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Shedding light on dark markets: First insights from the new EU-wide OTC derivatives dataset

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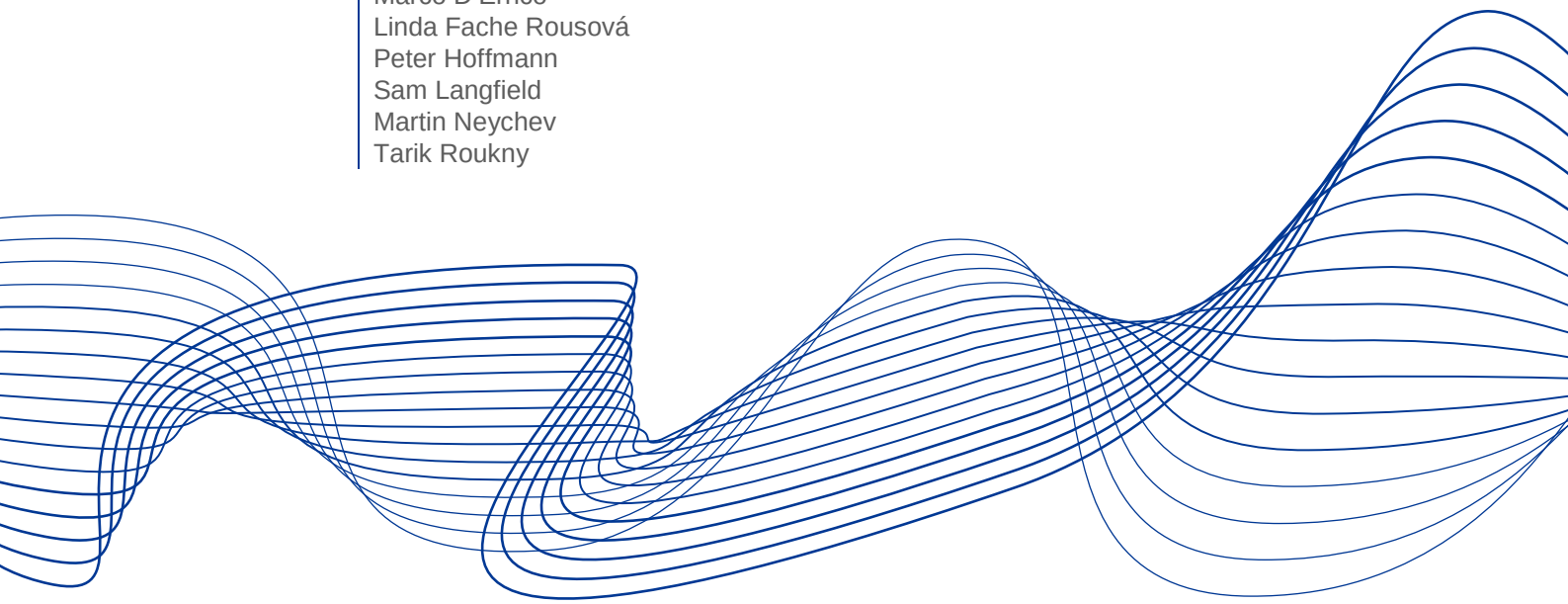


ESRB
European Systemic Risk Board
European System of Financial Supervision

Contents

Executive Summary

"Light is the best of disinfectants; the most efficient policeman."

US Supreme Court Justice Louis Brandeis (1914)

Policy is only as good as the information at the disposal of policymakers. Few moments illustrate this better than the uncertainty before and after the default of Lehman Brothers and the subsequent decision to stand behind AIG. Authorities were forced to make critical policy decisions, despite being uncertain about counterparties' exposures and the protection sold against their default.

Opacity has been a defining characteristic of over-the-counter derivatives markets – to the extent that they have been labelled "dark markets" (Duffie, 2012). Motivated by the concern that opacity exercerbates crises, the G20 leaders made a decisive push in 2009 for greater transparency in derivatives markets. In Europe, this initiative was formalised in 2012 in the European Markets Infrastructure Regulation (EMIR), which requires EU entities engaging in derivatives transactions to report them to trade repositories authorised by the European Securities Markets Authority (ESMA). Derivatives markets are thus in the process of becoming one of the most transparent markets for regulators.

This paper represents a first analysis of the EU-wide data collected under EMIR. We start by describing the structure of the dataset, drawing comparisons with existing survey-based evidence on derivatives markets. The rest of the paper is divided into three sections, focusing on the three largest derivatives markets (interest rates, foreign exchange and credit).

In **Section 2**, we look at interest rate derivatives, which represent around three quarters of the gross notional of all derivatives markets. The market is large because of widespread demand for interest rate risk management: as part of their business model, banks typically borrow at short maturities and lend long, while insurers and pension funds borrow long and lend short. Consistent with this hedging motive, we find that banks' interest rate derivative portfolios increase in value when interest rates rise, while those of insurers and pension funds decrease. A set of dealers, including some large banks, intermediate between end customers; these dealers therefore take small net positions vis-à-vis interest rate risk despite maintaining large gross portfolios.

In **Section 3**, our focus shifts to credit default swaps (CDS). Unlike interest rate derivatives, few single-name CDS contracts are centrally cleared, meaning that CDSs transfer counterparty (as well as fundamental) credit risk. The market is highly concentrated: most trades relate to a few reference entities, which in turn account for a large share of gross notional. Dealers occupy the lion's share of transactions and associated net and gross notional. Overall, the dealers have a small net/gross ratio, reflecting their intermediation role. Other financial institutions (including hedge funds and mutual funds), non-financial corporations, as well as insurance and pension funds are generally net buyers of protection.

Finally, in **Section 4**, we analyse foreign exchange derivatives. Foreign exchange derivatives, which mostly comprise forward contracts (either outright forwards or forwards as part of a swap agreement), are not centrally cleared, in contrast with many interest rate derivatives. Compared with credit derivatives, the foreign exchange derivatives market is relatively decentralised. Most trades involve at least one bank, but many of these trades take place with non-financial counterparties. FX derivatives therefore allow NFCs to hedge unwanted foreign exchange risk, and constitute a closer link between the financial system and the real economy than interest rate or credit derivatives.

Section 1
Introduction

The derivatives market – once one of the most opaque financial markets in the world – is in the process of becoming one of the most transparent to regulators. In Pittsburgh in September 2009, G20 leaders committed to requiring all over-the-counter derivative contracts to be reported to trade repositories, which make the data available to relevant authorities. In the EU, this commitment is implemented in the European Markets Infrastructure Regulation.[1] Since 2014, counterparties resident in the EU (including central clearing counterparties) have been required to report the details of new and outstanding derivatives transactions to trade repositories. EMIR grants the European Systemic Risk Board and European Securities and Markets Authority exclusive access to the full EU-wide dataset.

The derivatives market is voluminous and heterogeneous; transaction-level data on derivatives are therefore highly complex. Various problems associated with the structure of the datasets and the quality of reporting compound this inherent complexity. Grappling with this complexity is a substantial project with a high expected payoff: analysis promises to shed light on the hitherto "dark" OTC derivatives markets (Duffie, 2012), and ultimately to inform macroprudential policymaking. This paper represents a first step in that direction.

The purpose of this paper is to describe the groundwork in terms of data analysis that has been conducted in view of three medium-term policy objectives:

- The first objective is to improve policymakers' understanding of the functioning of the derivatives market. Before the G20's initiative in 2009, the derivatives market was notoriously opaque. On 15 September 2008, for example, there was significant uncertainty regarding the net volume and distribution of credit protection written by and referenced on Lehman Brothers (Scott, 2014). In a retrospective analysis of the causes of the crisis, the US Federal Crisis Inquiry Commission (2011) concludes that the "Federal Reserve realised far too late the systemic danger inherent in the interconnections of the unregulated OTC derivatives market and did not have the information needed to act". This lack of information impaired policymakers' effectiveness in 2008. With transaction-level derivatives data, today's policymakers are better equipped.
- The second objective is to identify possible sources of systemic risk. In derivatives markets, systemic risk is determined by the interplay between market risk, counterparty risk and liquidity risk, and the distribution of these risks across market participants. Combining information about counterparties' exposures to risk factors with counterparty-level data can therefore help regulators to identify key sources of systemic risk (Duffie, 2014). In derivatives markets, activity is typically concentrated around a relatively small core of major dealers, which generates systemic fragility with respect to distress at a dealer bank (Langfield, Liu and Ota, 2014). The new transaction-level derivatives data provide policymakers with the opportunity to analyse these sources of systemic risk.

[1] See **Art. 9** of EMIR. Other jurisdictions have introduced similar provisions, including the US (via **Title VII of the Dodd-Frank Act**). According to the Financial Stability Board (FSB), as of June 2016, 19 out of 24 FSB jurisdictions had in force trade reporting requirements, covering more than 90% of OTC derivative transactions (FSB, 2016).

- The third objective is to inform the development of macroprudential policies. Policies can be applied with respect to institutions or activities. In terms of institutions, cross-sectional macroprudential policy should focus on the distribution of market risk, counterparty risk and liquidity risk across derivatives market participants; time-varying macroprudential policy should focus on the build-up of such risk in good times. Excessive concentrations or accumulations of risks can be addressed via charges or outright limits. In terms of activities, macroprudential policymakers could consider the scope of mandatory central clearing (to address counterparty risk) and restrictions on margins or haircuts (to address liquidity risk) (Clerc et al, 2016). Analysis using transaction-level derivatives data can help to inform the design, selection and calibration of such macroprudential policies.

1.1 Overview of the EMIR dataset

According to EMIR, all EU-located legal persons (counterparties) entering into a derivative contract must report the details of that contract to a trade repository (TR) authorised by ESMA. At the time of writing, the authorised trade repositories are CME, DTCC, ICE, KDPW, Regis-TR and UnaVista.[2] These six TRs provide daily data to over 60 institutions in the EU, which have access to the data pertaining to their respective jurisdiction. The ESRB and ESMA uniquely have access to the full EU-wide dataset.

Table 1
Overview of counterparty variables reported under EMIR

Counterparty (CP) data
Reporting timestamp
Counterparty ID, name, etc - both for the reporting entity, and for the counterparty of the reporting entity
Corporate sector of the CP
ID of broker, beneficiary, etc.
Counterparty side (buyer/seller)

The EMIR data cover all derivatives classes (including credit, commodity, equity, interest rates and foreign exchange) and encompass trades cleared by central clearing counterparties (CCPs). Both OTC and exchange-traded contracts are subject to the reporting requirement. Around 85 variables are reported for each transaction (see Tables 1 and 2). These include information on counterparties; details on the characteristics of the contract (e.g. type of derivative, underlying, prices, amount outstanding); how and on which venue the contract was executed or cleared; valuation and collateral; and life-cycle events (e.g. whether the observation pertains to a new contract, a modification or revaluation of an old contract, or termination).

Such comprehensive reporting under EMIR implies huge data volumes. By the end of 2015, 27 billion records had been received and processed by the six TRs in the EU, averaging around 330 million records per week (ESMA, 2015a). Furthermore, the reporting obligation is imposed on all EU counterparties, rather than on a subset of market players. It therefore provides the first complete picture of the EU derivatives market.

[2] The full names of the six authorised trade repositories are CME Trade Repository Ltd. (CME); DTCC Derivatives Repository Ltd (referred to hereafter as “DTCC”); ICE Trade Vault Europe Ltd. (“ICE”); Krajowy Depozyt Papierów Wartościowych S.A. (“KDPW”); Regis-TR S.A. (“Regis-TR”); and UnaVista Limited (“UnaVista”). DTCC Derivatives Repository Ltd is one of four subsidiaries of the DTCC Global Trade Repository (DTCC GTR), which is a global TR with worldwide operations.

Table 2

Overview of contract variables reported under EMIR

Contract type Product and underlying IDs Notional/deliverable currencies	**Clearing** Clearing status Clearing obligation Clearing timestamp CCP ID
Transaction details Trade ID (UTI) Execution venue / timestamp Maturity / settlement / termination Information on price, notional, type of delivery.	**Interest rates** Fixed rate / floating rate Payment frequencies Day count convention Reset frequencies
Risk mitigation / reporting Confirmation means and timestamp	**Foreign Exchange** Exchange rate Exchange rate basis Forward exchange rate
Collateral Portfolio code Collateral value	**Commodities** Commodity base Further details on energy deriviatives
Modificatios to the report Action type New Modify Error Cancel Compression Valuation update	**Options** Option type / style Strike price

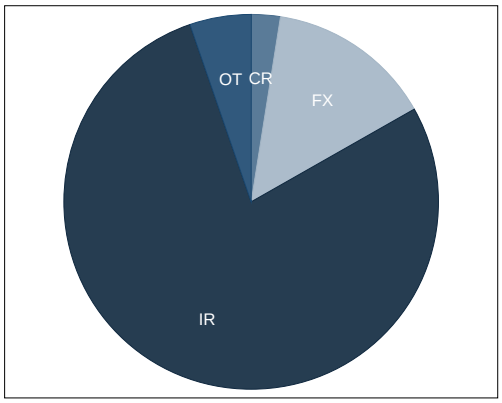
1.2 Comparison with the Bank for International Settlements' survey

The semi-annual survey of the OTC derivatives market by the Bank for International Settlements (BIS) provides basic information and a benchmark against which to compare aggregate volumes from the new EMIR dataset. Compared to EMIR's comprehensive coverage, the BIS surveys a limited set of derivative dealers, which report their aggregate derivative positions on a global consolidated basis, including the positions of their foreign affiliates (after netting intra-group positions). About 70 major derivative dealers from 13 countries participate in the BIS' semi-annual survey; despite the limited sample, the semi-annual survey captures a large portion of the global OTC market (BIS, 2013 and 2015).[3]

The BIS survey provides information on the relative importance of each derivative class in the OTC market (Chart 1). As of end-2015, by far the most important derivative class in terms of notional amount of outstanding contracts is interest rates derivatives (around 78%), followed by foreign-exchange derivatives (14%) and credit derivatives (3%). In Section 2, we focus on interest rate derivatives owing to their predominance in the wider derivatives market. In Section 3, we turn to credit derivatives, which played a key role in the 2008-09 financial crisis. In Section 4, we look at foreign exchange derivatives, which represent a relatively under-studied segment of the derivatives market.

