Interconnectedness in the CDS Market[1]

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April 2014

Concentrated risks in markets for credit default swaps (CDS) are widely considered to have significantly contributed to the recent financial crisis. In this paper we study the structure of the CDS market using explicit connections based on the total number of CDS transactions, notional value of CDS transactions, and network diagrams. The main objective is to provide statistics that characterize the CDS market, the degree of counterparty concentration, the size of different contracts as well as underlying contractual features, and a preliminary analysis of interconnectivity. Our new approach informs the discussion of the structure and resulting fragility or stability of the CDS market and studies potential contagion among its participants.

I. Introduction

The concentration of transactions and positions in credit default swaps (CDS) markets among a select group of large dealers is widely considered to have significantly contributed to the recent financial crisis. Due to the highly concentrated and interconnected nature of bilateral CDS contracting, the counterparty risk associated with potential defaults of large protection sellers is a potential source of systemic risk. Historically, the decentralized nature of over-the-counter (OTC) derivatives markets has made it difficult for regulators and market participants to obtain reliable information about prices and market exposures. The lack of transparency with respect to exposures held by market participants complicates the management of counterparty risk. Reportedly, this was one of the reasons why, prior to the recent crisis, certain market participants like American Insurance Group (AIG) were able to create large, yet unobservable, exposures (e.g. Markrose et al. (2012)).

To the extent that counterparty failures of a large swap market participant can result in sequential counterparty defaults and shock transmission through the swap market, the ensuing contagion can become systemically important. The U.S. Congress signed the Dodd-Frank Wall Street Reform and Consumer Protection Act (DFA) into law on July 21st 2010. The DFA envisioned a set of reforms that

[1] This memorandum was reviewed by Christof Stahel and Jennifer Marietta-Westberg (DERA), and Peter Curley and Gregg Berman, Division of Trading and Markets (TM). The U.S. Securities and Exchange Commission, as a matter of policy, disclaims responsibility for any private publication or statement of any of its employees. The views expressed herein are those of the author and do not necessarily reflect the views of the Commission or of the author's colleagues upon the staff of the Commission.
[2] We thank Troy Causey and Benjamin Huston for excellent research assistance.

would, among other things, "promote the financial stability of the United States by improving accountability and transparency in the financial system."[3] The U.S. Congress, in passing the DFA, identified the over-the-counter (OTC) derivatives market as a key source of instability[4], and an overarching aim of Title VII of the DFA is to mitigate the buildup and transmission of systemic risk in the swaps market.[5]

One of the requirements of Title VII is to mandate central clearing of certain contracts that, when aggregated, are deemed to have the potential to create systemic risk. Central clearing is a market practice that may result in significant systemic risk mitigation. Its function is to transfer counterparty risk that was previously borne by each party to a swap transaction to central counterparties (CCPs). CCPs are designed to reduce the likelihood that the default of a large swap market participant results in sequential counterparty defaults and systemic risk transmission through the swap market.[6] The effectiveness of CCPs is predicated on the requirement that clearing members post capital and that they collect margin so that defaults by either counterparties or clearing members can be absorbed. CCPs are considered to be an effective risk-sharing mechanism that mitigates counterparty risk, even though it does not necessarily eliminate it.

Many academic papers have studied the risks in the OTC markets for CDSs.[7] Some have argued that Title VII reforms may reallocate systemic risk without actually reducing it – if, for example, mandatory clearing for one product precludes more efficient multilateral netting across products (see Duffie and Zhu (2010)). Acharya, Shachar, and Subrahmanyam (2010) provide a good overview of Dodd-Frank Act of 2010 and CDS clearing requirements.

We seek to better understand the structure of the CDS market, and specifically look at the topology, i.e. the mapping of the linkages between dealers involved in CDS transactions. To do so we use data from the DTCC's Trade Information Warehouse (TIW), which holds records on approximately 98% of all global credit derivative transactions by notional amount. Given the breadth of coverage, we are able to have a

[3] The Dodd-Frank Act was enacted "to promote the financial stability of the United States by improving accountability and transparency in the financial system, to end 'too big to fail', to protect the American taxpayer by ending bailouts, to protect consumers from abusive financial services practices, and for other purposes." Pub. L. No. 111-203, Preamble.

[4] See S. Hrg. 111-803, "Over the Counter Derivatives Reform and Addressing Systemic Risk" Hearing before the Committee on Agriculture, Nutrition and Forestry, United States Senate, December 2, 2009.

[5] For the remainder of this discussion, "swap" refers both to swaps regulated by the Commodity Futures Trading Commission (CFTC) and to security-based swaps regulated by the Securities and Exchange Commission (SEC). The statutory requirements imposed by Title VII of the Dodd-Frank Act on both markets are similar and, in many cases, the rulemaking efforts of both agencies have evolved in parallel.

[6] See Craig Pirrong, "The Economics of Central Clearing: Theory and Practice," ISDA Discussion Papers Series, No. 1 (2011), at 6 ("Widespread defaults on derivatives contracts may harm more than the counterparties on the defaulted contracts. The losses suffered by the victims of the original defaults may be so severe as to force those victims into financial distress, which harms those who have entered into financial contracts with them—including their creditors, and the counterparties to derivatives on which they owe money. Such a cascade of defaults can result in a systemic financial crisis.").

[7] See, for example, Arora, Gandhi, and Longstaff (2012), Duffie and Zhu (2011), and Gregory (2010).

reasonably complete picture of inter-dealer transactions and positions.[8] A limitation of the data is that it does not provide information on transactions that fall outside the regulatory ambit of U.S. regulators, which are those transactions between two foreign counterparties on a foreign reference entity.[9]

To gain an understanding of the structure and conditions for stability and fragility of the CDS market, we map the network of connections between different dealers and non-dealers entities. Network-based approaches have been successfully used to study fragility and systemic risk of different markets.[10] Such approaches allow for the study of market structure of a market by capturing bilateral connections, evaluating their relative magnitude, and establishing important players as a way to understand systemic risk. Network approach is useful in studying dynamics of contagion, i.e., how a failure or decline of one financial institution can lead to the demise of other financial institutions and fragility of the whole market.[11]

We study the structure of the CDS market using explicit connections based on the total number of CDS transactions, the notional value of CDS transactions, and network diagrams. The end goal is to provide insights into the fragility and stability of the network, and study potential contagion among its participants. Allen and Gale (2000) and Freixas, Parigi, and Rochet (2000) provide some of the first formal models of financial contagion. To investigate the fragility of the system, we estimate several network measures for the system between dealers.

