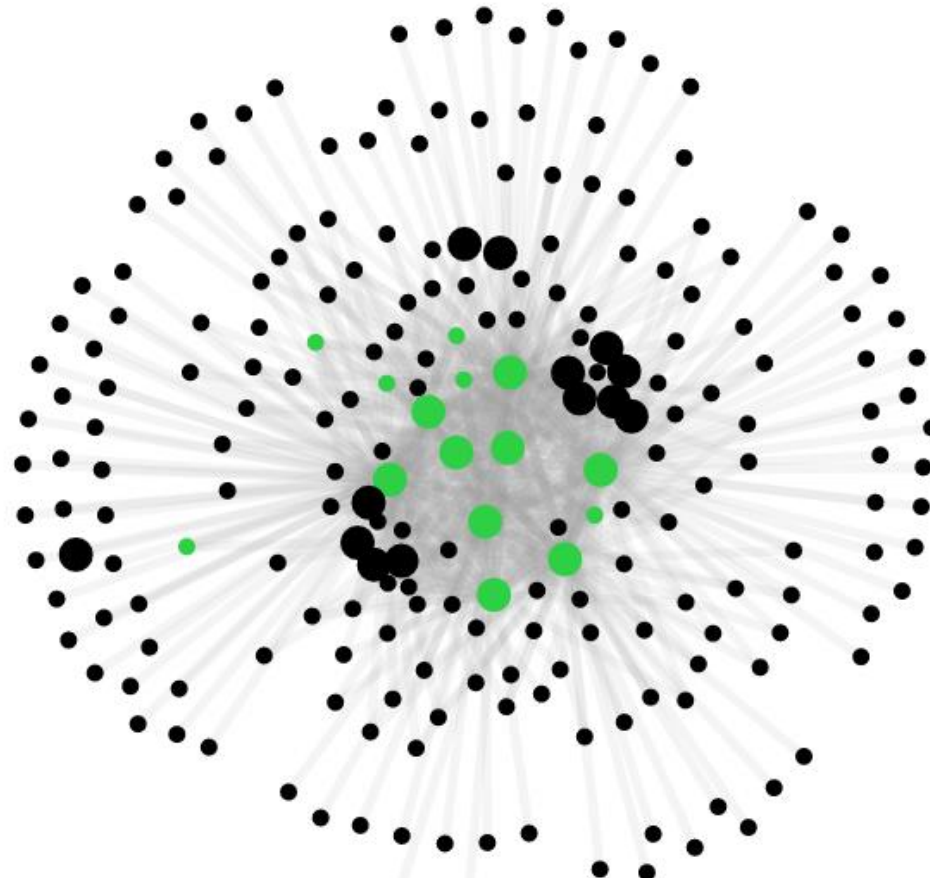
● Dealer

· Nondealer

● Selected Dealer

· Selected Nondealer

OFR
OFFICE OF FINANCIAL RESEARCH

Centrality

Nondealer : Sector = 0.08505
Dealer : Sector = 0.00000
Dealer : Dealer = 0.00000
Nondealer : Dealer = 0.00000