[3] Comparison of the aggregates obtained from the BIS semi-annual survey with those from the BIS triennial survey, which covers many more institutions (around 400) from many more countries (47), suggests that the market share of semi-annual reporters is about 97% for interest rate and credit derivatives. Still, neither survey covers positions between two non-reporting entities. By contrast, EMIR covers all EU-resident entities.

Chart 1
Notional shares of OTC derivative classes



Note: "CR" denotes credit derivatives, "FX" denotes foreign- exchange derivatives, "IR" denotes interest rate derivatives, and "OT" indicates other classes, including commodities and equity-linked derivatives.
Source: BIS semi-annual OTC derivatives survey (end-2015) and authors' calculations.

According to the BIS survey, the total notional of outstanding OTC interest rate derivatives globally stood at €353,303bn at end-2015; that of credit derivatives €11,310bn; and that of foreign exchange derivatives €64,810bn. Throughout this paper we use EMIR data retrieved from DTCC, the largest trade repository. Our sample covers 70%, 73% and 61% of these BIS aggregates for interest rate, credit and FX derivatives respectively (see Table 3). This partial coverage of the global market is reasonable given that EMIR reporting requirements apply only to EU-resident entities, and in light of DTCC's partial market share. On the other hand, EMIR's comprehensive coverage of EU-resident entities – compared with the subset of global market players surveyed by the BIS – biases upwards the relative magnitude of EMIR aggregates.[4]

Table 3
EMIR data from DTCC compared with the BIS's global OTC derivatives survey

(notional amounts outstanding)

	Interest rate derivatives	Credit derivatives	Foreign exchange derivatives
EMIR data from DTCC, EU aggregate	€247,428bn	€8,291bn	€39,629bn
BIS semi-annual survey, global aggregate	€353,303bn	€11,310bn	€64,810bn
Ratio (EMIR/BIS)	70%	73%	61%

Source: DTCC OTC interest rate, credit and foreign exchange derivatives datasets (based on the 02/11/15 trade state report) and BIS semi-annual OTC derivatives survey from end-2015.
Note: DTCC aggregates are obtained from Tables 4, 7 and 11 as the sum of the "final values" at the bottom of each table plus all observations in the lower part of the table below "Non-LEI counterparties" (excluding intra-group positions).

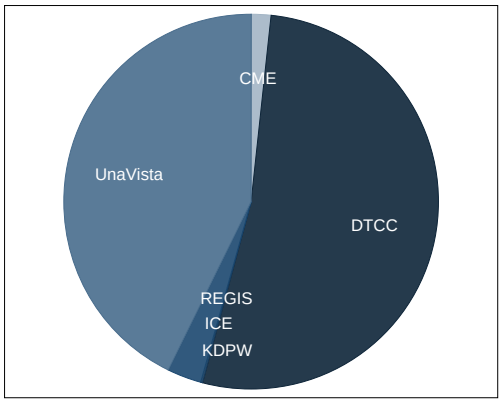
[4] Other considerations should be borne in mind when comparing BIS and EMIR aggregates. First, the consolidation perimeter differs: the BIS survey is conducted on a global consolidated basis, whereas intra-group trades in the EMIR data are identified by an intra-group flag reported under EMIR, which we further complement with information on global ultimate ownership from Orbis (see section 1.4). As an example of the potential difference, in statistical and supervisory data collections from banking groups, the consolidation perimeter can refer to broad economic scope including insurance corporations or to the prudential scope, which excludes insurance corporations. Second, there are minor differences in product classifications: for credit, the BIS survey covers only credit default swaps, whereas EMIR includes all credit derivatives; the BIS survey classifies some cross-currency interest rate swaps as foreign exchange derivatives, whereas EMIR records them as interest rate derivatives. Third, the discrepancy in the reporting date – BIS data are valid as of 31/12/15, whereas EMIR data refer to 02/11/15 – may play a minor role. See Fache Rousová, Kulmala and Osiewicz (2015) for a fuller discussion of the differences between BIS and EMIR data.

1.3 EMIR data from DTCC

The existence of multiple trade repositories – each of which receives and processes a subset of data reported under EMIR – poses a challenge for ESMA, the ESRB and other authorities to access, manage and analyse EMIR data, particularly in comparison to other jurisdictions that have adopted a single TR (HKMA, 2015). In Europe, on a daily basis, each trade repository generates multiple reports of different types, and has done so since the start of reporting in February 2014. The number, content and structure of the reports varies across trade repositories.

In general, all trade repositories are obliged each day to provide the relevant authorities with details on all new trades and modifications of outstanding trades, which were reported to them by counterparties on the previous day. This information is contained in so-called "trade activity" reports. In addition, most TRs provide a "trade state" report, which contains transaction-level information on the stock of all outstanding contracts at a given date. This report is derived by TRs by accumulating data from all past trade activity. This information is crucial from a macroprudential perspective, but is not (yet) a mandatory requirement under EMIR.

Chart 2
Market shares of trade repositories in OTC interest rate derivatives



Note: Based on the average notional amount of open trades for each TR over the period January-August 2016.
Source: Trade repositories' public data.

DTCC is the largest trade repository in terms of market share. In interest rate derivatives, DTCC covers 53% of the market (Chart 2), but the extensive use of central clearing in Interest rate derivatives inflates the relative market share of UnaVista, which receives most CCP reports. In most cases, the counterparties to these centrally cleared trades report to DTCC, meaning that DTCC's coverage – after "de-duplicating" the data – is more extensive than implied by its 53% market share.

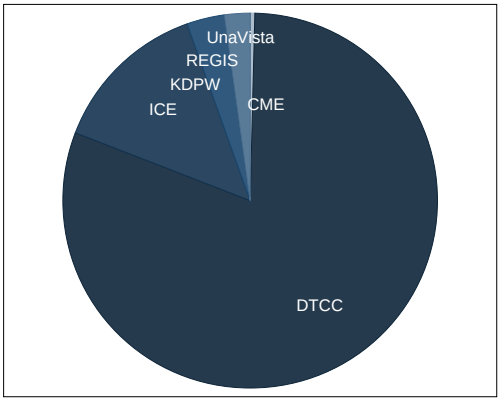
In OTC credit derivatives, DTCC has a larger market share of 80% (Chart 3), and its market share in FX derivatives stands at around 66% (Chart 4).[5]

In light of DTCC's broad coverage of interest rate, credit and foreign exchange derivatives, this paper focuses on derivatives transactions reported to DTCC. In parallel, efforts are underway within the ESRB to merge DTCC's dataset with those of other trade repositories in order to achieve a more complete coverage of the derivatives market. In this respect, ESMA's work to improve the harmonisation of data across TRs – particularly with respect to variable names and data quality – is crucial.

[5] The chart stands at 66% based on average over the period from January to August 2016. The share increases to over 75% when using data from the two most recent months (July and August 2016). The significant increase in the DTCC's share can be attributed to a sharp downward correction observed in June 2016 in the data published by UnaVista.

Chart 3

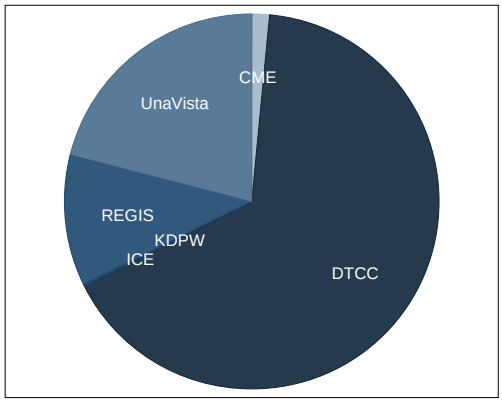
Market shares of trade repositories in OTC credit derivatives



Note: Based on the average notional amount of open trades for each TR over the period January-August 2016.
Source: Trade repositories' public data.

Chart 4

Market shares of trade repositories in OTC foreign exchange derivatives



Note: Based on the average notional amount of open trades for each TR over the period January-August 2016.
Source: Trade repositories' public data.

DTCC provides regulators with more than 40 separate files each day, which are organised as follows:

- **4 types of report** – including trade state, trade activity, trade modifications, counterparty positions and collateral;[6]
- **2 types of venue** – either over-the-counter or exchange-traded;
- **5 types of underlying** – including all main derivative classes (rates, equity, credit, FX, commodities).

In addition, DTCC provides further reports on collateral and rejection rates due to non-compliance with the reporting rules.

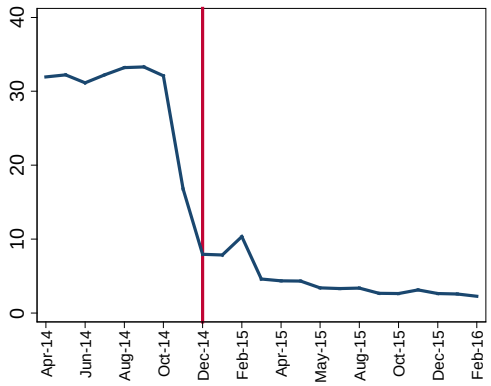
1.4 Improvements in data quality

Since the advent of the EMIR reporting obligation in February 2014, data quality has significantly improved. To illustrate this, Chart 5 plots the time series of the share of missing observations on several key variables. Steps by ESMA to improve data quality have been instrumental in driving this downward trend in the share of missing observations; most notably, the introduction of Level 1 validations by trade repositories in December 2014 led to a significant reduction in the number of missing observations.

[6] The trade state report provides transaction-level information on the stock of all outstanding contracts at a given date. The trade activity report provides information on new transactions – including compressions of extant contracts, complicating the identification of genuinely "new" trades. The modification report provides details on daily modifications to existing contracts. The counterparty position report provides aggregated data at the counterparty level (e.g. gross bilateral exposures for a given asset class/instrument type). The collateral report provides information on the market value of collateral used at the counterparty and collateral portfolio level.

Chart 5

Percentage of missing observations for selected variables



Note: This chart depicts the time series of missing observations, computed as the mean percentage of missing variables across four variables: beneficiary ID, notional amount, effective date, and price multiplier.
Source: ECB calculations based on month-end DTCC trade state reports provided to the ECB.

Another data quality issue relates to reconciliation of both sides of the same trade. To this end, ESMA has put forward guidelines regarding the definition of an interim unique trade identifier (ESMA, 2015b), pending a global unique trade identifier (UTI) defined by the Committee on Payments and Market Infrastructures (CPMI) and the International Organisation of Securities Commissions (IOSCO). UTIs serve two purposes. First, two observations on the same trade facilitate an additional quality check; in some cases, we are able to use the superior data quality of one observation to improve the quality of the duplicated observation – underscoring the utility of EMIR's double-reporting obligation. Second, by successfully matching two sides of the same trade, it is possible to obtain a more precise "de-duplicated" quantification of total gross notional in a given market.

EMIR data only contain information on the characteristics of each derivative transaction. Information on counterparties, for example, is limited. However, EMIR's use of the legal entity identifier (LEI) permits us to merge the derivatives data with external data that contain counterparty-level information. In particular, we merge the derivatives data with data from Bureau van Dijk's Orbis dataset and Bloomberg data. This facilitates the generation of useful summary statistics and allows us to identify the sector of each LEI at two different levels: the LEI itself, and a global ultimate owner for each LEI, based on ownership data from Orbis. The GUO's sector may differ from that of LEI, allowing us to conduct a sector analysis at two different levels of aggregation.

Section 2
Interest rate swaps

Interest rate derivatives (IRDs) constitute the largest segment of the OTC derivatives market, accounting for about 78% of total gross notional according to BIS data. Financial institutions use IRDs extensively to hedge and speculate on interest rate risk. In view of the importance of IRDs, academic attention has recently shifted towards banks' and other financial institutions' exposure to interest rate risk (Begenau et al, 2015; Gomez et al, 2016). These contributions estimate US institutions' interest rate risk exposures from publicly available data. With granular transaction-level data, these estimates can be verified and refined for European banks' derivatives market activity.

The OTC IRD market is in transition from a bilateral market to one that is mostly centrally cleared. In the US, certain IRDs are subject to a central clearing obligation owing to provisions in the Dodd-Frank Act (Benos et al, 2016). In the EU, the obligation for certain counterparties to centrally clear certain derivatives started being phased-in from 21 June 2016.[7] These structural changes mean that the current juncture is a particularly insightful time at which to study the IRD market. Looking forward, analysis of the IRD market can help to inform the design of macroprudential policy with respect to the scope of central clearing obligations.

2.1 Processing the data

In this subsection, we describe the steps that we take to transition from the raw trade state report from DTCC circa 02/11/15 to one that is fit for analysis. This processing procedure discards erroenous observations and hones in on a subset of trades that are standardised and amenable to comparison.