Counterparties transact in CDS contracts referenced to U.S. and international entities, corporate firms, and sovereigns. As a result, we separate CDS contracts into subgroups and provide summary statistics for the aggregate transaction activity of CDSs referencing sovereign, corporate financial and corporate non-financial entities. Financials and non-financials are separately reported because of the possible correlation between reference entities and CDS counterparties who are themselves financial institutions. Even though the lack of transparency prevents investors from understanding the extent to

[8] Using a sample of 35 financial reference entities during the financial crisis period of 2007-2009, Shachar (2012) studies the role of dealers in providing liquidity. Using a snapshot on 30 December 2011 CDS positions data, Peltonen, Scheicher, and Vuillemey (2013) study the determinants of the network structure of CDS markets. Finally, using all CDS transactions occurring globally between May 1 and July 31 2010, where at least one G14 dealer was counterparty to the trade, Chen et al. (2011) analyze the aggregate market liquidity and trading activity in the CDS market.

[9] The version of the database that has been provided by the DTCC includes all transactions that include at least one of the following: 1) a U.S. reference entity, 2) a U.S. counterparty, 3) a foreign branch of a U.S. counterparty, or 4) a foreign affiliate of a U.S. counterparty. This implies that neither foreign branches of U.S. counterparties nor their foreign affiliates are excluded.

[10] See papers by Battiston, Deli Gatti, Gallegati, Greenwald, and Stiglitz (2009), Billio, Getmansky, Lo, and Pelizzon (2012), Acemoglu, Carvalho, Ozdaglar, Tahbaz-Salehi (2012), Acemoglu, Ozdaglar, Tahbaz-Salehi (2013), and Deibold and Yilmaz (2013).

[11] Networks can be constructed using direct connections such as repayment of interbank loans (Acemoglu, Ozdaglar, Tahbaz-Salehi (2013)), interbank payment flows (Soramaki, Bech, Beyeler, Glass, and Arnold (2007)), linkage of balance sheets (Shin (2008, 2009)), municipal bond transactions (Li and Schurhoff (2012)) and asset commonality (Allen, Babus, and Carletti (2012)), or indirect connections based on principal component analysis (PCA) or causality in equity returns (Billio, Getmansky, Lo, and Pelizzon (2012)) and CDS spreads (Billio, Getmansky, Gray, Lo, Merton, and Pelizzon (2013)).

which interconnections amplify counterparty risk, market reactions after the failure of Lehman Brothers demonstrate the importance of understanding the magnitude of such correlations in the CDS market. In particular, when both the counterparty and the underlying CDS reference entity are financial institutions, a failure by a major counterparty may cause CDS spreads on other institutions to increase once protection sellers incorporate estimates of specific counterparty failures into CDS prices.

We provide a methodology to study the CDS market. Our approach considers the size, interconnectedness, and complexity of individual dealers and non-dealers entities and their inter-relations, allowing us to assess potential systemic vulnerabilities of the CDS market. We also attempt to illustrate the importance of system-wide stress-testing approaches to evaluate vulnerabilities and the potential impact of destructive feedback loops. Such feedback loops can arise due to non-linear interconnectedness between dealers and non-dealers entities, where the distress of one dealer can lead to negative repercussions for other market participants which in turn feed back into further distress of that dealer. The approach we propose to evaluate interconnectivity should allow practitioners and policy makers to focus on the comprehensive benefits and costs associated with dealer interconnectedness.

This paper provides a set of statistics that characterize the CDS market, the degree of counterparty concentration, the size of different contracts, and the underlying contractual features. Preliminary findings show a high degree of interconnectivity among major market participants. Our findings are relevant in accessing the degree of potential contagion as risk is transmitted across market participants, and stability of the system. Future work will explore in detail some of the determinants of these linkages.

The rest of the paper is organized as follow. Section 2 provides a brief discussion of CDS contracts. Section 3 describes the data used in the analysis. Section 4 discusses the reported metrics and our methodology for estimating interconnectedness. Section 5 presents our results. Section 6 discusses opportunities for future work, and Section 7 concludes.

II. CDS contracts

A CDS contract is a bilateral agreement that transfers credit exposure on a specific reference obligation of the reference entity between counterparties. The protection buyer makes periodic payments to the protection seller in exchange for a positive payoff when a pre-specified credit event occurs.[12] In this case, the seller of the CDS contract pays the buyer either the notional amount of the CDS contract against delivery of the reference obligation, or the difference between the notional amount and the

[12] The International Swap and Derivatives Association (ISDA) has developed a standard legal documentation format for CDS contracts that includes a list of credit-event situations (ranging from bankruptcy to debt restructuring). Though contract counterparties are free to amend the ISDA definitions, the vast majority of CDS trades are covered by the standard ISDA documentation.

remaining value of the reference obligation as determined in an auction process, depending on whether physical or cash settlement is specified.

A party to a CDS contract may exit the contract through termination or novation. For a termination to occur both contract parties must agree to terminate, possibly for an additional payment that depends on current market conditions. A novation is executed by identifying a market participant that is willing to assume the obligation of one of the original counterparties at prevailing market prices. Other contract changes have been related to "compression" mechanisms, which are designed to cancel redundant contracts when counterparties have taken mutually offsetting positions. For example, if the same counterparties have entered into offsetting positions on contracts with the same economic terms, a compression trade cancels these contracts and creates a new contract with the same net exposure as the original contracts.

Selling protection through a CDS contract replicates a leveraged long position in bonds of the underlying reference entity, exposing protection sellers to risks similar to those of a creditor. By contrast, buying protection through CDS replicates a leveraged short position in the bonds of the underlying reference entity. This allows protection buyers to either hedge credit risk to which they may already be exposed or to effectively take a short position on the credit risk of the underlying reference entity.

Due to their bilateral nature, non-centrally cleared over-the-counter CDS contracts also expose each counterparty to a potential default by the other counterparty. From the perspective of a protection buyer, counterparty risk arises when the protection seller defaults and the buyer loses its protection against default by the reference entity. By contrast, the protection seller carries the risk that the buyer may default, depriving the seller of the expected revenue stream. Depending on the performance of the reference entity at the time of a counterparty default, the CDS contract may be more or less valuable than the original CDS and may therefore involve an unanticipated gain or loss. Thus, both holders of a CDS contract face the risk of losses in two ways. First, through the performance of the reference entity and, second, through potential counterparty default.