Nondealer
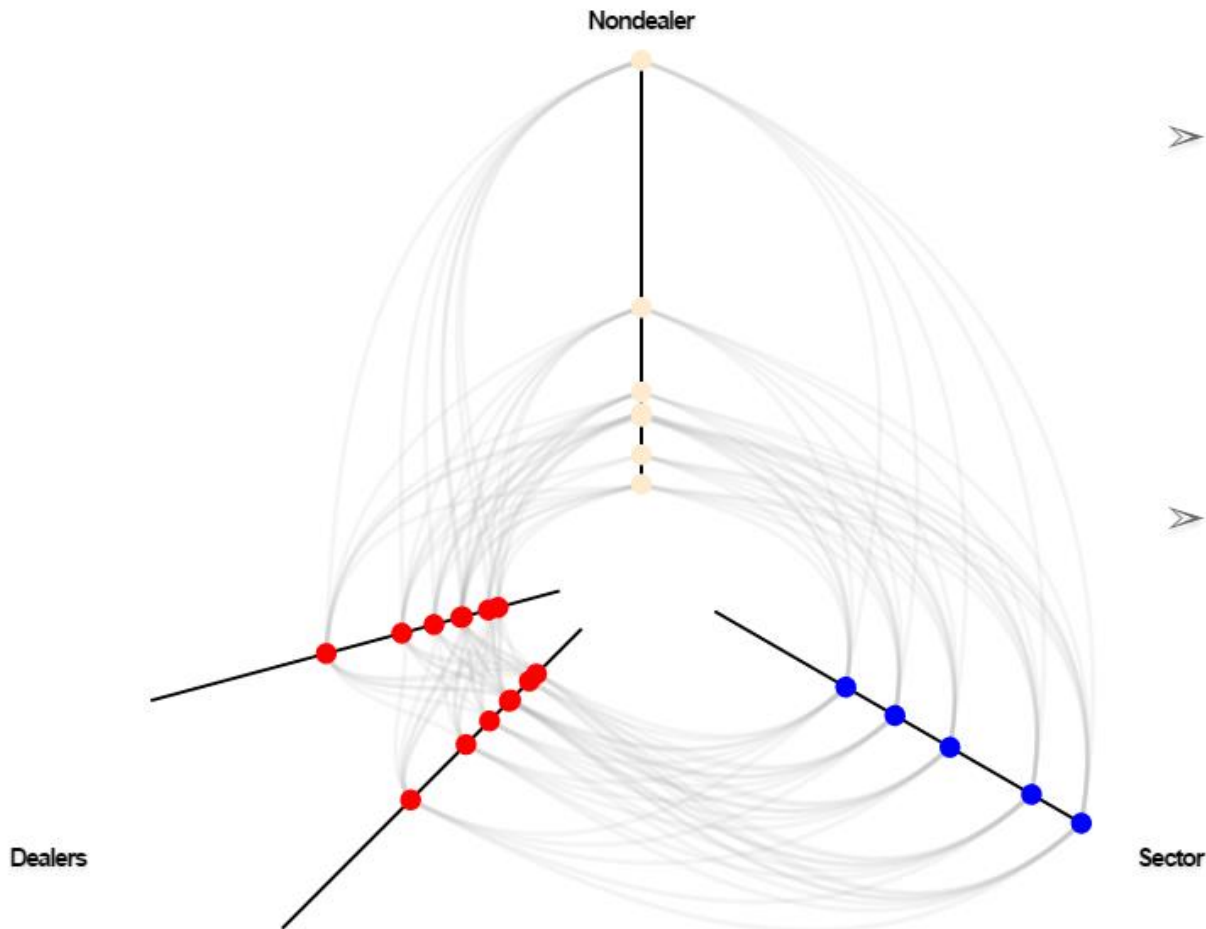
Dealers

Sector

> **Features:**

   – Controlled orientation.

   – Defined axes and scaling.

   – Evident classification.

   – Multiple network representation.

> **Our use:**

   – Interdealer network

   – Dealer-to-Nondealer network

   – Nondealer-to-Sector network

   – Sector-to-Nondealer network

> **Two directions to consider:**

   – Clockwise

   – Counterclockwise

➢ **Why are these networks important?**

- – Interdealer network: risk redistribution.

- – Dealer-to-Nondealer network: risk assumption (end users) and intermediation (dealers).

- – Nondealer-to-Sector network: spillover channels to unregulated entities.

- – Sector-to-Dealer network: traditional catalysts.

➢ **How are relationships weighted?**

- – Interdealer network: net notional exposure.

- – Dealer-to-Nondealer network: net notional exposure.

- – Nondealer-to-Sector network: gross notional.

- – Sector-to-Dealer network: gross notional.

OFR
OFFICE OF FINANCIAL RESEARCH

➢ **Net Notional**: for weighting counterparty relationships (for i, across j).

$$w(i,j) = \frac{|Sold(i,j) - Bought(i,j)|}{\sum_j |Sold(i,j) - Bought(i,j)|}$$

➢ **Gross Notional**: for weighting reference entity relationships (for i, across k).

$$w(i,k) = \frac{Sold(i,k) + Bought(i,k)}{\sum_k Sold(i,k) + Bought(i,k)}$$

➢ **Eigenvector Centrality**:

Consider adjacency matrix $\mathbf{A}$ in $\mathbf{Ax} = \lambda \mathbf{X}$

$w(i,j) = A_{i,j}$ for counterparty networks.

$w(i,k) = A_{i,k}$ for reference entity networks.

➢ **Why do we care about the interdealer market?**

– Dealers are a counterparty in 98% of CDS transactions.

– Dealers hold the majority of collateral in this market.

– Dealers are CCP clearing members; failure can propagate risk.

➢ **Gauging centraliity**

– Interconnectivity may be more important than risk exposure.