While the IRD market encompasses a wide range of products, including bespoke products tailored to specific needs, most market activity is concentrated in a few relatively standardised products. Interest rate swaps account for the majority of the stock at around 88%. Among the remainder, interest rate options account for 4.9% and interest rate forwards for 3.3%.

To gain a representative insight into the IRD market, we focus on a specific type of OTC contract: the 6M Euribor plain-vanilla fixed-for-floating interest rate swap (IRS). In this subsection, we provide an overview of the data processing procedure by which we transition from the raw dataset, which includes over six million outstanding contracts, to the subset of such IRSs.

The processing procedure is described in detail in Table 4. The first column describes the various steps followed, while column 2 reports the number of observations discarded at each step. Column 3 reports the associated gross notional amount that is dropped at each step, and column 4 the share of that step in the total gross notional.

[7] See **http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R2205**.

Table 4

Statistics of the processing procedure for IRDs

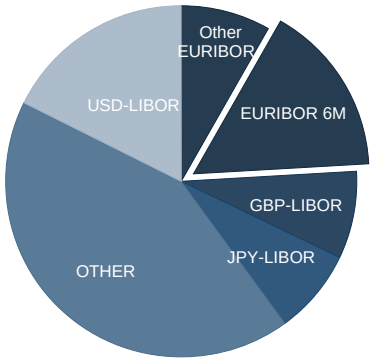
	# Obs.	Notional (€bn)	Notional (%)
Initial values	**6,077,028**	**403,795***	**-**
Observation dropping			
Implausible values	35,120	-	
No counterparty side	17,424	722	0.2
Missing mark-to-market value	1,253,677	80,926	20.1
Duplicates (trade IDs)			
Inconsistent			
notional	77,444	4,276	1.3
counterparty ID	22,052	1,110	0.3
maturity date	14,040	837	0.3
intragroup flag	44,420	3,146	1.0
De-duplication	352,469	15,648	5.0
Non LEI counterparties	194,216	6,093	2.1
Non swaps	514,850	67,977	23.4
Basis swaps	187,792	10,564	4.8
Embedded options	5,211	98	0.0
Spread on floating leg	335,766	27,896	13.1
Upfront payment	145,577	5,160	2.8
Cross-currency	71,138	2,360	1.3
Diff. notional across legs	17,211	1,611	0.9
Intragroup	773,371	43,609	24.9
Non Euribor 6M	1,695,446	109,131	82.8
Final values	**319,804**	**22,631**	

Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).
Note: The notional amount (in €bn and as a % of the total) for each row is calculated when the respective observations are dropped from the dataset. All notional amounts are reported in euro after conversion using exchange rates on 02/11/15.
* The initial notional amount is computed after observations with implausible reported gross notionals (i.e. greater than €10bn or lower than €1,000) are dropped.

The cumulated steps above the middle horizontal line in Table 4 represent the “cleaning” procedure. Observations dropped above this line are either erroneous or redundant. In total, we drop 1,306,221 erroneous observations owing to implausible gross notional values (greater than €10bn or lower than €1,000) or missing values on the fields related to the “counterparty side” (which is crucial for subsequent analysis) or “mark-to-market value” (wherein a missing observation suggests that the trade has in fact been cancelled). We then proceed to identify duplicates on the unique trade identifier. First, we apply an internal consistency check by dropping observations where two reports pertaining to the same transaction are inconsistent with respect to their reported gross notional, counterparty IDs, maturity date or intragroup flag. Second, we de-duplicate the data by dropping one observation per pair of matched transactions. Finally, we delete 194,216 observations where at least one of the counterparty identifiers is not an LEI.

At the middle horizontal line, we are left with a de-duplicated dataset containing non-missing observations on 4,066,166 interest rate derivative transactions that were open on 02/11/15. The most significant observation loss is caused by the removal of missing mark-to-market values; a large fraction of these transactions with missing mark-to-market values are in fact closed trades that are erroneously still reported as being alive. As such, we are confident that the 4,066,166 observations remaining at the first horizontal line in Table 4 cover the vast majority of unique interest rate derivative transactions that were open on 02/11/15.

Chart 6
Breakdown of underlying benchmark



Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

Chart 6 depicts the breakdown of this dataset in terms of the underlying benchmark rate used to determine the payments of the floating leg. Two thirds of contracts are referenced on EUR-Euribor or the three main Libor rates (USD, GBP and JPY). Among Euribor contracts, the 6M tenor accounts for the largest share. For subsequent analysis, it is useful to focus only on one benchmark type, such that the descriptive statistics are internally consistent. We choose to focus on plain-vanilla fixed-for-floating interest rate swaps referenced on 6M-Euribor, which represent the modal type of interest rate derivative.

After the middle horizontal line in Table 4, we restrict the dataset accordingly. To this end, we drop non-swap interest rate derivatives; basis swaps; swaps with embedded options; swaps with a non-zero spread on the floating leg; swaps with non-zero upfront payments; and cross-currency swaps. We also discard cross-currency swaps and contracts with different notionals in the two legs. Finally, we discard intragroup transactions, using the intragroup flag reported in the EMIR data and the global ultimate ownership (GUO) LEI hierarchy provided by Orbis. After applying all of these filters, we are left with a dataset comprising 319,804 observations.

2.2 Summary statistics of processed interest rate swap data

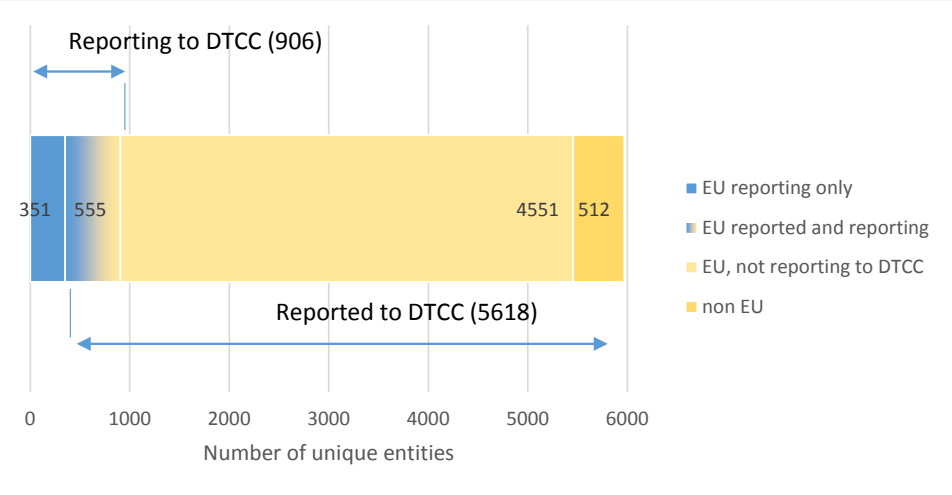
This section presents summary statistics for the subset of 391,804 observations that are identified as plain-vanilla fixed-for-floating 6M Euribor IRS. These summary statistics point to new stylised facts regarding the microstructure of the OTC IRS market, thereby providing motivation for future research. Given the complex nature of EMIR data, these summary statistics also act as a "sanity check" as to whether the main features of the data are consistent with existing survey-based knowledge of the OTC derivatives market.

Approximately one third of IRSs in our six-month Euribor subset are centrally cleared. Charts 7-12 and Chart 15 are based on the full set of trades, while Charts 13 and 14 and Table 5 present separate statistics for centrally cleared and non-cleared trades.

Under EMIR, all EU-resident counterparties engaging in derivatives trades are required to report them to an authorised trade repository. If the two counterparties on each side of the trade are both resident in the EU, then both entities report the same transaction. If one is resident outside of the EU, the transaction is reported by its EU-resident counterparty, such that we are able to observe the non-EU entity. 906 unique EU-resident entities report interest rate swaps to DTCC (see Chart 7). These 906 reporting entities report as counterparties a further 5,618 entities – of which 555 are also reporting entities; 4,551 are EU-resident entities that do not report to DTCC (but rather to another TR); and 512 are non-EU counterparties that are not subject to a reporting requirement under EMIR.

Chart 7

Geographical structure of the reporting scheme under EMIR (IRS)

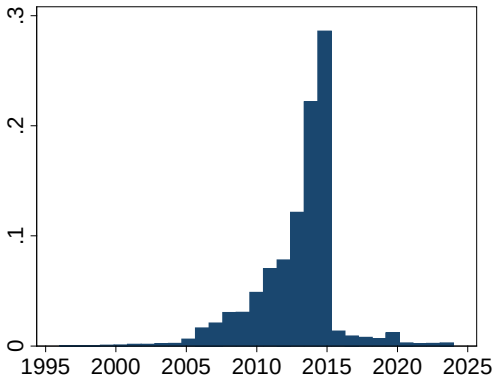


Source: DTCC OTC interest rate swaps dataset (based on the 02/11/15 trade state report).

Chart 8 plots the distribution of effective dates, which indicate the date from which cash-flows are exchanged (as opposed to the execution date, which refers to the date on which the contract is agreed). The modal effective date is 2015, reflecting the now common market practice of compressing economically redundant trades into new contracts with a smaller gross notional (ISDA, 2012; Schrimpf, 2015). There is, nevertheless, a long left tail: some outstanding IRSs are several years old, and were therefore agreed upon and priced in a very different interest rate environment. We also observe a right tail of IRSs that become effective after their execution date; these are so-called "forward-starting" swaps.

Chart 8

Frequency distribution of effective date across trades

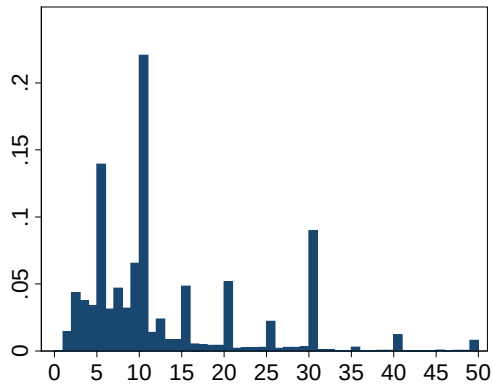


Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

Chart 9

Frequency distribution of original maturity across trades

(in years)



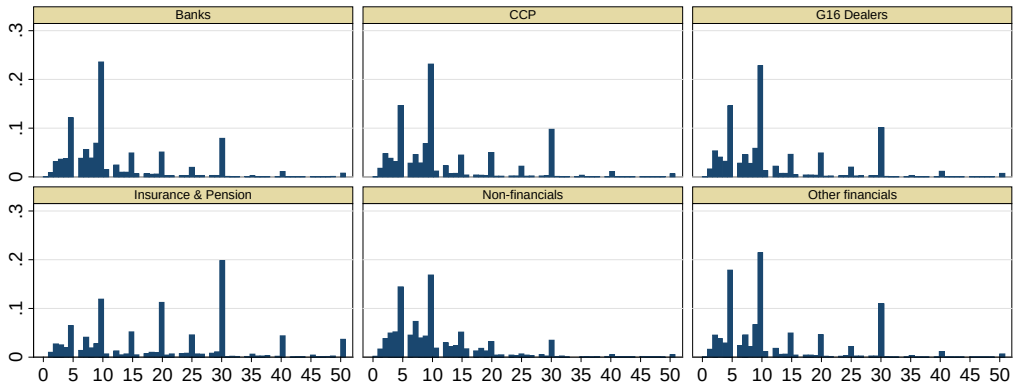
Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

The time-profile over which cash-flows are exchanged is given by the difference between the effective date and the date on which the contract matures. The frequency distribution of these original maturities is shown in Chart 9. The distribution is right-skewed: most swaps have an original maturity of 10 years or less, but with a long right tail. We also observe bunching at multiples of five years – particularly at 5, 10 and 30 years – pointing to considerable standardisation. The maximum original maturity is 50 years, corresponding to conventions in fixed-income markets.[8]

Chart 10 shows the frequency distribution of original maturities across different sectors. To this end, we use information from Orbis in order to assign counterparties to one of the following six groups: G16 dealers,[9] banks, central counterparties, pension funds and insurance companies, other financial institutions (such as mutual and hedge funds), and non-financial institutions.

The distribution of maturities is similar across sectors – except for insurers and pension funds, which have a tendency to use longer maturities. About 20% of IRSs with at least one counterparty as an insurer or pension fund have a maturity of 30 years, compared with a global average of less than 10%. Insurers and pensions funds are also disproportionately extensive users of IRSs with original maturities of 20, 40 and 50 years. Insurers' and pension funds' preference for long-dated swaps reflects the long duration of their liabilities, which is often so long that insurers are unable to buy assets with similar duration, giving rise to a mismatch. The interest rate risk inherent in such a duration mismatch can be managed by taking long-dated pay-float positions in interest rate derivatives, as we describe in subsection 2.4.

Chart 10
Frequency distribution of original maturity across counterparty type



Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

[8] Note that in a single trade state report the maturity of an IRS and its effective date are not independent due to survivorship bias. The fraction of contracts with old effective dates will be larger for long maturity contracts than for short maturities since short maturity contracts with old effective dates will have already expired. Also note that the distribution of maturities in the daily flow of new contracts will be quite different from the distribution of the stock of outstanding maturities in Chart 9, as short maturity IRS are renewed more frequently than long maturity IRS to keep their fraction of the stock constant.