Standardized contractual features

The International Swap and Derivative Association (ISDA) has developed protocols related to contract standardization. The original Master Agreement was established in 1992 and revised in 2002. The primary purpose of these agreements was to create, among other considerations, standards for the netting and collateralization of contracts as well as the standardization of certain contract specifications such as contract tenors and credit event triggers.

In 2009, ISDA developed the so called "Big Bang Protocol," which introduced procedures to determine whether a credit event occurred and specified auction procedures for the pricing of defaulted bonds. ISDA also introduced contract standardization around maturity dates and premium payments (the fixed rates that determine the amount of the periodic payment). For example, CDS premiums were set at 100 or 500 basis points for U.S. contracts and at 25, 100, 500 or 1,000 basis points for European single name

CDS. Since pre-specified premia will prevent contracts from having zero value on the initiation date, the contract typically requires upfront payments to compensate for the difference between the market and the standardized premia. Finally, a number of issues related to default triggers for European firms caused ISDA to issue the "Small Bang" protocol in July 2009. The protocol also applies to the handling of any globally outstanding CDS trades that have some form of restructuring specified. The motivations for the convention changes in European contracts are similar to the ones in the North American conventions – to facilitate central clearing, gain efficiencies in trade and operational processing and reduce the gross notional amount outstanding in the market.

III. Data Description

We use transaction data in single-name CDS submitted to the Trade Information Warehouse, a service offering operated by DTCC Derivatives Repository Limited ("DTCC-TIW"). The Trade Information Warehouse was established by DTCC in November 2006 as the electronic central registry for CDS contracts. We use transaction data from January 1st 2012 until December 31st 2012. Transaction data is recorded on daily frequency.

We have access to all DTCC's Trade Information Warehouse data on CDS transactions except for solely foreign transactions. That is, our sample includes all transactions that include at least one of the following: 1) a U.S. reference entity, 2) a U.S. counterparty, 3) a foreign branch of a U.S. counterparty, or 4) a foreign affiliate of a U.S. counterparty. For example, transactions between two non-US counterparties are excluded from the analysis unless those two non-US counterparties have transacted in CDS where the reference entity is a US entity.[13]

The data identify the counterparties to each transaction. Each individual market participant has a consistent identifier throughout the dataset and a classification of its type (dealer vs. non-dealer entity) and its domicile.[14] The non-dealers entities sample includes pension funds, asset managers, hedge funds, banks, and non-financial companies (though the dataset does not distinguish between them).[15]

[13] Data for the analysis includes "gold record" transactions submitted to the Trade Information Warehouse. A "gold record" is a record which has a status of "Certain" in the DTCC-TIW. "Certain" status is obtained if the transaction has been confirmed and has satisfied certain business validation rules and other requirements of DTCC-TIW. Under DTCC-TIW rules, a "gold record" generally represents the definitive record of the transaction and supersedes any other documentation or understanding, whether written, oral or electronic, between the parties. *See* Trade Information Warehouse Record Appendix to the DTCC Derivatives Repository Ltd Operating Procedures, Rev. 2012-1 (Release Date August 1, 2012), *generally and pp 4-5*.

[14] This classification is based on DTCC's data. As such, the universe of dealers may not necessarily correspond to the same set of entities that the Commission will require to register as "Security Based Swap dealers".

[15] Following the DTCC approach for reporting CDS gross and net notional amounts, we identify market participants based on counterparty family. A counterparty family will typically include all of the accounts of a particular asset manager or corporate affiliates rolled up to the holding company level. For more information: http://www.dtcc.com/downloads/products/derivserv/tiw_data_explanation.pdf

Each transaction record contains the following information: the name of the reference entity, trade date, effective date, contract maturity date, the identities of the participating counterparties including the type (dealer vs. non-dealer entity), whether the transaction is cleared[16], the executed notional amount, the market sector to which the reference entity belongs, and other transaction specific information. Transactions are classified into several types. A transaction can be a new trade, cash settlement of an existing trade, or can be novated.[17] Contracts can be partially or fully closed out or assigned/novated before maturity.

We apply a number of filters to the data. First, we eliminate index CDS and product/tranches CDS, thus leaving single-name corporate and sovereign CDS for analysis.[18] We then delete trades that have been re-assigned within a company and trades where a counterparty has completed a legal name change, while keeping contracts that are partially terminated and assigned. Erroneous records, such as negative notional amounts, also are removed from the data. Finally, we aggregate the names of the counterparties by the highest level name available. Specifically, we aggregate by parent name, fund name, or firm name if no higher level information is noted to better understand each counterparty's aggregate involvement in the CDS market.

IV. Methodology

We use several measures of connectedness to map out the network between dealers and non-dealers entities. To protect privacy of market participants, we anonymize the identity of the participant counterparties. This is primarily accomplished using several masking techniques when presenting our results.

To assess the systemic importance of dealers and non-dealers entities, we define the following simple measures of connectedness:

- **Gross Notional Amounts.**

  Notional Bought: The gross notional amount bought by each counterparty

  Notional Sold: The gross notional amount sold by each counterparty

- **Number of Contracts.**

  Number of Contracts Bought: The number of CDS contracts bought by each counterparty

[16] Transactions are cleared by ICE Clear Credit. ICE Clear Credit became in 2009 the world's first central counterparty (CCP) for CDS contracts. The full list of 28 clearing members which can clear contracts through ICE Clear Credit is available at https://www.theice.com/publicdocs/clear_credit/ICE_Clear_Credit_Participant_List.pdf.

[17] DTCC labels novated transactions as "assigned" to a different counterparty, and cash settled transactions as "terminated."

[18] Multi-name non-index CDS trades are also excluded from our analysis. Single-name corporate and sovereign CDS contracts included in our analysis represent 74.15% of all CDS transactions in 2012.