– High centrality is possible when risk exposure is low.
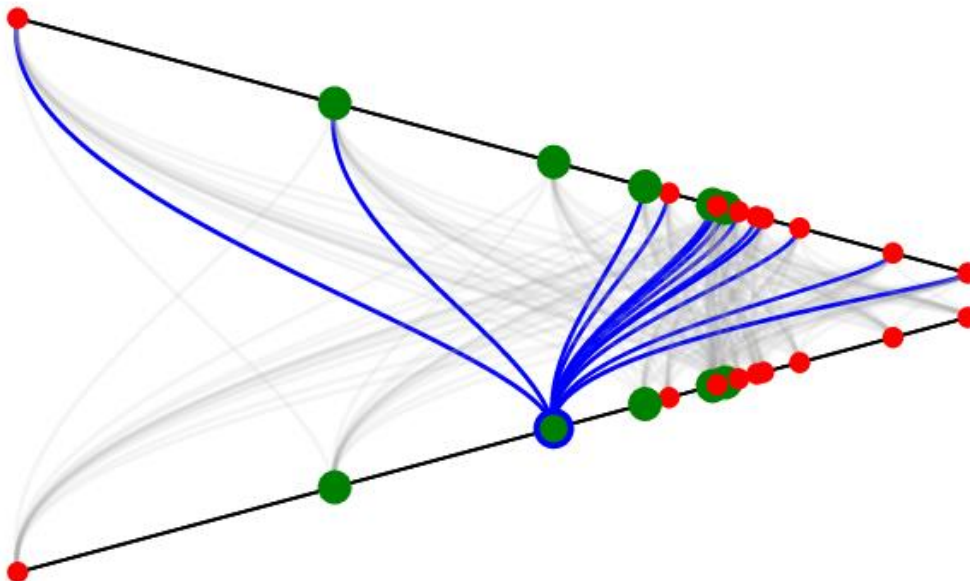
Centrality
Dealer : Dealer = 0.20531
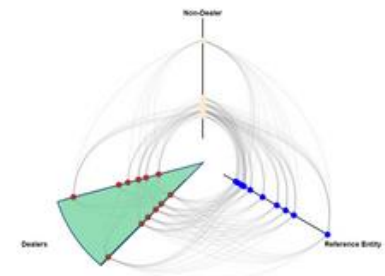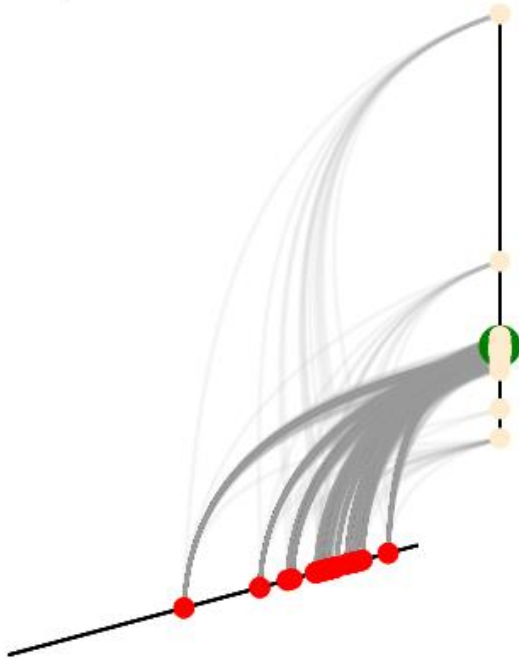
Centrality
Nondealer : Dealer = 0.67190
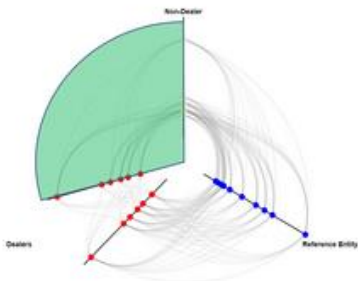
> **Why is the dealer-to-nondealer relationship important?**

– Clockwise: dealers which intermediate clients.

– Counterclockwise: clients which offset dealers.

– CCP: emergent counterparty to all counterparties, risk backstop in CDS market.

– CCP centrality increases over time.

– Implications for proprietary trading (post Volcker).