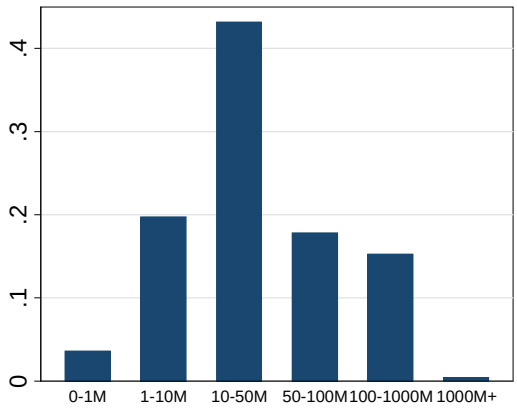
[9] The group of G16 dealers includes Bank of America, Barclays, BNP Paribas, Citigroup, Crédit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JPMorgan Chase, Morgan Stanley, Nomura, Royal Bank of Scotland, Société Générale, UBS, and Wells Fargo.

Chart 11 shows the frequency distribution of gross notional amounts (with uneven bin sizes for the sake of presentational clarity). Nearly half of the swaps in the "processed" dataset have a gross notional of €10-50m. Approximately 15% of swaps have a gross notional of more than €100m; a few even exceed €1,000m.

Chart 12 depicts the distribution of the interest rate paid on the fixed leg of the IRS. To plot this chart, we divide our sample into four periods (according to the execution date of the contract): 1996-2000, 2001-07, 2008-12, and 2013-15.[10] These four periods broadly correspond to different interest rate environments: prevailing interest rates in the latter two periods were substantially lower than those in the first two periods. We can therefore verify whether the fixed rates are in line with what one would expect based on the evolution of interest rates over time. The distribution of rates has shifted to the left for contracts with a more recent execution date, which suggests that the data quality of the fixed leg variable is reasonable: a negligible fraction of IRSs with an execution date between 2013 and 2015 have a fixed leg rate greater than 4%.

Chart 11

Frequency distribution of gross notional across trades

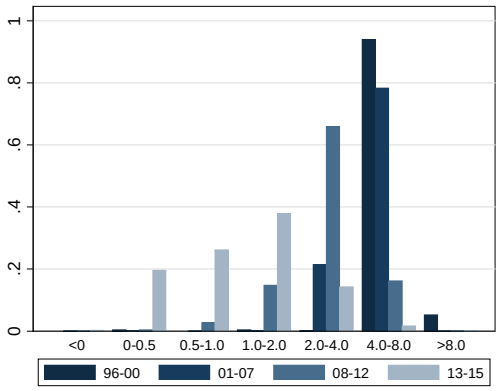


Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

Chart 12

Distribution of fixed leg rate by execution date

(in %)



Note: This chart does not include forward-starting swaps.
Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

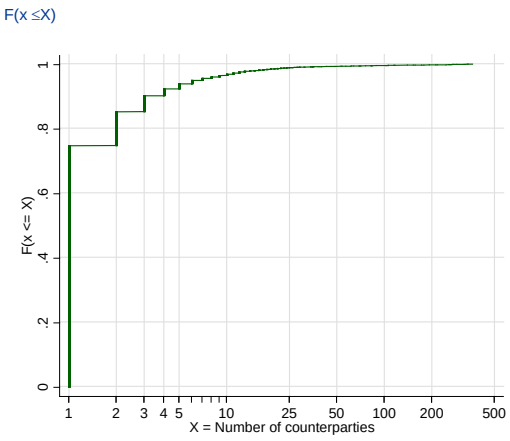
[10] By dividing our sample in this way, we introduce "survivorship bias": the actual average original maturity of contracts executed over 1996-2000 or 2001-2007 was lower than might be inferred from the chart. The bias results from the fact that we refer only to the trade state report on 02/11/15, which includes outstanding transactions that are open on that date. Naturally, transactions that are open on this date but with an execution date several years in the past must have a long original maturity. Despite this survivorship bias, Chart 12 provides (to a first order approximation) a reasonable sanity check regarding the quality of the reported fixed leg rate.

2.3 Network properties of outstanding interest rate swap contracts

Interest rate swaps are traded over-the-counter; it is therefore insightful to investigate the network structure of the market. In this subsection, we shed light on “who trades with whom”.

Chart 13

Degree distribution of the IRS network for non centrally cleared trades



Note: This chart does not show the 10 institutions with the largest number of counterparties (for presentational clarity).
Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

A first impression of the network density can be garnered from the degree distribution across the 5,969 market participants, where "degree" measures the number of unique counterparties with which each counterparty trades. We do this in Chart 13 for non-centrally cleared trades. Fewer than 10% of counterparties have outstanding transactions with more than five unique trading partners. At the same time, there is a long tail of institutions with a large number of counterparties. This is in line with the common insight that OTC markets can be interpreted as a sparse network in which many participants trade with the same small set of counterparties (Li and Schürhoff, 2014).

The matrix in Table 5 provides an overview of “who trades with whom” in non-centrally cleared IRSs based on the counterparty classifications obtained from Orbis. Each cell corresponds to the gross notional outstanding between two sectors, relative to the total gross notional outstanding. Just under three quarters of total outstanding notional is concentrated in contracts between G16 dealers and/or other banks. About one quarter takes place between dealers or banks and “customers” such as insurance companies, pension funds, other financial institutions (e.g. investment funds), non-financial corporates, and others (including governments). A small minority of trades take place directly between these customers.

Table 5

Matrix of share of interactions between market participants, weighted by notional

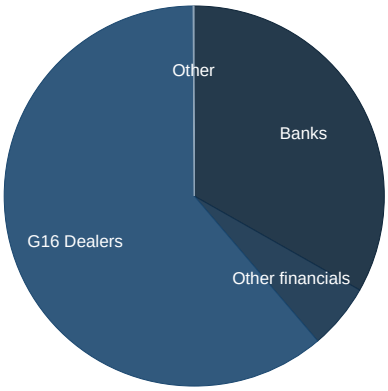
Pay Fixed \ Pay Float	G16 dealers	Banks	ICPFs	Other Finan.	Non-financial	Other	Total
G16 dealers	19.2%	21.3%	1.7%	5.2%	0.3%	3.4%	51.1%
Banks	24.9%	7.2%	0.3%	0.7%	0.1%	0.8%	34.1%
ICPFs	1.4%	0.2%	0.0%	0.4%	0.0%	0.0%	2.0%
Other Finan.	4.4%	0.6%	0.8%	0.0%	0.0%	0.9%	6.7%
Non-financial	0.5%	0.4%	0.0%	0.0%	0.0%	0.0%	0.9%
Other	3.6%	1.2%	0.0%	0.4%	0.0%	0.0%	5.1%
Total	54.0%	30.9%	2.8%	6.7%	0.5%	5.1%	100.0%

Note: This table includes only trades which are not centrally cleared. "Other" includes governments, central banks and counterparties with an unidentified sector.
Source: DTCC OTC interest rate swaps dataset (based on the 02/11/15 trade state report).

As we shall see below, activity in the CDS market is similarly concentrated, with 67% of trades taking place between G16 dealers and/or banks (see Table 10 in Section 3), but with a larger share between G16 dealers (i.e. 30% compared with 19% in the case of interest rate derivatives). The

larger presence of commercial banks and insurers in the interest rate derivative market reflects their demand for interest rate derivatives in order to manage interest rate risk on their balance sheets.

Chart 14
Share of total notional of centrally cleared contracts by type of market participant



Note: This chart includes only trades which are centrally cleared (in contrast with Table 5, which includes only trades which are not centrally cleared).
Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

We have not constructed a “who-to-whom” matrix for centrally cleared trades as this requires an ex-post matching of counterparties that report a trade with a CCP. This matching is non-trivial since the reporting does not keep track of the "initial" trading partners of a centrally cleared trade, and is therefore left for future work.

Chart 14 simply reports a breakdown of counterparties to centrally cleared transactions. Centrally cleared trades with a G16 dealer or bank as a counterparty account for approximately 95% of total centrally cleared notional.[11]

Visualisation of the outstanding bilateral IRS positions can shed further light on the network structure of this over-the-counter market. A complete analysis of the network properties over time and across different IRS is beyond the scope of this paper. Instead, to visualise the network, we focus on the subset of plain-vanilla 6M Euribor IRSs with a maturity of 10 years. We also collapse multiple trades between two counterparties into a single link. Hence, Chart 15 depicts a link between two counterparties if they are connected by at least one 10-year Euribor 6M swap contract. This procedure reduces the total number of links considerably, allowing us to draw a clearer picture of an important subset of the 6M Euribor IRS market. The size of each node in Chart 15 corresponds to a counterparty’s gross notional (with a lower bound on node size to ensure that small counterparties are visible). Similarly, the width of a link corresponds to the gross notional between two counterparties. As with the node size, we apply a lower bound to the width of each link to ensure visibility. The colour of each node indicates its sector classification.

Like Table 5, Chart 15 conveys the insight that G16 dealers are central: they are connected to a large number of counterparties, some of which are connected to only a single dealer. Moreover, G16 dealers tend to be connected to each other. Some banks also act as central dealers, with many connections to each other, G16 dealers, and “customers”. Interestingly, we observe several layers of intermediation. Frequently, peripheral nodes do not have direct access to the core of the network, but instead access it only indirectly via a peripheral intermediary that is connected to the core.

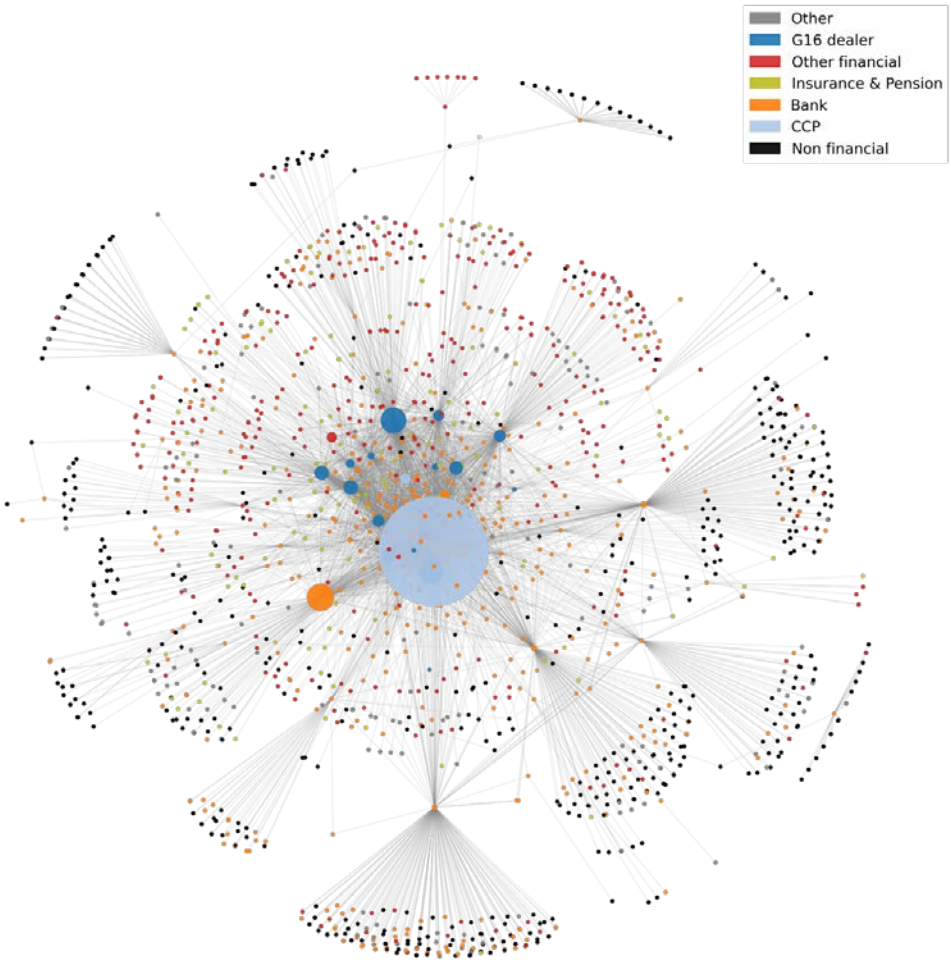
Furthermore, we see that the most important counterparty (in terms of notional) is a CCP. This reflects the fact that approximately one third of the IRS market is centrally cleared, with a single

[11] To compute these charts, we simply analyse the transactions with a CCP as a counterparty. Entities that report a CCP as a counterparty must be members of that CCP. Our analysis therefore does not tell us how many transactions from non-members are indirectly cleared via clearing members.

clearing house accounting for about nine out of ten of all centrally cleared trades. This CCP is connected to a relatively small number of counterparties.

Chart 15

Network of gross notional links between counterparties in a subset of the IRS market (based on Euribor 6M interest rate swaps with an original maturity of 10 years)



Note: Undirected unweighted network representation of 10-year plain-vanilla 6M Euribor IRS with a 10-year maturity. Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

Chart 15 focuses only on Euribor 6M IRSs with a maturity of 10 years. In order to garner a sense of how networks across different underlying benchmarks compare, we compute a similarity measure for the full networks of IRS contracts for Euribor 6M and Euribor 3M. Hence, we group all IRS contracts with the same underlying benchmark in one network regardless of the maturity of the contract.

We measure network similarity by the number of links that are present in both the 6M and 3M networks relative to the average number of links in both networks. We compute this measure for the subset of nodes that are present in both networks. We find that approximately 40% of links are present in both networks.[12] Similarly, we can compute the average node Jaccard index.[13] For a node that is present in two networks, the Jaccard index measures how many of the node's neighbours are present in both networks. We obtain a Jaccard index of approximately 49%, broadly consistent with our finding regarding network similarity.