Number of Contracts Sold: The number of CDS contracts sold by each counterparty

- **Number of Connections.**

  Number of Buy Side Connections: The number of different counterparties from which a specific market participant buys CDS contracts

  Number of Sell Side Connections: The number of different counterparties to which a specific market participant sells CDS contracts

  Number of Buy and Sell Side Connections: The number of different counterparties to which a specific market participant both buys and sells protection

- **Average Number of Contracts per Day.**

  Average Number of Contracts Bought per day: The average number of CDS contracts bought per day by each counterparty

  Average Number of Contracts Sold per day: The average number of CDS contracts sold per day by each counterparty

- **Concentration Index**. We construct a concentration measure that captures the dispersion of trades across different counterparties. For each dealer and non-dealer entity i we calculate the fraction of CDS contract purchases from other dealers and non-dealers entities j. The concentration index is then computed as the sum of squares of these fractions. Specifically:

$$C_i = \sum_{j=1}^{N} B_{ij}^2$$

  where i≠j, and B_{ij}^2 is the fraction of CDS purchases by a dealer or non-dealer entity from other dealers and non-dealers entities. N is the total number of market participants. By construction, the index can range from 0 to 1/(N-1). It takes the value 1 when a single counterparty buys 100% of its CDS contracts from only one counterparty, and approaches 1/(N-1) for the case where purchases are perfectly diversified across a large number of sellers.[19] The result is proportional to the diversification that each counterparty achieves in the long side of its portfolio (i.e. the CDS contracts bought). [20]

- **Dealers Topology.** We provide information relative to the overall bilateral exposure (aggregated for both long and short positions) between counterparties using network diagrams. The

[19] In our case, to mask the identities of dealers and non-dealers entities, N represents 12 different entity groupings: the top 10 dealers, the set of all other dealers, and the set of all non-dealers entities. The concentration index, thus, ranges from 1/11 to 1.

[20] Similarly, we construct a sell-side concentration index using, for each dealer and non-dealer entity i, the fraction of CDS contract sales to other dealers and non-dealers entities j. Notice that the concentration index is directional, i.e. buy-side concentration need not to be equal to sell-side. Because in our analysis buy-side and sell-side share similar results, we omit the latter for the sake of conciseness.

graphical representation of the network is characterized by bilateral relations across market participants based on gross notional calculations.

V. Results

This section describes the results of our empirical analyses. Although the calculations are presented on a highly aggregated basis that incorporates many reference entities and counterparties, we reduce the scope of the network connections by providing separate analyses that concentrate on different reference entities for CDS contracts.

Summary statistics

As of December 2012, there were 1,682 single-name entities referenced in outstanding CDS contracts. The gross notional value for all CDS contracts traded in 2012 is $4.8 trillion. At the end of the same year, contracts had a gross notional value outstanding of $11.97 trillion. Single-name corporate and sovereign CDS respectively represent 90.71% ($10.86 trillion) and 9.08% ($1.09 trillion). Table 1 shows that the average daily volume was $17.7 billion in 2012.[21] This corresponds to a total of 814,273 trades in 2012, or approximately 3,005 contracts traded per day. There were a total of 398 market participants that only bought CDS protection, 246 that only sold protection, and 808 that were on both sides of the market.

Table 1: CDS Market Statistics. Aggregate market statistics for single-name CDS transactions in the year 2012 obtained from the DTCC Trade Information Warehouse

Total gross notional amount (mm)	$4,819,173
Average daily volume (mm)	$17,718
Total number of contracts	814,273
Number of entities that only buy protection	398
Number of entities that only sell protection	246
Numbers of entities that buy and sell protection	808
Total number of entities that transact	1,452
Reference entities	1,682

[21] During the 2012 calendar year we identify 271 distinct trading dates due to some trading activity on weekends and holidays.

Table 2 reports the number of unique counterparties for different reference entities. The table provides a sense of the type of protection being demanded by market participants and how widely the associated counterparty risk is distributed. Table 2 indicates that the top 20 reference entities in terms of unique counterparties are either sovereigns or financial institutions. The reference entity that has attracted the most interest is the French Republic, which has 270 distinct counterparties. The second most popular reference entity is the Kingdom of Spain, which has 242 counterparties. For those reference entities that are outside the top 20, counterparty interest declines rapidly. Table 2 shows that the average number of counterparties for reference entities in ranking bins (21-100), (101-500) and (500-1682) drops monotonically from 85 to 45 to 12.

Table 2: This table provides the number of unique counterparties for the 1,682 different reference entities, sorted on the basis of the number of counterparties per reference entity. It reports the number of unique counterparties for the top 20 reference entities and the average number of counterparties for three activity bins (21-100, 101-500, 501-1,682).

Reference Entity	Number
French Republic	270
Kingdom of Spain	242
Republic of Italy	182
Federal Republic of Germany	161
Federative Republic of Brazil	153
Morgan Stanley	132
The Goldman Sachs Group, Inc.	130
Bank of America Corporation	128
Republic of Turkey	127
Chesapeake Energy Corporation	124
J. C. Penney Company, Inc.	119
Japan	117
Hewlett-Packard Company	117
Russian Federation	115
JP Morgan Chase & Co.	115
Safeway Inc.	112
Republic of Korea	111
United Mexican States	110
Sprint Nextel Corporation	109
Kingdom of Belgium	101
Average (Top 21-100 Entities)	85
Average (Top 101-500 Entities	45
Average (Top 501-1,682 Entities)	12

Table 3 provides a more granular look at the size of the market for CDS contracts. It reports the number of contracts traded and the gross notional amounts of contracts for different reference entity types and market sectors. In 2012, Corporates represent 74.88% of the contracts traded and 61.73% of gross notional amount. Sovereign CDS contracts and others comprise the remainder. Financials represent the largest portion of corporate contracts traded, comprising 19.21% of the total number of contracts and 19.50% of the total gross notional amount of CDS traded.

Table 3: This table reports the number of contracts traded and the gross notional amounts of contracts for different reference entity types and market sectors.

	Number of Contracts		Gross Notional Amount	
Grouping	Amount (#)	Total (%)	Amount ($mm)	Total (%)
Corporate	609,759	74.88	2,974,889	61.73
Financials	156,388	19.21	939,796	19.5
Consumer services	112,626	13.83	469,971	9.75
Consumer goods	91,351	11.22	423,458	8.79
Industrials	56,262	6.91	261,405	5.42
Basic materials	46,561	5.72	208,693	4.33
Technology	32,716	4.02	154,907	3.21
Telecommunications services	30,616	3.76	134,351	2.79
Utilities	29,170	3.58	123,340	2.56
Energy	26,596	3.27	119,538	2.48
Healthcare	15,763	1.94	79,306	1.65
Telecommunications	3,707	0.46	18,173	0.38
Oil & Gas	2,953	0.36	17,762	0.37
Government	2,147	0.26	12,820	0.27
Health care	2,011	0.25	8,002	0.17
Unknown	892	0.11	3,365	0.07
Sovereign (Government)	113,133	13.89	1,310,457	27.19
Others	3,869	0.48	25,380	0.53
Unknown	87,512	10.75	508,447	10.55
Grand Total	814,273	100.00	4,819,173	100.00

Concentration

Since the data identifies buyers and sellers, Table 4 tabulates the number of contracts held by different buyers and sellers, aggregated across different size bins. Dealers represent majority of buyers and sellers by both the number of contracts and the gross notional amount. For example, the top 10 buyers and

sellers of CDS are all dealers; however, non-dealers entities are represented in the top 20 buyers and sellers of the CDS contracts.