CCP Centrality

Centrality
Nondealer : RE = 0.23891
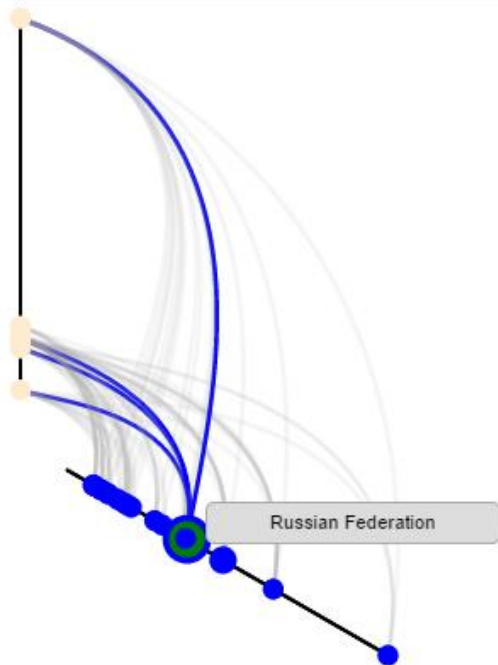
➢ **Why is the nondealer to reference entity network important?**

– Clockwise: nondealers which may set the price of risk.

– Counterclockise: spillover channels from credit sectors to

those who bear risk.

– Identify risk flows in the least-regulated network.

– Network measures may assist in early identification.

Russian Federation

OFR
OFFICE OF FINANCIAL RESEARCH
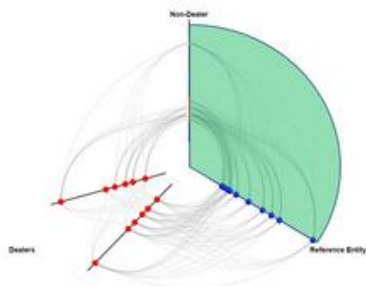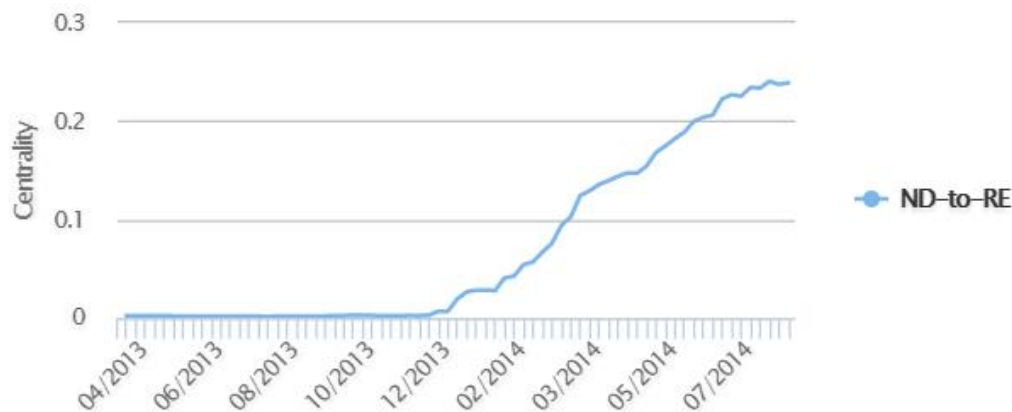
> **Why is the sector-to-dealer network important?**

– Clockwise: Determine targets of credit provision.

– Counterclockwise: Identify main sources of credit intermediation.

– Correlated sectoral distress may increase with interconnectedness.