It should be noted that these similarity measures do not pertain to the "global" structure of the network. Two networks with low similarity scores may still have similar structures, for example with a core-periphery structure and the same set of dealers in the core. In fact, we have verified that the core-periphery structure illustrated in Chart 15 is present across different interest rate swap underlyings and maturities. We leave a more detailed study of the dynamic and cross-sectional properties of the network structure of the IRS market for future work.

2.4 Interest rate risk across sectors

Surveys and aggregate market statistics usually refer to derivative exposures in terms of gross and net notional. However, these charts have no direct economic interpretation. Two swaps can have the same notional and yet have very different sensitivities to changes in interest rates, for example due to differences in maturities. In order to calculate a better measure of risk transfer, we compute interest rate sensitivities for each individual contract, and aggregate these at the sector level.

Expectations of future interest rates play a central role in the valuation of interest rate swaps. These expectations are captured by the forward curve of the underlying benchmark floating rate. The value of an interest rate swap is therefore a function of the relevant forward curve $F(t,\tau)$ with tenor τ and contract parameters $\{P\}$ (such as the maturity or the fixed rate). Here, we compute the value V of an IRS contract using a single-curve valuation model such that $V = V(\{P\}, F(t,\tau))$. We obtain the prevailing market forward curve, $F(t,\tau)$, for the 6M Euribor benchmark from Bloomberg.

In order to measure interest rate risk, we follow the standard textbook approach – described in Sundaresan (2009) – of "PV01", which denotes the "present value" of a 1 basis point (bp) increase in the forward curve.[14] The perturbation of a 1 basis point parallel upward shift is an arbitrary shock, intended to elicit contracts' sensitivity to an upward change in interest rates. As a first step, the remainder of this section focuses on this arbitrary one basis point parallel shift, but the framework that we develop is generalizable to any magnitude of parallel shift, or even non-parallel movements in interest rates.

We therefore compute the interest rate sensitivity of an IRS contract by perturbing the 6M Euribor forward curve by $\Delta F(\tau) = 1bp$, corresponding to a parallel upward shift in the forward curve. The

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12 Specifically, the measure is computed as follows. First, we determine which nodes (i.e. counterparties) are active in both the Euribor 6M and Euribor 3M markets. We restrict our computation to this subset of nodes. We then iterate over all edges (i.e. trades between two counterparties) in the network of Euribor 6M IRS and check whether the edge is also present in the network of Euribor 3M IRS. The similarity measure is then simply the fraction of edges that are present in both Euribor 3M and 6M relative to the average number of edges in the Euribor 3M and 6M networks.

13 The node Jaccard index is defined as follows. For a given node N that is present in network A and B the Jaccard index is the ratio of the cardinality of the intersection of the sets of neighbours that node N has in networks A and B relative to the cardinality of the union of the sets of neighbours that node N has in networks A and B.

14 The same measure is sometimes referred to as "DV01", which stands for "dollar value". We use the currency-neutral "PV".

perturbed forward curve is then given by $F(t,\tau) + \Delta F(\tau)$, and we compute the "shocked" value of an IRS contract as $\bar{V} = \bar{V}(\{P\}, F(t,\tau) + 1\text{bps})$.

We then define PV01 as the contract value when the forward curve is perturbed $\bar{V}$ minus the contract value when the forward curve is unperturbed V), i.e.

$PV01 = \bar{V}(\{P\}, F(t,\tau) + 1bps) - V\big(\{P\}, F(t,\tau)\big)$.

We compute this measure across all IRS held by the counterparties in a given sector. We also compute a measure of gross interest rate risk, which is the absolute value of PV01. Table 6 provides this breakdown of interest rate risk in the 6M Euribor swap market at the LEI sector level. G16 dealers are most active in the interest rate swaps market, with 204,517 open contracts, with a total gross notional of €15,919bn, referenced on 6M Euribor as of 02/11/15. However, their net exposure to interest rate risk due to these open contracts is small relative to that borne by other sectors. G16 dealers' net PV01 is negative €21m: smaller (in absolute terms) than the PV01s of any other sector. This reflects G16 dealers' primary role as intermediaries: most of their activity in the interest rate swaps market serves to match would-be buyers and sellers of interest rate risk. This match-making activity mostly balances out, such that G16 dealers' residual exposure to interest rate risk is relatively small.

Table 6
Value of interest rate swaps by sector

	No. of contracts	Gross notional (€ bn)	% pay-fixed	Net PV01 (€ m)	Gross PV01 (€ m)	Net/Gross PV01 (%)
G16 dealers	204,517	15,919	47.0	-21	11,528	-0.2
Banks	194,609	10,927	51.8	245	7,682	3.2
Insurers and pension funds	7,324	592	38.2	-344	860	-39.9
Other financials	39,749	2,631	51.9	-39	2,330	-1.7
Non-financials	7,209	188	83.2	73	141	51.7

Source: DTCC OTC interest rate swap dataset (based on the 02/11/15 trade state report plain-vanilla fixed-for-floating 6M Euribor IRSs).
Note: "Other" includes governments, central banks, CCPs and counterparties with an unidentified sector.

By contrast, insurers and pension funds (ICPFs) use interest rate swaps primarily to manage interest rate risk. With considerably fewer contracts than G16 dealers – 7,324, and a total gross notional of €592bn – ICPFs nevertheless bear much more interest rate risk. Their PV01 arising from 6M Euribor interest rate swaps is negative €344m as of 02/11/15: in other words, the mark-to-market value of their contracts would decrease by €344m following a one basis point parallel increase in the 6M Euribor forward curve. ICPFs' "short" position in the interest rate swap market mirrors their naturally "long" balance sheet exposure to interest rate risk: ICPFs are typically funded by liabilities with a longer duration than that of their assets, generating a duration mismatch. Their PV01 of negative €344m in 6M Euribor interest rate swaps therefore suggests that much of ICPFs' activity in this market is driven by a hedging motive.

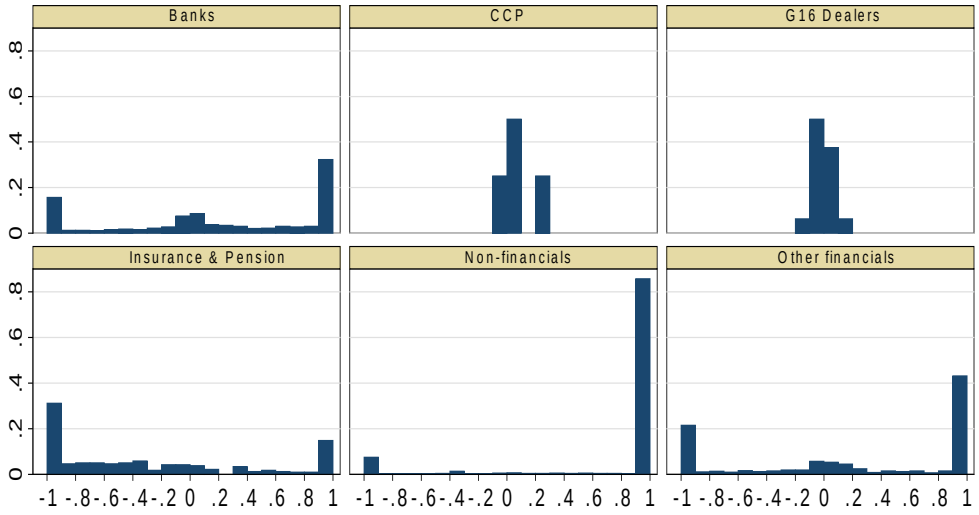
A similar argument with respect to hedging applies to non-dealer banks. In contrast to ICPFs, banks typically fund long-duration assets with short-duration liabilities. Their liabilities therefore reprice more quickly than their assets, generating a naturally "short" position in interest rate risk: their net worth falls when interest rates rise. This makes banks and insurers obvious counterparts in interest rate derivatives. Banks – excluding the G16 group of dealers, which comprise a separate category in Table 6 – have a positive net PV01 of €245m in 6M Euribor interest rate swaps as of

02/11/15 – almost the mirror image of ICPFs' net PV01 of negative €344m.[15] In this way, the derivatives market can in principle facilitate risk-sharing across the financial system.

Notwithstanding these sector-level insights, there is substantial within-sector heterogeneity in IRS activity in certain sectors. Chart 16 helps us to examine within-sector heterogeneity by plotting the distribution of the net/gross PV01 ratio by sector. As one might expect, G16 dealers exhibit relatively little heterogeneity in their net/gross PV01 ratios: the distribution is concentrated around 0%, underscoring the conclusion that G16 dealers play an intermediation role in the interest rate swaps market, and hold relatively little residual exposure to interest rate risk. In the ICPF sector, relatively few firms have near-zero net/gross PV01: most ICPF firms are on the left-hand-side of the distribution, reflecting their deeply negative net PV01 exposure. By contrast, the net/gross PV01 distribution within the banking sector exhibits wide dispersion: some banks have a near-zero net/gross PV01, pointing to an intermediation role, but others have a relatively high net/gross PV01 (with either a positive or negative sign), suggesting that interest rate swaps are used to take positions in interest rate risk for these banks. Likewise, the distribution of the net/gross PV01 statistic across other financial institutions points to substantial heterogeneity within that sector. Many other financial institutions place themselves fully on one side of the market with net/gross PV01 either negative or positive 1, while a minority have near-zero net/gross PV01 ratios.

Chart 16

Unweighted distribution of PV01 net/gross ratio (aggregated at LEI level)

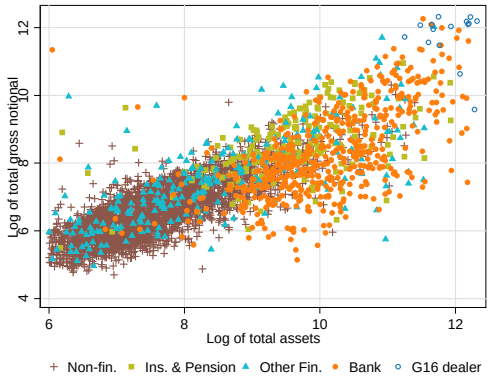


Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report plain-vanilla fixed-for-floating 6M Euribor IRSs).

[15] Despite taking similarly large net positions (in absolute terms), banks behave differently to ICPFs in the IRS market. Their net/gross PV01 of 3.2% is closer to that of G16 dealers (-0.2%) than ICPFs (-39.9%), suggesting that some banks play an intermediary "match-making" role in the IRS market.

Chart 17

Log gross notional in interest rate swaps versus log total assets at LEI-level



Source: DTCC OTC interest rate derivatives dataset (based on the 02/11/15 trade state report).

Chart 17 provides further information on entities' activity (at the individual LEI level) in the IRS market according to LEIs' sector classification. The scatterplot correlates entities' size – measured by their total assets – with their gross notional in 6M Euribor interest rate swaps as of 02/11/15. Entities are then classified as a G16 dealer, bank, other financial institution, ICPF or non-financial firm, as in Table 6. As one would expect, size is highly correlated with gross notional: bigger firms are more likely to be active users of interest rate swaps. However, this broad insight masks heterogeneity across sectors. Some other financial institutions, for example, are heavier users of interest rate swaps than their balance sheet size would suggest. These firms could be using interest rate swaps to take proprietary positions on the future path of interest rates as part of their overall investment strategy and business model. By contrast, some banks are lighter users of interest rate swaps than their balance sheet size would suggest. These banks could be retail banks that specialise in taking deposits and granting loans – but which lack the sophistication, inclination or incentives to hedge their natural interest rate risk in the swaps market.

Section 3
Credit default swaps

Credit default swaps represent a widely recognised source of systemic risk in OTC derivatives markets (Cont, 2010; Brunnermeier et al., 2013a). They have been closely associated with the opacity attributed to derivatives markets in the aftermath of the recent financial crisis.[16] The default of Lehman Brothers and the subsequent decision to stand behind AIG demonstrate the prevalence of this complexity and opacity: Lehman was a major CDS dealer, on which a substantial amount of protection had been sold, among others by AIG. At that time, consequential policy decisions were taken – despite authorities' limited knowledge regarding the structure of counterparty credit exposures and CDS protection sold.

An important feature of the microstructure of the CDS market is that it is highly concentrated on a small number of counterparties (Brunnermeier et al, 2013b; Peltonen et al, 2014; Kenny et al, 2016). In addition to this highly concentrated structure, single-name CDS contracts are written on counterparties such as dealers. Accordingly, the failure of a major dealer could trigger systemic financial distress on two levels: first, its counterparties would incur direct losses; second, CDSs written on the dealer would be triggered, leading to severe losses for the protection sellers (Duffie, 2010).

Credit default swaps transfer both underlying (fundamental) credit risk and expose participants to counterparty risk (Duffie and Huang, 1996; Arora et al, 2012). In contrast with extensive central clearing in the markets for IRS and index CDS, most single-name CDSs are not centrally cleared. Moreover, despite improvements in CDSs' standardisation and the widespread use of risk-mitigation techniques such as compression, outstanding notional amounts from bilateral exposures are still large. Therefore, CDSs represent an important source of counterparty risk. Regarding underlying credit risk, CDSs feature a jump to default (binary) property, which is peculiar to this type of contract: a credit event implies a sudden and significant payment due from the protection seller.

The remainder of this section focuses on single-name CDSs reported under EMIR to DTCC, which is the largest trade repository by market share. As in Section 2, we analyse DTCC's trade-state report on all outstanding contracts on 02/11/15.