Consistent with previous studies (e.g., ECB (2009) and Peltonen, Scheicher, and Vuillemey (2013)), we find that the 5 largest buyers, by the number of contracts, are the counterparties for 44.08% of all contracts bought in 2012. Cumulatively, the top 10 and 20 buyers respectively represent 72.20% (44.08 + 28.12) and 85.77% (72.20 + 9.83 + 3.74) of all market activity in 2012. Based on our counterparty classifications, we observe that the top 10 buyers of CDS contract are all dealers. However, among the top 11-20 buyers (i.e. Tier 3 and 4), there are also some non-dealers entities.

Selling activity is even more concentrated. The top 10 sellers of CDS protection transact in 77.39% of all contracts traded in 2012, while the top 20 sellers capture 91.62% of all contracts sold. Similar to buyers, the top 10 sellers are all dealers, but there are some non-dealers entities in the top 11-20 sellers (i.e. Tier 3 and 4). The disproportionate amount of selling relative to buying suggests that non-dealers entities tend to be net buyers of protection and dealers are net protection sellers.[22]

Table 4 also aggregates the top buyers and sellers by the gross notional amount of CDS contracts traded in 2012. The qualitative implications are similar to those based on the number of contracts. For example, the top 20 buyers of CDS protection purchase 85.66% of the notional amount of all contracts in 2012, while the top sellers of CDS protection sell 92.44% of the notional amount of all contracts.

Table 5 reports the number of connections, i.e. the number of counterparties from which each entity (dealer or non-dealer) either buys or sells CDS contracts. This table indicates the degree to which non-dealers entities transact exclusively with dealers. During 2012, there were 7,634 unique connections between buyers and sellers. The top 5 counterparties have a total of 2,191 buying connections with distinct counterparties, while the top 20 counterparties have 3,693 buying connections. We find similar results for the selling and the combined buying and selling connections. While the vast majority of transacting activity is funneled through dealers (Table 4), end-users allocate, at least some portion of their trades, across a fairly large set of non-dealers.

Next we tabulate the average number of contracts traded per counterparty. Table 6 demonstrates that buying and selling per day also is concentrated among the top 20 counterparties. The top buyers (sellers) transact on average 275.0 (300.2) contracts per day. Activity levels drop for counterparties that fall below the Tier 4 classification where the majority of counterparties buy or sell less than one contract per day. These results indicate that much of the activity is concentrated among a select number of counterparties.

[22] We independently verify this claim by computing net notional amounts by counterparty type (i.e. dealers and non-dealers entities). As a whole, dealers have negative net notional (i.e. net sellers), while non-dealers entities have positive net notional (i.e. net buyers).

Table 4: This table reports statistics for transaction activity for the year 2012 by counterparty groupings. We group the top 20 counterparties who are buyers of single-name CDS contracts into four bins. We also report statistics for all of the remaining dealers (row 5) and non-dealers entities (row 6). We group into bins to preserve counterparty anonymity. Since we sort bin composition for each statistical category, bin membership may change for each statistic. The statistics reported are the number of contracts and total dollar volume (in millions).

	Buy Side				Sell Side			
	Number of Contracts		Gross Notional Amount		Number of Contracts		Gross Notional Amount	
Grouping	Amount (#)	Total (%)	Amount ($mm)	Total (%)	Amount (#)	Total (%)	Amount ($mm)	Total (%)
Tier 1 (top 5)	358,905	44.08	2,191,535	45.48	391,787	48.11	2,400,887	49.82
Tier 2 (6-10)	228,941	28.12	1,297,372	26.92	238,439	29.28	1,403,087	29.11
Tier 3 (11-15)	80,069	9.83	474,753	9.85	83,745	10.28	468,251	9.72
Tier 4 (16-20)	32,437	3.98	175,075	3.63	33,792	3.95	182,729	3.79
Other dealers	6,056	0.74	51,107	1.06	5,988	0.73	45,390	0.94
Other non-dealers	107,865	13.25	629,330	13.05	60,522	7.43	318,828	6.62
Grand total	814,273	100.00	4,819,173	100.00	814,273	100.00	4,819,173	100.00

Table 5: This table reports distribution of distinct counterparties for the year 2012 by counterparty groupings. We group the top 20 counterparties of single-name CDS contracts into four bins based on the number of unique connections based on the following criteria: (1) exclusively buy protection from the other counterparty (Buy Side Connections), (2) exclusively sell protection to the other counterparty (Sell Side Connections), and (3) buy and sell protection to and from the other counterparty (Buy and Sell Side Connections). We also report the number of connections for all of the remaining dealers (row 5) and non-dealers entities (row 6). We group into bins to preserve counterparty anonymity. Since we sort bin composition for each statistical category, bin membership may change for each statistic.

	Buy Side	Connections	Sell Side	Connections	Buy and Sell Side Connections	
Grouping	Amount (#)	Total (%)	Amount (#)	Total (%)	Amount (#)	Total (%)
Tier 1 (top 5)	2,191	28.70	2,568	33.64	1,643	32.36
Tier 2 (6-10)	1,131	14.82	1,303	17.07	795	15.66
Tier 3 (11-15)	292	3.82	313	4.10	197	3.88
Tier 4 (16-20)	79	1.03	84	1.10	74	1.46
Other dealers	124	1.62	120	1.57	116	2.28
Other non-dealers	3,817	50.00	3,245	42.51	2,252	44.36
Grand Total	7,634	100.00	7,634	100.00	5,077	100.00

Table 6: This table reports the average number of contracts traded per day by counterparty. The Top Buyers and Sellers are sorted into seven categories based on the average number of contracts traded per day. The first four Tiers contain the 20 most active counterparties. Tiers 5 and 6 respectively include the next 80, 100 most active counterparties, and Tier 7 includes all other counterparties (201-1,206).