– Financial sector linkages known, sovereign linkages underappreciated.
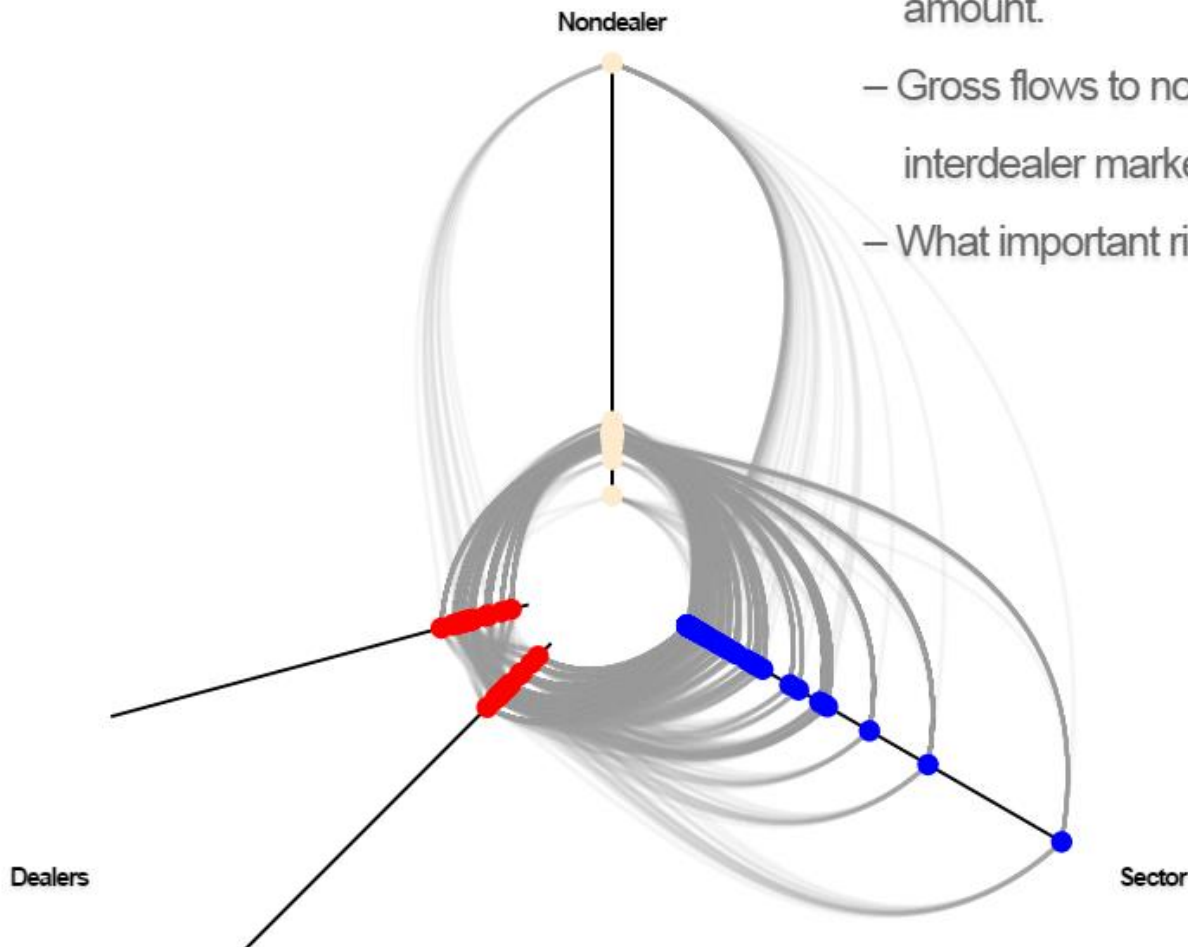
Centrality
Dealer : Sector = 0.37648