3.1 Processing the data

This subsection summarises the "processing" procedure that takes us from the raw dataset to one that is suitable for economically meaningful descriptive statistics. The processing procedure serves two major purposes. First, it allows us to identify and eliminate inconsistent or erroneous observations. Second, we focus on single-name CDS, for two main reasons. First, as noted by Augustin et al (2014), most studies on the CDS market focus on the single-name segment. Focusing on this market segment thus ensures comparability with existing studies. Second, the current regulatory technical standards (RTS) mandated by ESMA require the underlying of a

[16] See for instance Barth, Carpio and Levine (2012) and the speech by then **SEC Chairman Christopher Cox** shortly after the default of Lehman Brothers. Also, Haldane (2009) highlights how uncertainty about Lehman's exposures, together with uncertainties about the consequences of its defaults, exacerbated panic at the onset of the crisis.

derivative to be identified via an International Securities Identification Number (ISIN), which is not possible for CDSs with indices and baskets as underlying.[17]

The stock of all outstanding transactions in DTCC's raw trade state report dated 02/11/15 amounts to 1,624,235. Before starting the processing procedure, we convert all notional positions to EUR using the exchange rates prevailing at market close on 02/11/15. This allows us to gauge the economic magnitudes of dropped observations, and to consistently aggregate transactions once the dataset is processed.

The processing procedure is summarised in Table 7. The first column indicates the type of procedure conducted at each step. The second column reports the number of observations that is dropped; the third and fourth columns report, respectively, the gross notional (in euros) and the share of that gross notional in the total (at the time the observations are dropped). Categories above the middle horizontal line refer to systematic issues that need to be dealt with before analysing the data. The items below the line relate to observations which we eliminate for the purposes of our analysis, but which may be used in other types of analyses.

Table 7
Statistics of the processing procedure for CDS

	# Obs.	Notional (€bn)	Notional (%)*
Initial values	**1,624,235**	**18,478***	**-**
Observation dropping			
Implausible values	1,122	538	2.91
Incorrect ISIN	92,046	617	3.44
Implausible notional	14,602	12	0.07
Missing mark-to-market value	305,235	4,409	25.47
Duplicates (trade IDs)			
Inconsistent:			
notional	1,764	34	0.26
counterparty ID	2,064	28	0.22
maturity date	316	5	0.04
intragroup flag	62	1	0.01
counterparty side	2,682	27	0.21
reference entity	7,520	52	0.40
De-duplication	145,083	1,294	10.15
Non LEI counterparties	34,175	300	2.61
Intragroup	187,985	2,869	25.70
Missing reference entity	93,784	954	11.51
Non-ISIN, non-index reference entity	18,356	184	2.51
Index & basket CDS	96,711	3,463	48.41
Total return swaps	3,213	30	0.83
Final values	**617,377**	**3,660**	**-**

Source: DTCC OTC credit derivatives dataset (based on the 02/11/15 trade state report).
Note: The notional amount (in €bn and as a % of the total) for each row is calculated when the respective observations are dropped from the dataset

[17] These contracts are simply identified with a "B" (basket) or an "I" (index). In our view, future technical standards should address this omission such that authorities are able to analyse the characteristics of basket and index CDS contracts, which represent a large and growing share of the CDS market.

The processing procedure starts by eliminating transactions deemed problematic due to unreliable reporting in terms of implausible notional (greater than €10bn and lower than €1,000 including negative and zero); transactions with unidentifiable reference entities; and transactions for which the mark-to-market value of the contract is missing. The next step drops observations identified as duplicates based on the trade ID of the transactions. We first drop transactions which appear three times. We identify a substantial number of duplicate observations in terms of trade IDs, given that many transactions involve two EU counterparties, both of which are subject to a reporting requirement under EMIR. Some of these observations present inconsistencies in terms of the notional reported; the IDs of the counterparties; the counterparty side (i.e. both reporting "Buy" or "Sell" side); the maturity date; the underlying reference entity; and the intragroup nature of the trade. We drop these inconsistent observations, which account for a relatively minor share of the total notional. From the remaining duplicate observations, we eliminate one to avoid double counting. Finally, we drop all transactions involving counterparties that are not identified by an LEI.

Using the intragroup flag in the DTCC dataset and information from Orbis on entities' global ultimate owner (GUO), we eliminate intragroup transactions. Around 12% of the remaining reports do not contain any information on the underlying reference entity. We discard these observations, together with those where the reference entity appears misreported.

Among the remaining contracts, the single-name CDS market accounts for 87% in terms of transactions, but only around 52% in terms of notional. In contrast, contracts on indices and baskets represent 13% of transactions, and over 48% when weighted by notional. The larger notional for index products is in line with information from surveys.[18] After dropping index and basket CDS, plus a minor share of total return swaps,[19] we are left with 617,377 observations representing a total notional of approximately €3.7tn. The remainder of this section focuses on this subset of the data.

3.2 Summary statistics of processed credit default swap data

This section presents summary statistics of the single-name CDS market. These provide a "sanity check" as to whether the main features of the data are consistent with survey-based knowledge of the CDS market. In addition, the results deliver novel insights into the structure of the market thanks to the granularity of the EMIR dataset, paving the way for future research.

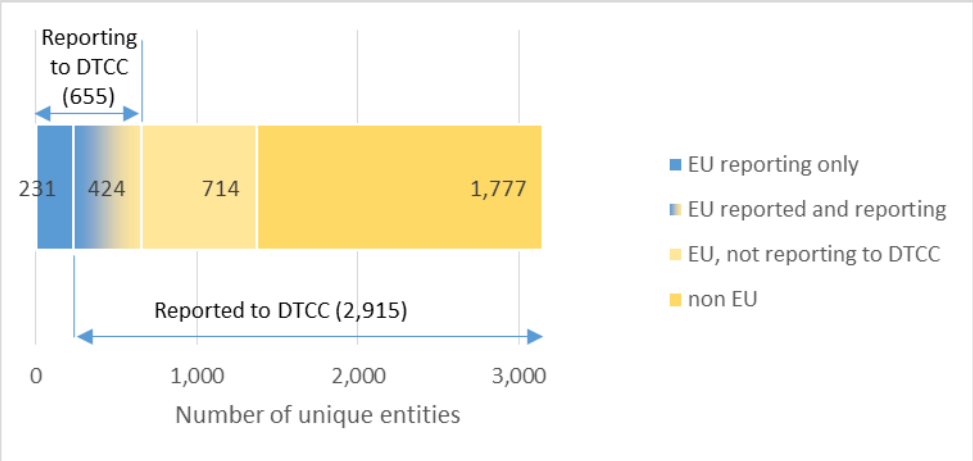
As noted in the first section of the paper, under EMIR all EU counterparties engaging in derivatives trades are required to report them to trade repositories. However, the other side of CDS contracts is frequently taken by non-EU entities, which are therefore also present in our dataset. Chart 18 depicts this graphically. We observe 655 unique reporting (EU-resident) entities. These EU counterparties report trades with a total of 2,915 counterparties, 424 of which are within the set of reporting entities (i.e. they are also EU entities). Under EMIR, contracts between two non-EU institutions are not subject to a reporting obligation, even if the underlying reference entity is an EU institution or sovereign.

[18] See for instance the **BIS OTC CDS data for single-name instruments**.

[19] These represent credit derivatives that are not default swaps.

Chart 18

Geographical structure of the reporting scheme under EMIR (CDS)

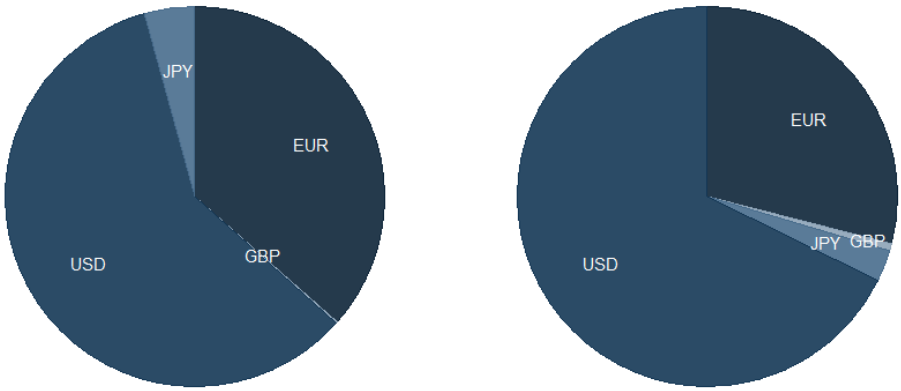


Source: DTCC OTC credit derivatives processed single-name dataset (based on the 02/11/15 trade state report).

Chart 19 depicts the share of outstanding contracts and the share of notional by currency. The overwhelming majority of contracts are denominated in USD or EUR. The predominance of USD-denominated CDSs is even more apparent when considering gross notional instead of the number of transactions. CDSs denominated in JPY or GBP are also present, but in much less significant quantities.

Chart 19

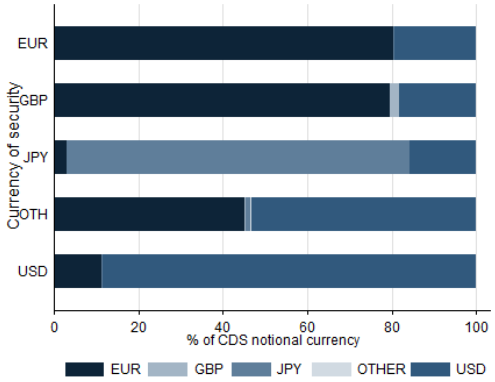
Share of outstanding contracts (left) and associated gross notional (right) by currency



Source: DTCC OTC credit derivatives processed single-name dataset (based on the processed 02/11/15 trade state report).

Chart 20

Notional currency of CDS contracts by currency of the underlying security



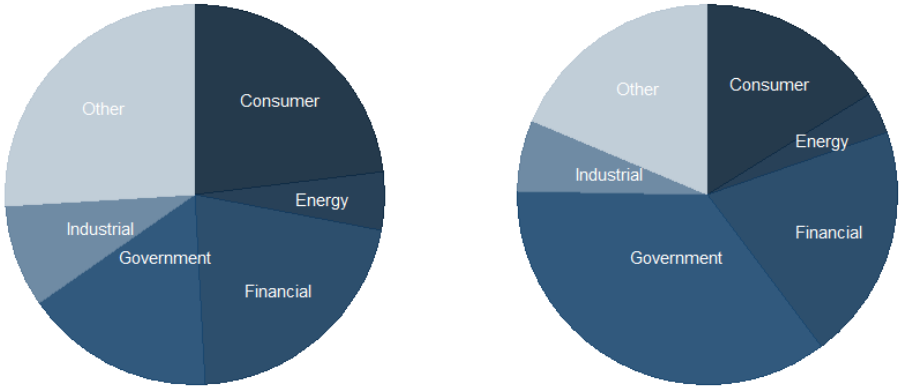
Note: "USD" stands for US dollars, "JPY" for Japanese yen, "EUR" for euro, and "GBP" for British pound.
Source: DTCC OTC processed single-name credit derivatives dataset (based on the processed 02/11/15 trade state report).

Chart 20 provides a breakdown of the currency of CDS contracts (x-axis), vis-à-vis the currency of the underlying security (y-axis).[20] The currency of the contract does not always coincide with the currency of the underlying security. For instance, the second row of Chart 20 indicates that, among all underlying securities denominated in GBP, 80% of the associated CDS contracts are denominated in EUR. For securities denominated in "other" currencies, the associated CDS contracts are mostly denominated in either USD or EUR. For securities denominated in JPY, EUR, and USD, however, the vast majority of the associated CDS contracts are denominated in the same currency.

The underlying reference securities can be grouped according to different criteria. In Chart 21, we depict breakdowns obtained by matching the reported ISIN with the sector classification provided by Bloomberg. While Bloomberg provides 12 different sectors, we keep only the five most significant ones, and aggregate the rest under "Other".[21]

Chart 21

Share of outstanding contracts (left) and share of outstanding notional (right) by type of underlying reference entity



Note: (left) the share of contracts and (right) the share of notional by sector of reference entity (using Bloomberg's sector classification of ISINs: **http://www.bloombergindexes.com/content/uploads/sites/3/2013/05/Index-Family-Methodology.pdf**, p.10). Source: DTCC OTC credit derivatives processed single-name dataset (based on the processed 02/11/15 trade state report).

[20] The currency of the underlying instrument has been retrieved from Bloomberg using the ISIN identifier. The distribution of currencies for the underlying instruments is as follows: 57% in USD, 30% in EUR, 6% in GBP, 5% in JPY, and the residual in "other".

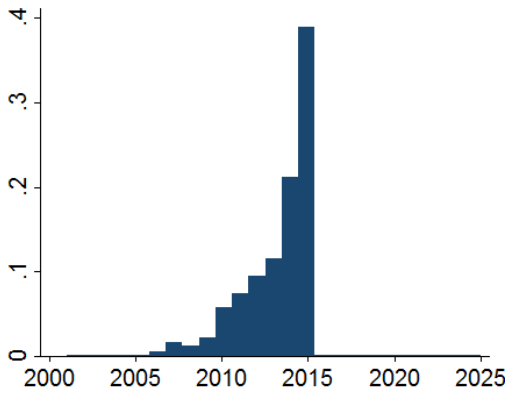
[21] This includes the following sectors: Asset Backed Securities, Basic Materials, Communications, Mortgage Securities, Technology, Utilities and a residual of Unidentified.

As can be seen, CDSs referenced on government debt or financial institutions account for the largest share of outstanding contracts and notional. The concentration in these two categories of reference entity reflects the fact that government debt and bank bonds represent the largest and most liquid segments of the fixed-income market.