Top buyers	Average number of contracts per day	Top Seller	Average number of contracts per day
Average Tier 1 (top 5)	275.0	Average Tier 1 (top 5)	300.2
Average Tier 2 (6-10)	175.4	Average Tier 2 (6-10)	182.7
Average Tier 3 (11-15)	61.4	Average Tier 3 (11-15)	64.2
Average Tier 4 (16-20)	24.9	Average Tier 4 (16-20)	25.9
Average Tier 5 (21-100)	3.9	Average Tier 5 (21-100)	2.5
Average Tier 6 (101-200)	0.7	Average Tier 6 (101-200)	0.4
Average Tier 7 (201-1,206)	0.1	Average Tier 7 (201-1,206)	0.0

Sectors: Corporate/Financial, Corporate/Non-financial, and Sovereigns

Tables 7 reports bilateral buyer relations for different sets of reference entities. Panels A, B, and C respectively present results for all reference entities in the sample, corporates, and sovereigns. Each panel displays results for the top 10 dealers, other dealers, and non-dealers entities.[23] To understand each panel's content, note that each row represents the fraction of CDS protection purchases by a top10 dealer (as well as the other categories) from the other top 10 dealers, other dealers, and non-dealers entities. For example, the first row of Panel A in Table 7 reports that Dealer 1 respectively buys 3.11% and 12.03% of its credit protection from Dealers 2 and 7. It also shows that 17.96% of Dealer 1's CDS protection purchases are to accommodate the demand of non-dealers entities.[24]

Based on our Concentration measure, we find that trading in sovereign CDS (Panel C) is more concentrated compared to corporate reference (Panel B) entities. Specifically, the Concentration index is 0.11 for All and Corporate reference entities, while it increases to 0.14 for Sovereign reference entities. The most noticeable changes are for dealers 1, 2, 4, 5, and 10. While all of these dealers appear to have diversified corporate CDS trading (buying substantial shares from all the other counterparties), their interactions with other dealers are more concentrated for their sovereign CDS transactions (they concentrate most of their buying from the remaining dealers 3, 6, 7, 8, and 9).[25]

[23] As shown in Tables 4, 5, and 6, the top 10 counterparties for buys and sells based on number of contracts and the gross notional amount calculations are all dealers.
[24] By construction each row sums up to 100%. Columns do not need to sum up to 100%.
[25] The network of sell relationships has similar results. Results are not reported but available upon request.

Table 7: This table reports the network of buyer bilateral relations. Panels A, B, and C respectively define the network as it extends across all reference entities, all corporate reference entities, and all sovereign reference entities. Each panel displays results for the top 10 dealers, other dealers, and non-dealers entities. To understand each panel's content, note that each row represents the fraction of CDS purchases by a top 10 dealer (as well as the other categories) from the other top 10 dealers, other dealers, and non-dealers entities. Each row reports the fraction of trades that each identified counterparty conducts with each of the other counterparties.

Panel A. Network of buyer bilateral relations across all reference entities

	1	2	3	4	5	6	7	8	9	10	Other Dealers	Non-dealers	Concentration Index
1	0.00%	3.11%	9.84%	4.43%	3.53%	14.09%	12.03%	9.40%	11.08%	3.20%	11.33%	17.96%	0.12
2	5.69%	0.00%	9.79%	2.89%	3.02%	16.85%	16.61%	9.33%	12.06%	4.09%	7.22%	12.44%	0.12
3	8.75%	4.84%	0.00%	5.28%	6.32%	11.73%	11.25%	5.58%	6.39%	7.79%	11.59%	20.45%	0.11
4	6.66%	3.69%	7.89%	0.00%	5.33%	13.26%	11.09%	8.44%	10.16%	3.82%	12.10%	17.55%	0.11
5	5.66%	2.98%	10.78%	3.31%	0.00%	14.36%	13.91%	12.46%	10.33%	2.83%	9.46%	13.92%	0.11
6	9.04%	5.92%	10.01%	5.35%	7.54%	0.00%	8.42%	6.61%	6.72%	9.26%	10.72%	20.41%	0.11
7	12.25%	6.53%	11.50%	6.01%	10.38%	15.18%	0.00%	7.54%	7.68%	7.65%	1.70%	13.57%	0.11
8	9.20%	5.65%	6.77%	4.99%	7.07%	10.15%	7.62%	0.00%	8.40%	8.13%	9.64%	22.38%	0.11
9	10.23%	5.57%	7.13%	5.98%	6.71%	10.80%	7.39%	7.97%	0.00%	6.09%	7.37%	24.76%	0.12
10	4.14%	3.42%	13.17%	4.18%	3.08%	19.69%	13.74%	10.37%	10.05%	0.00%	4.81%	13.35%	0.12
Other Dealers	10.14%	3.30%	12.51%	4.91%	5.68%	20.73%	7.23%	11.40%	13.37%	5.45%	0.00%	5.27%	0.12
Non-dealers	12.54%	3.54%	14.04%	6.20%	7.07%	23.43%	1.85%	10.04%	9.23%	4.80%	7.27%	0.00%	0.13
Average													**0.11**

Panel B. Network of buyer bilateral relations across all corporate reference entities

	1	2	3	4	5	6	7	8	9	10	Other Dealers	Non-dealers	Concentration Index
1	0.00%	4.52%	8.95%	6.16%	5.09%	13.41%	11.82%	10.13%	9.67%	4.51%	10.06%	15.68%	0.10
2	7.52%	0.00%	8.51%	3.79%	3.84%	16.44%	17.26%	8.24%	10.84%	5.21%	6.65%	11.70%	0.11
3	8.82%	5.24%	0.03%	7.02%	6.62%	14.37%	11.01%	6.78%	6.22%	8.05%	8.59%	17.24%	0.10
4	8.14%	3.83%	7.26%	0.00%	6.71%	12.19%	11.29%	8.58%	8.72%	4.75%	11.66%	16.90%	0.10
5	8.11%	4.29%	10.62%	4.66%	0.00%	15.16%	12.68%	14.92%	7.99%	4.02%	6.86%	10.68%	0.11
6	9.64%	6.73%	12.22%	6.13%	8.68%	0.00%	9.45%	7.68%	6.08%	10.49%	7.30%	15.61%	0.10
7	11.60%	7.57%	11.38%	7.56%	10.07%	15.03%	0.00%	8.16%	7.13%	8.67%	1.17%	11.66%	0.10
8	10.20%	5.95%	7.10%	5.55%	7.99%	10.97%	8.37%	0.00%	8.74%	8.63%	6.72%	19.78%	0.11
9	10.07%	5.83%	6.98%	7.11%	5.57%	10.00%	7.45%	9.37%	0.00%	7.62%	4.43%	25.59%	0.12
10	5.22%	4.34%	12.05%	5.28%	3.99%	19.08%	13.41%	10.11%	9.52%	0.00%	3.32%	13.68%	0.12
Other Dealers	9.81%	3.98%	12.14%	6.09%	6.07%	18.31%	7.83%	11.71%	13.69%	6.76%	0.00%	3.61%	0.11
Non-dealers	13.15%	3.82%	12.77%	8.58%	8.27%	22.80%	2.00%	10.81%	8.45%	4.55%	4.80%	0.00%	0.12
Average													**0.11**