Government
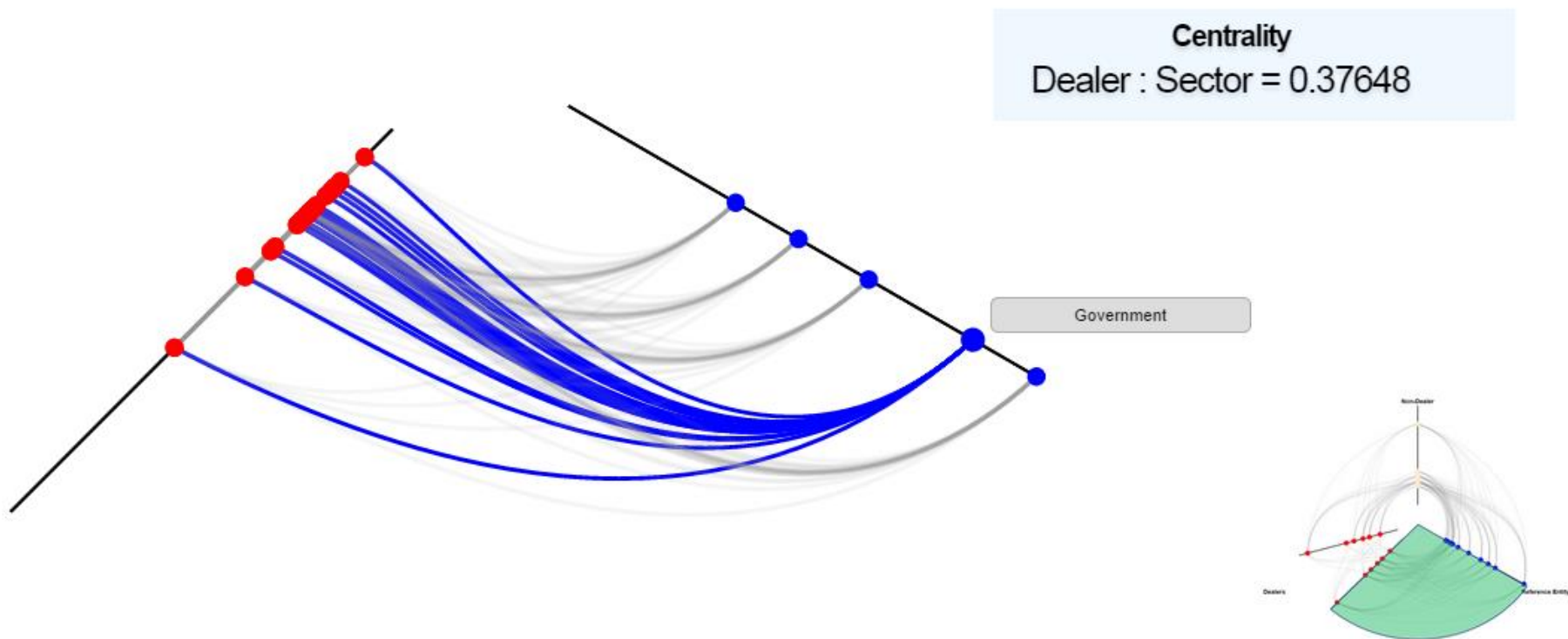
> **2010**

– Dealers net sold USD 326 B in single name exposures to nondealers.

– Largest three dealers account for 49% of this total.

– The largest nondealer accounted for 7% of nondealer net protection purchases.

– Nondealer flows represented 12% of the interdealer market.
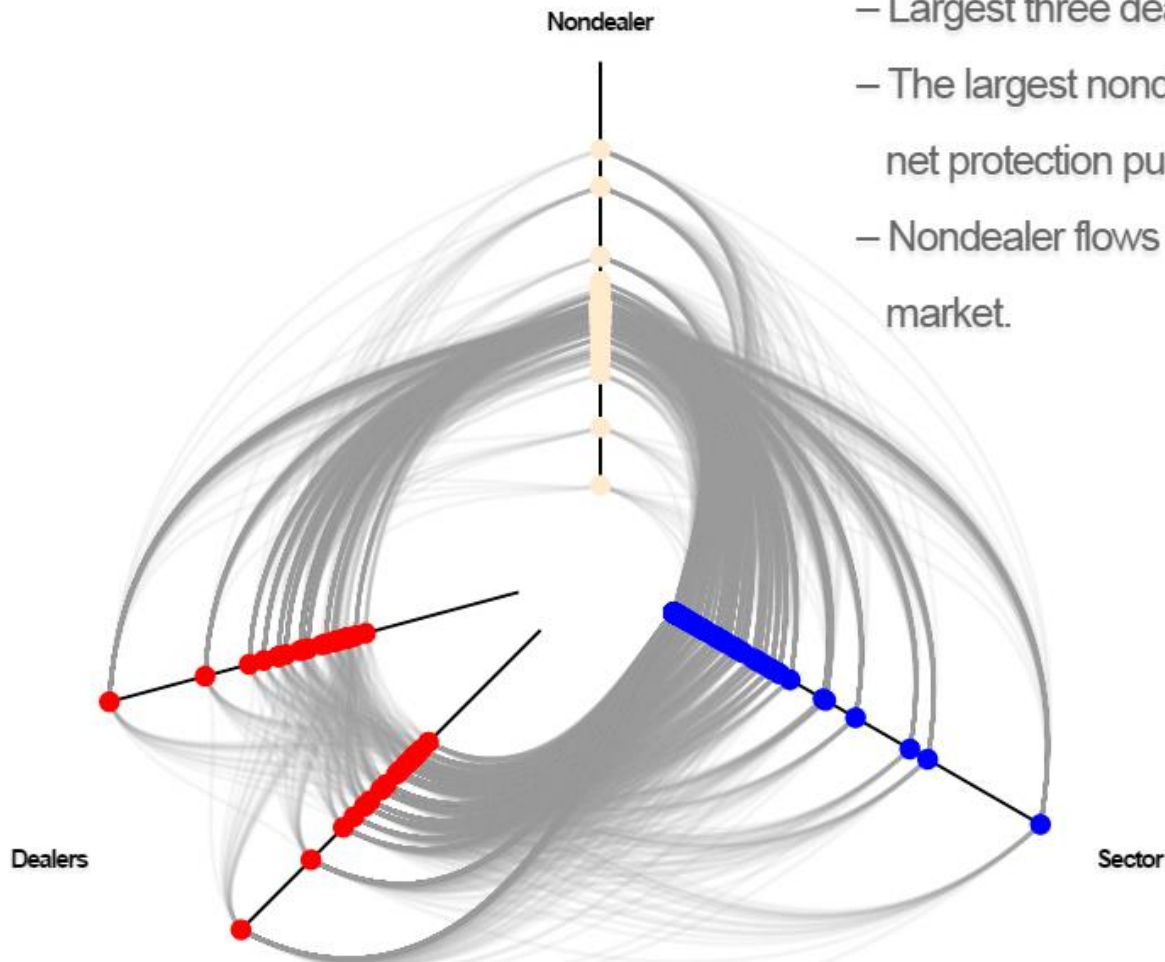
➢ **2014**