Chart 22 shows the distribution of effective dates across transactions. Relative to the IRS counterpart in Chart 8, we see greater concentration around 2014 and 2015. To a large extent this reflects the shorter average maturity of CDS contracts relative to IRS. Additionally, the use of compression in recent years amplifies the concentration of effective dates: by collapsing multiple outstanding contracts into a single (new) contract, the resulting new contracts exhibit more recent effective dates.

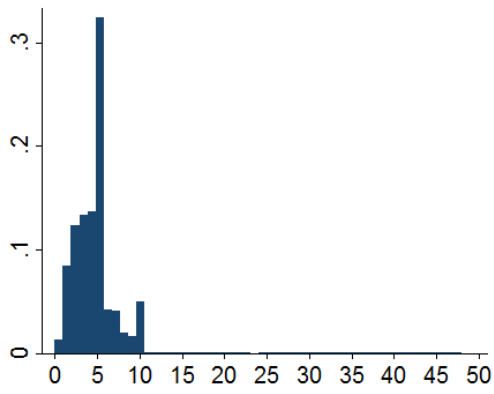
Chart 23 shows the unweighted frequency distribution of original maturities across all trades. The distribution is right-skewed – much more so than the IRS counterpart shown in Chart 9. Almost 35% of CDS contracts are written with a five-year maturity, thanks to the standardisation of CDS contracts that took place after the so-called "big bang"[22]. There is also a significant share of contracts with maturities of less than five years, and we also see bunching at the 10-year mark. More than 99% of the contracts have a maturity less than or equal to 10 years.

Chart 22
Frequency distribution of effective dates across trades



Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

Chart 23
Frequency distribution of original maturities across trades

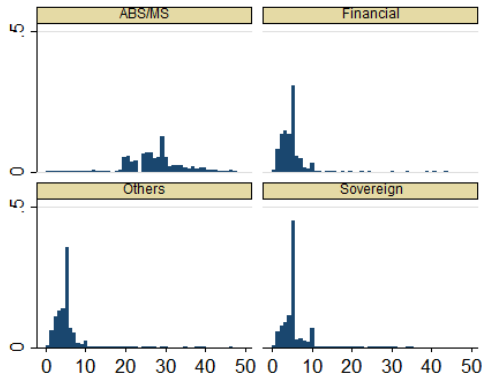


Source: DTCC OTC credit derivatives dataset (based on the 02/11/15 trade state report).

[22] In April 2009 the International Swaps and Derivatives Association (ISDA) introduced a number of documentation changes in its **Credit Derivatives Determinations Committees and Auction Settlement CDS Protocol** (the so-called "Big Bang" Protocol). The main purpose of the changes was to increase standardisation of the market, in particular the single-name portion, and in particular in relation to streamlining CDS settlements.

Chart 24

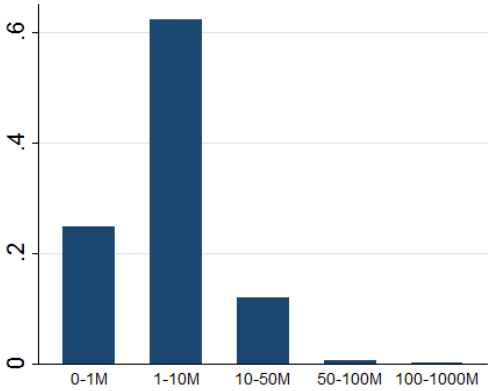
Breakdown of maturity distribution by sector



Note: "ABS/MB" denotes Asset Backed Securities and Mortgage Securities; "others" includes Energy, Industrial, Consumer, Technology, Utilities, Basic Materials, Communications and other unidentified sectors, according to **Bloomberg's classification of ISINs**, p.10.
Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

Chart 25

Distribution of notional across trades



Source: DTCC OTC credit default swap single-name dataset (based on the processed 02/11/15 trade state report).

Chart 24 presents a breakdown of maturity by sector of the reference entity. Asset-backed and mortgage-backed securities represent the class of underlyings for which the distribution of maturities is concentrated in maturities in excess of 10 years.[23] For CDSs written on governments, almost half of all transactions are accounted for by the five-year maturity bucket. For the other sectors, the distribution of maturities closely resembles the aggregate picture shown in Chart 23.

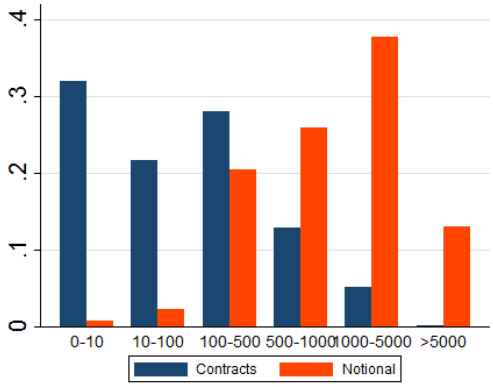
In Chart 25, we plot the frequency distribution of gross notional amounts across transactions (with uneven bin sizes for the sake of presentational clarity and ease of comparison with the IRS data). The majority of trades (60%) in the processed single-name CDS data have a gross notional of €1-10m. Relative to the IRS dataset, we see a substantial share accounted for by small trades, with more than 25% of the trades involving a gross notional of less than €1m. At the other extreme, the share of contracts with a large notional is very small.

We now proceed to analyse distributions related to the underlying reference entities. In this way we can confirm that the market is highly concentrated. There are a small number of reference entities on which a substantial amount of CDS contracts are written; at the same time, these contracts account for a large share of the total gross notional traded in the market.

[23] Comparing Chart 23 with Chart 24, it is evident that the ABS/MS market plays a relatively minor role. In terms of notional these markets account for only around €35bn of gross notional (corresponding to 0.8% of the total).

Chart 26

Distribution of contracts and associated notional across underlying references



Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

In Chart 26, we categorise underlying reference entities by the number of CDS contracts written on them. In addition, for each bin, we compute the aggregate notional of the contracts related to the underlying references in the bin. For instance, the first bin labelled "0-10" groups all reference entities on which fewer than 10 contracts are written. This bin shows that reference entities on which very few contracts are written account for a substantial number of CDS contracts (about 30%) but a minor share of gross notional. This reveals a high concentration of gross notional in a few underlying reference entities: those on which more than 1,000 contracts are written account for less than 10% of the transactions but almost 60% of the total gross notional.

Table 8

Summary of net and gross positions in CDSs by sector

	No of contracts	Gross notional (EUR bn)	Net notional (EUR bn)	Net/Gross (%)
G16 dealers	1,014,550	5890	-69.9	-1.2
Banks	96,256	676	5.5	0.8
Other financials	63,810	264	53.0	20.1
Non-financials	36,095	264	5.6	2.1
Insurance and pension funds	3,593	35	0.9	2.5

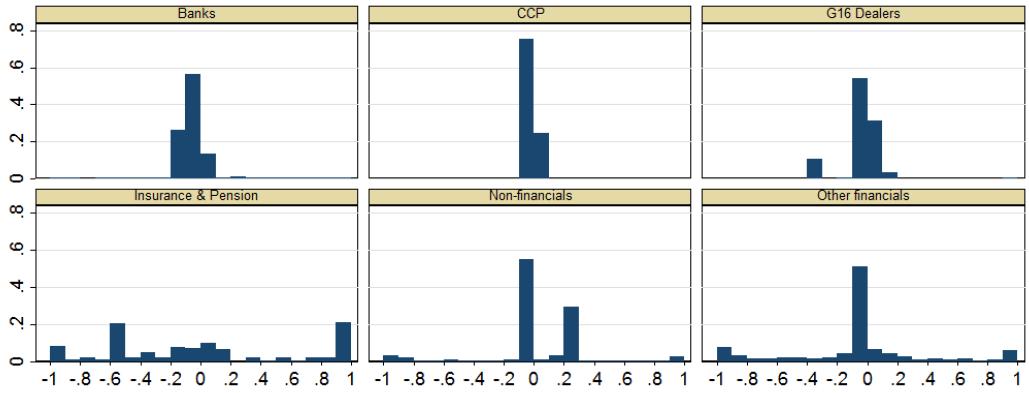
Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).
Note: A negative (positive) net position indicates net selling (buying) of protection.

Table 8 presents the number of contracts, gross notional and net notional positions, and the ratio of the latter two, by sector of the market participant. A negative (positive) net position indicates net selling (buying) of protection. We find that G16 dealers are net sellers of protection, although the net position is relatively small compared to the gross notional traded by this group. This low net/gross ratio reflects the intermediation role played by this sector. Banks, while also having a small net/gross ratio, are net buyers of protection. Other financial institutions (typically hedge funds and mutual funds) represent a substantial amount of protection bought, and at the same time feature the highest net/gross ratio (excluding the marginal "Other" category). Non-financial corporations are also net buyers of protection, though with a comparatively smaller net/gross ratio. Insurance and pension funds, on the other hand, have a relatively small net buying position.

Chart 27 presents an unweighted distribution of net/gross ratios by type of market participant, providing a more detailed view of the last column of Table 8. Banks and G16 dealers essentially operate with matched books with respect to fundamental credit risk, whereas other sectors – in particular insurers and pension funds – exhibit more heterogeneity.

Chart 27

Unweighted distribution of net/gross ratio



Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

Table 9

Positions of banks and dealers on euro area sovereign reference entities, by country of counterparty

(€ bn)

	Based on LEI			Based on GUO-LEI		
	Buy	Sell	Net	Buy	Sell	Net
Domestic	5.6	1.4	4.2	6.7	2.7	4.0
EA exc. domestic	108.0	115.0	-7.0	109.0	117.0	-8.0
Other EU	225.0	222.0	3.0	59.2	59.3	-0.1
US	83.0	95.3	-12.3	235.0	245.0	-10.0
CH	7.5	8.1	-0.7	30.6	30.4	0.2
JP	0.0	0.0	0.0	22.3	24.4	-2.1
Other	1.3	1.7	-0.4	1.4	1.5	-0.1

Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report). "Domestic" groups positions by counterparties with the same nationality as that of the reference entity (i.e. a bank in country X buying/selling protection on country X), "EA exc. domestic" groups positions by euro area counterparties with a nationality different from that of the reference entity (i.e. a bank in country X in the euro area buying/selling protection on country Y".

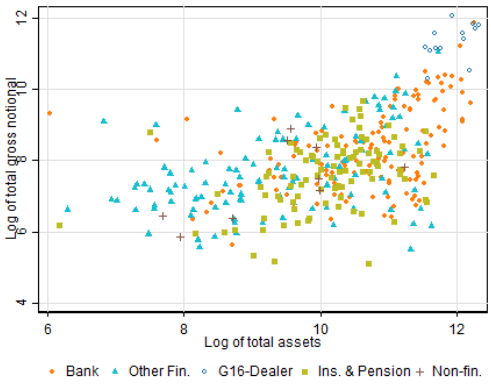
Table 9 looks at the geographical dimension of protection buying/selling by banks and G16 dealers in the CDS market for euro area (EA) sovereign reference entities. Regarding the grouping of countries, "domestic" collects all positions in which the country of the counterparty is the same as that of the reference entity (i.e. a bank in country X buying/selling protection on country X), whereas "EA exc. domestic" groups all positions taken by euro area counterparties in which the country of the counterparty differs from that of the reference entity (i.e. a bank in country X buying/selling protection on country Y). The distinction is made between positions aggregated at the LEI level as reported in the EMIR DTCC data, and positions aggregated at the level of the Global Ultimate Ownership (GUO) LEI hierarchy.

It is first worth noting that these results suggest, at least at this level of aggregation, little wrong-way risk between banks and G16 dealers and their respective sovereigns, in particular at the LEI level. On the other hand, the buying/selling positions of EA banks and dealers on EA reference entities other than that of the same country tend to be considerably larger. Other EU banks and dealers also engage in substantial buying/selling of protection on EA reference entities, with a significant net selling position.

When moving from the LEI aggregation to the GUO-LEI aggregation of counterparties, the decline in the net buying position (as well as gross buying and selling) of the "Other EU" counterparties is notable, as is the increase of both the US and Switzerland (in gross positions mostly) and Japan (in both net and gross positions). One explanation for these changes is that counterparties located in the latter countries use "Other EU" (typically UK) companies (that they ultimately own) in order to trade in the European sovereign CDS market. In sum – regardless of the aggregation in terms of

LEI/GUO-LEI and regardless of the scarcity of wrong-way risk – banks and dealers are net sellers of protection on EA sovereign reference entities.

Chart 28
Total assets versus notional, by sector of LEI



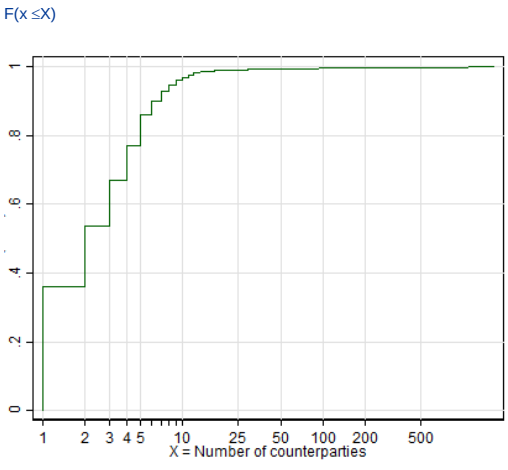
Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

Chart 28 shows a scatter plot comparing total assets and gross notional outstanding, by type of market participant (in logarithms for ease of comparison). As one would expect, the relationship between total assets and notional is positive: larger counterparties trade larger notional amounts. This holds irrespective of the type of market participant. Consistent with previous findings on global CDS data (Peltonen et al, 2014; D'Errico et al, 2016), non-financial corporations represent a limited fraction of CDS market participants, and do not have very high notional. Other financial institutions, conversely, represent a large segment; some individual other financial institutions have very large CDS positions.