Panel C. Network of buyer bilateral relations across all sovereign reference entities

	1	2	3	4	5	6	7	8	9	10	Other Dealers	Non-dealers	Concentration Index
1	0.00%	0.29%	14.87%	0.01%	0.00%	18.92%	14.56%	8.79%	16.92%	0.20%	9.38%	16.06%	0.15
2	0.73%	0.00%	13.28%	0.16%	0.82%	18.40%	15.11%	11.32%	15.33%	1.51%	8.77%	14.56%	0.14
3	9.40%	4.54%	0.00%	2.90%	6.17%	8.55%	12.59%	4.16%	6.83%	8.32%	10.96%	25.58%	0.13
4	0.12%	4.92%	13.83%	0.00%	0.21%	23.38%	12.39%	10.23%	20.30%	0.48%	5.39%	8.75%	0.15
5	0.00%	0.04%	12.90%	0.00%	0.00%	15.13%	17.87%	8.16%	17.34%	0.27%	11.97%	16.32%	0.15
6	9.63%	5.53%	7.76%	4.57%	6.88%	0.00%	7.36%	5.51%	9.26%	9.02%	10.17%	24.31%	0.12
7	14.80%	4.77%	13.63%	3.03%	11.93%	16.62%	0.00%	7.06%	9.54%	6.50%	0.17%	11.95%	0.12
8	8.79%	6.58%	7.97%	4.53%	6.54%	10.55%	7.51%	0.00%	9.00%	9.44%	7.25%	21.84%	0.11
9	11.61%	6.08%	8.25%	4.58%	8.89%	12.93%	7.90%	6.04%	0.00%	4.44%	7.51%	21.78%	0.12
10	0.21%	0.57%	18.45%	0.41%	0.12%	24.04%	15.96%	13.17%	13.32%	0.00%	4.58%	9.18%	0.16
Other Dealers	9.75%	3.47%	16.43%	1.99%	4.15%	23.61%	5.82%	9.26%	15.09%	4.08%	0.00%	6.35%	0.14
Non-dealers	12.37%	3.84%	17.14%	2.64%	5.24%	24.93%	0.46%	8.11%	11.06%	5.21%	8.99%	0.00%	0.14
Average													**0.14**

In particular, when trading sovereign CDS contracts, dealers tend to transact with dealers belonging to different countries, i.e., U.S. dealers are more likely to choose European counterparties than other U.S. counterparties. The same goes for European dealers, i.e., European counterparties are more likely to choose U.S. counterparties for their sovereign CDS contracts. By doing so, dealers and non-dealers entities might want to diversify credit risk. Billio, Getmansky, Gray, Lo, Merton, and Pelizzon (2013) find that credit risk of financial institutions and sovereigns is highly interrelated. Our results imply that geographical proximity may be an important attribute of trading in the market for sovereign CDS. That is, dealers tend to concentrate their trades with counterparties belonging to different geographical areas while reducing their participation with counterparties located in closer proximity.

In the final step, we provide a graphical representation of the network by characterizing the bilateral relations across all market participants. For each bilateral relation, we first sum the notional amount that counterparty *i* buys from *j* and the amount that *i* sells to *j* (which is equivalent to the amount *j* sells to *i* and *j* buys from *i*, respectively). To anonymize our results, we first "sterilize" our data by classifying bilateral notional amounts into six equally sized bins.[26] We then proceed to compute the average of each bin and then use the average notional amount for that bin rather than the exact bilateral amount. The practical implication of this filtering process is to translate raw notional amounts into six different connection sizes. By doing this, even if we are not able to preserve the exact ranking of the exposures (different raw notional amounts belonging to the same bin would be converted to the same number), we retain valuable information on the size of the exposures without necessarily providing direct information on raw notional amounts that could make identification of specific dealers possible.

Figures 1, 2, and 3 capture the overall gross notional amount traded between counterparties identified in Table 7. The thickness of connections between two dealers is indicative of the notional amount of CDS contracts traded. Every dealer bilateral relation that is classified within a particular bin is assigned the same thickness in the figures. Dealer relations that fall into bins with larger notional amount of contracts traded are represented by thicker lines. The size of the nodes reflects the overall amount traded by the specific counterparty.

Figures 1, 2, and 3 clearly show that the network is neither random nor sparse. In all three graphs, non-dealers entities seem to entertain most of the first and second order size connections with the top 10 dealers. The network for sovereign CDS appears to be characterized by larger discrepancies between node connections. By contrast, the network for corporate CDS seems to be more homogenous with more connections of similar size. These results are consistent with what we found in Table 7.

[26] The thickness of the bins depends of the volume of the specific market we are taking into consideration. For all CDS contracts the bins are 50 billion dollars, for corporate they are 25 billion, and for sovereign they are 16.7 billion.

Figure 1: Dealer Topology for all Reference Entities.