- Dealers net purchase USD 38 B.

- Nondealers: Largest three nondealers sell 6x this amount.

- Gross flows to nondealers have risen to 43% of the interdealer market.

- What important risk channels can we infer?

Nondealer

Dealers

Sector

> Which are central **nondealer intermediaries** of credit risk?

> Which **sectoral risks** are central to dealer?

> Which **dealers** are central client counterparties?

OFR
OFFICE OF FINANCIAL RESEARCH
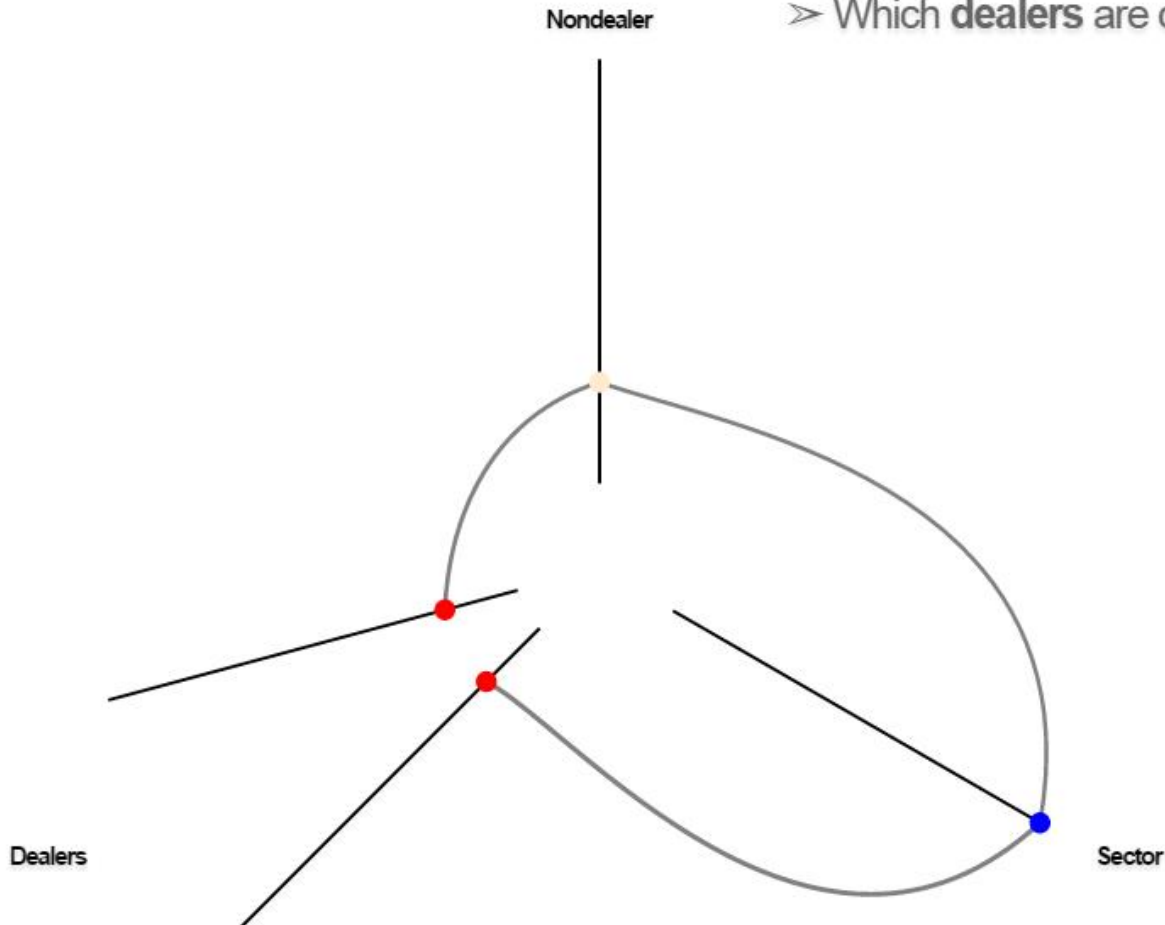
Centrality

Nondealer : Sector = 0.67400

Dealer : Sector = 0.00000

Dealer : Dealer = 0.00000

Nondealer : Dealer = 0.43275

➢ What **sectors** are central risks to nondealers?

➢ Which **nondealers** are central dealer counterparties?

➢ Which **dealers** are central in risk redistribution?

➢ Which **dealers** are central sectoral intermediaries?
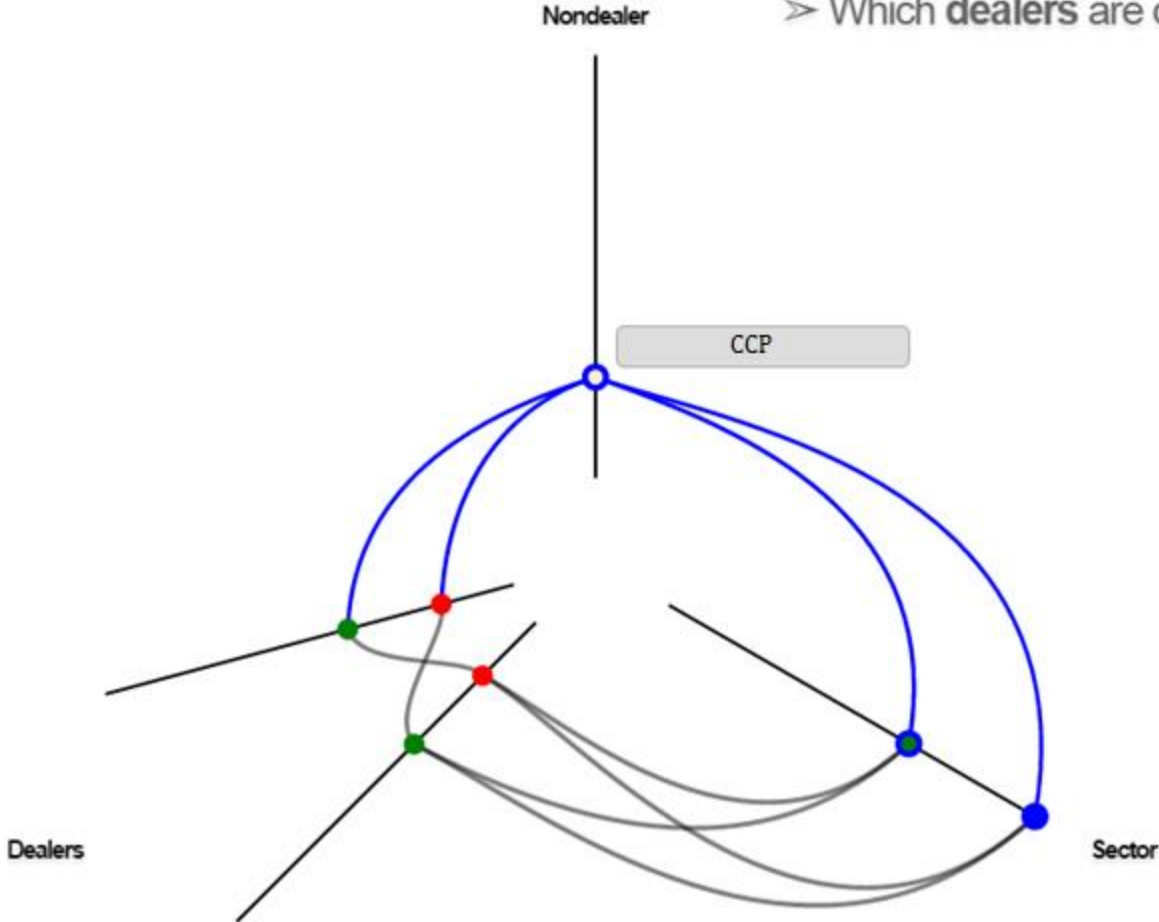
Visualization and Measurement

- Hive plots are tractable network representations.

- Network measures identify important sources and sinks of risk.

- Exploration enables contextual understanding.

Applications for systemic risk monitoring

- Identification of risk channels across networks.

- Evidence for policy recommendations.