CDS Network Graph

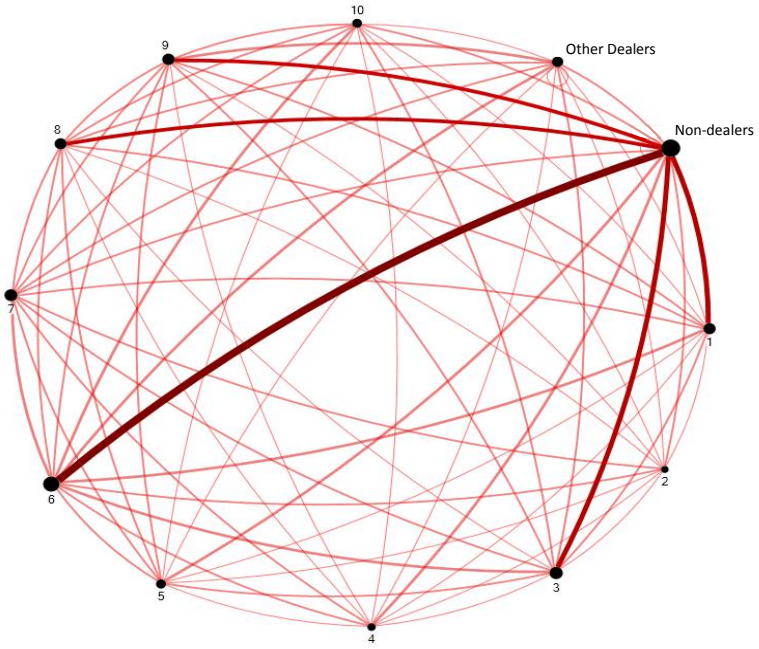
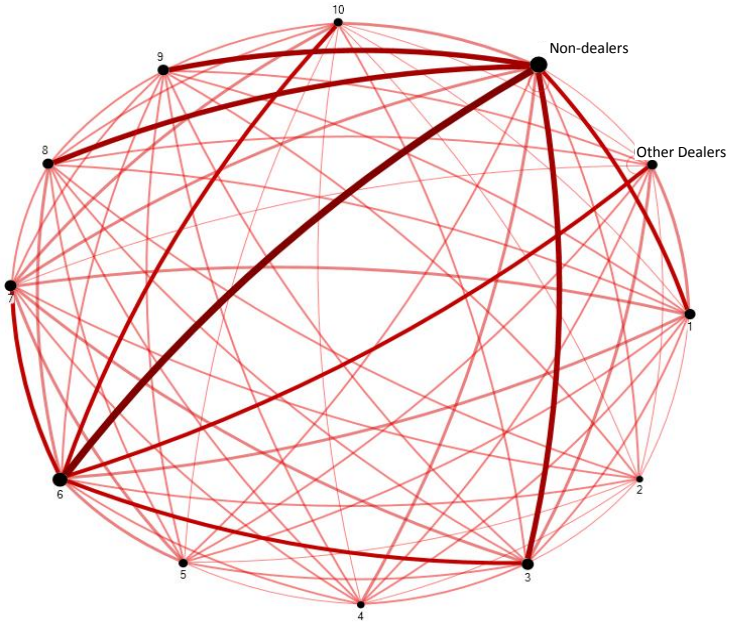


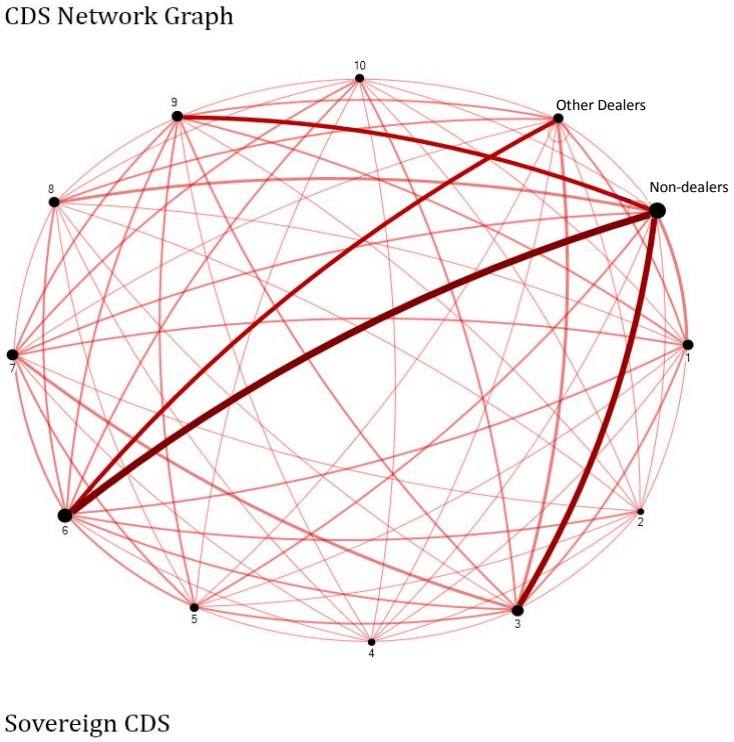
Figure 2: Dealer Topology for Corporate Reference Entities.

CDS Network Graph



Corporate CDS

Figure 3: Dealer Topology for Sovereign Reference Entities.



VI. Future Direction of Work

So far our analysis has focused on gross notional amounts. The first step forward will be to compute net notional amounts. For a particular reference entity, the net notional of a counterparty is the sum of the gross notional amounts of protection bought less the sum of the gross notional amounts of protection sold on that reference entity. If protection sold exceeds protection bought, the net notional will be negative. Because the net economic exposures of all market participants must sum to zero, net notional outstanding for the reference entity is the sum of the net protection bought by net buyers (or equivalently net protection sold by net sellers). Aggregate net notional data is the sum of net protection bought (or equivalently sold) across all counterparties. Compared to gross notional, net notional allows for differentiation of market participants between net buyers and net sellers to best reflect the size of credit risk transferred and counterparty risk.

Another high priority moving forward is to incorporate positions data into our analysis. It would be important to check whether the network picture changes moving from transactions to positions data. A possible result could be that although the largest ten dealers transact approximately 75% of CDS notional volume, they may hold a smaller share of CDS positions.

In our analysis, so far, we do not distinguish between contracts that are considered cleared, clearable, or non-cleared transactions. In future versions of our work we are planning to separate contracts into clearable but not cleared, clearable and cleared, and non-clearable and, for each, conduct separate network analyses.

Finally, moving forward, we intend to provide a dynamic picture of the network. So far we employed exclusively 2012 transaction data providing a static picture of the CDS market and its network. In the future we will work with time-series data to study the dynamics of network relationships form 2006 to 2012.

VII. Conclusion

In this paper we study the opaque over-the-counter market of credit default swaps (CDS). Using network methodology, we are able to map the network of interconnectedness between dealers and non-dealers entities of CDS contracts. We find that the network of dealers is highly concentrated for different kinds of CDS contracts. We find that trading in sovereign CDS is more concentrated compared to corporate reference entities. As progressively more contracts are cleared, it is important to study network relations for clearable and cleared contracts to see whether risk is being concentrated in certain entities. Understanding the dynamics of network topology and the effect of an eventual migration to central clearing on dealer interconnectedness will provide a broader understanding of the fragility and potential contagion of the CDS network. This will help regulators and academics identify factors necessary to prevent network fragility.

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