3.3 Network properties of outstanding credit default swap contracts

Like interest rate swaps, credit default swaps are traded over-the-counter. Interesting insights can therefore be obtained by analysing the market from a network perspective.

Chart 29
Degree distribution of the CDS network



Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

Chart 29 presents the degree distribution of the CDS network. It summarizes the number of counterparties with which each market participant interacts. We see that the market has a sparse structure: 40% of counterparties interact with only one other counterparty. Furthermore, around 80% of market participants feature five or fewer connections. On the other hand, a high number of connections are concentrated in only a few market participants, typically the dealers.

Table 10 presents the matrix of bilateral CDS exposures expressed as shares of total notional by type of counterparty, aggregated across all reference entities in the sample.[24] Entries in the matrix indicate the share of total notional that the row-sector buys (in protection) from the column-sector (which is the seller of protection).

[24] A qualitatively similar matrix emerges if we compute the number of transactions instead of the notional.

As expected, almost 30% of all notional in the market is accounted for by trades between dealers. An additional 36% of notional is accounted for by transactions between banks and dealers on either the buy or sell side. Once more, the table shows that the CDS market is highly concentrated, with much of the activity taking place in a specific segment. These findings are also in line with previous work on CDS market microstructure (Peltonen et al, 2014; Cont and Minca, 2014).

Table 10

Matrix of share of interactions between market participants, weighted by notional

Buy \ Sell	G16 Dealers	Banks	Other financials	ICPFs	Non-financial	Other	Total
G16 Dealers	29.5%	17.4%	7.1%	0.3%	4.2%	2.4%	60.9%
Banks	18.5%	1.9%	0.9%	0.0%	0.1%	0.0%	21.3%
Other financials	8.2%	1.1%	0.4%	0.0%	0.1%	0.1%	10.0%
ICPFs	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.5%
Non-financial	4.4%	0.1%	0.2%	0.0%	0.0%	0.0%	4.6%
Other	2.5%	0.0%	0.1%	0.0%	0.0%	0.0%	2.7%
Total	63.5%	20.6%	8.6%	0.4%	4.4%	2.5%	100.0%

Note: "Other" includes Government, Central Bank, CCPs and empty or unidentified sectors. The red squares refer to the intensity of the respective sector-to-sector relationship.
Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

Similar to the IRS dataset, we represent the CDS market graphically as a network in Chart 30. To do this, we select the network of exposures stemming from CDS contracts written on the 10th most traded reference entity (in terms of notional), which is a non-financial corporation belonging to the "Consumer" sector. As Chart 30 shows, the core of the network is composed of the G16 dealers and a few banks which trade with peripheral institutions and each other. Peripheral institutions are heterogeneous in type and mainly trade with a small subset of core institutions. This concentration of activity driven by few market participants is a feature consistent across other most actively traded reference entities. Furthermore, this result is also in line with the results of D'Errico et al. (2016), who study the global CDS network and show that the network structure across reference entities is relatively similar.

As in Section 2, we construct the network by adding a link between two nodes (reporting LEIs) if there exists at least one CDS contract between them. We show the resulting network in Chart 30. The size of a given node indicates the total notional of CDS contracts with this node as a counterparty; for small notional values, we impose a minimum node size to ensure that nodes are visible. The colour of the node indicates its sector. The structure of the network is markedly different from the IRS counterpart shown in Chart 15. In particular, the intermediation role of the G16 dealers is much more pronounced. In addition, we observe three large banks and two "other financials" in intermediation roles for the reference entity considered. The periphery of the network is mostly composed of other financial institutions. While the role of banks and other financial institutions as connectors may depend on the particular reference entity considered, the role of major dealers as connectors in the market is a consistent finding across reference entities.

Chart 30

Network of gross notional links between counterparties in a subset of the CDS market (based on a representative reference entity)

Note: Undirected unweighted network representation of gross CDS contracts for an arbitrarily chosen underlying reference.
Source: DTCC OTC credit derivatives single-name dataset (based on the processed 02/11/15 trade state report).

Section 4
Foreign exchange forwards

Foreign exchange (FX) derivatives constitute the second-largest segment, in notional terms, of the OTC derivatives market, after interest rate derivatives. FX derivative contracts entail an obligation between two counterparties to exchange future cash flows in different currencies. They are an interesting object of study for three reasons. First, FX derivatives are not centrally cleared; to date, the market has escaped the central clearing requirements that have been applied or are in the process of being applied to most interest rate and credit derivatives, both in Europe and the US (Duffie, 2011). As such, the FX derivatives market has a markedly different network structure and susceptibility to contagion of counterparty credit risk. Second, as we shall see, FX derivatives typically have relatively short maturities; as such, daily transaction volumes outnumber those of interest rate derivatives, despite the latter having a much larger outstanding notional. Third, the number of counterparties that actively trade FX derivatives is much larger than that of interest rate and credit derivatives, the trading of which is dominated by banks and other financial institutions. Many FX derivatives are traded between banks and non-financial counterparties, as they allow NFCs to hedge expected future cash flows in different currencies. As such, the FX derivatives market provides for a closer link between the financial system and the real economy. Moreover, the relatively important role of NFCs in the market means that the average level of counterparties' financial sophistication is lower than in the interest rate and credit derivatives markets.

To aid comparison, our analysis of FX derivatives parallels that of interest rate and credit derivatives. We start by describing the cleaning procedure, by which we discard erroneous observations and focus the dataset on a single underlying (in this case EUR/USD). We then proceed to show summary statistics of that particular subset of the FX derivatives market. As in previous sections, we base our analysis on the DTCC trade state report from 02/11/2015.

4.1 Processing the data

More than 85% of FX derivatives are forward contracts. In the trade repositories' data these contracts are of two types: outright forwards and forward legs of FX swaps. An outright forward entails a contractual agreement to exchange two currencies at a pre-agreed future date and exchange rate. An FX swap entails an initial exchange of two currencies (typically on a spot date or before), together with a commitment to a reverse exchange at a pre-agreed future date and rate (forward leg). Although outright forwards and FX swaps entail different market risks, there is unfortunately no information in the EMIR data that allows us to distinguish these two types.

In the subsequent analysis, we focus our attention on these two types of FX forward contracts. Furthermore, we focus on a specific type of contract: EUR/USD forwards. In this subsection, we provide an overview of the data processing procedure that allows us to transition from the raw dataset, which includes over six million outstanding contracts (similar to the total number of interest rate derivatives), to the subset of FX forwards on the EUR/USD cross.

The data processing procedure is described in Table 11. As in previous tables, the first column describes the various steps followed, while column 2 reports the number of observations that are discarded at each step. Column 3 reports the associated gross notional amount that is dropped at each step, and column 4 the share of that step in the total gross notional.

Table 11

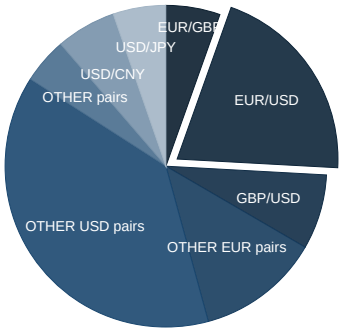
Statistics of the processing procedure for FXDs

	# Obs.	Notional (€bn)	Notional (%)*
Initial values	**6,609,385**	**68,800**	**-**
Observation dropping			
Implausible values	2,875	-	
Negative/zero notional	145,040	-	
No counterparty side	53,910	358	0.52
Implausible execution date	99,854	1,130	1.65
Missing tenor	38,619	395	0.54
Missing mark-to-market value	1,278,525	16,500	24.65
Irretrievable currency pair	184,924	978	1.94
Irretrievable contractual exchange rate	78,629	747	1.51
Duplicates (trade IDs)			
Inconsistent:			
notional	161,672	1,240	2.55
counterparty ID	15,518	219	0.46
maturity date	9,214	51	0.11
intragroup flag	5,408	15	0.03
De-duplication	611,749	4,621	9.79
Non LEI counterparties	512,714	1,890	4.44
Non Forward	477,583	10,800	26.54
Non "EUR/USD"	2,333,006	22,000	73.61
Intragroup	119,249	1,060	13.44
Final values	**480,796**	**6,829**	**-**

Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report).
Note: The notional amount (in €bn and as a % of the total) for each row are calculated when the respective observations are dropped from the dataset. All notional amounts are reported in euro after conversion using exchange rates on 02/11/15.

As in previous tables, we start by dropping observations with extreme values for the notional amount (i.e. greater than €10bn and lower than €1,000). Next, we discard contracts where the field “counterparty side” is missing. After this, we apply consistency checks associated with the double reporting obligation. We discard triplicates as well as observations where the matching of two reports pertaining to the same transaction (based on the unique trade identifier) reveals inconsistencies between those two reports. Finally, we drop one observation per pair of matched transactions, and also delete transactions where at least one of the counterparty identifiers is not an LEI. Table 11 lists the number of observations that are dropped at each step.

Chart 31
Breakdown of underlying benchmark



Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report).

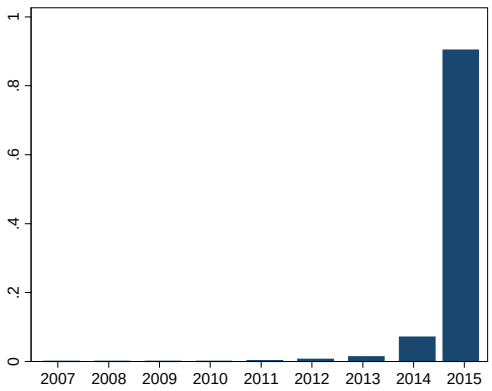
Next, we restrict the dataset to FX forwards. To this end, we drop FX swaps (which are mostly retail products) and options. We also focus the analysis only on EUR/USD forwards, which is the most frequently traded cross, as Chart 31 shows. This removes nearly three million transactions from the dataset. The final dataset consists of 480,796 EUR/USD forward transactions.

4.2 Summary statistics of processed foreign exchange forward data

This subsection presents summary statistics for the subset of 480,796 observations that are identified as EUR/USD forwards.

About 90% of the 480,796 outstanding EUR/USD forwards on 02/11/15 were executed in 2015 (Chart 32). FX forwards have a much shorter average original maturity than interest rate derivatives, which average about 10 years, and credit derivatives, which average five years on execution. Looking at the distribution of maturities (Chart 33), we see that it is positively skewed, with the vast majority of forwards having an original maturity of less than one year. We also see some degree of bunching – at the one, two, three, six and twelve month points – indicating some degree of standardisation in the market. However, in terms of maturities, the market is considerably less standardised than that of credit derivatives.

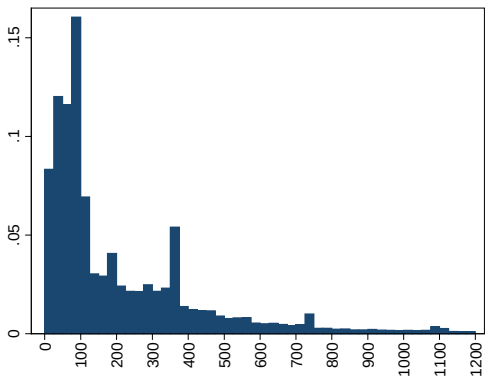
Chart 32
Frequency distribution of execution date across trades



Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report).

Chart 33
Frequency distribution of original maturity across trades

(in days)



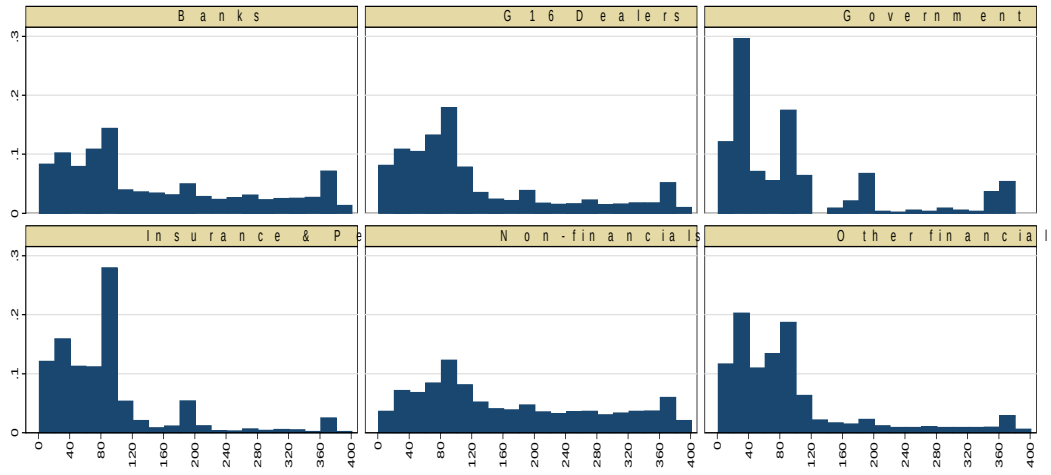
Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report).

Zooming in, we see that the distribution of original maturities varies by sector (Chart 34). Notably, non-financial firms have a more uniform distribution, suggesting that they prefer to hedge at somewhat longer maturities than the market average. Insurance and pension funds, by contrast, exhibit a clear preference for 90-day trades.

Chart 34

Frequency distribution of original maturity across counterparty type

(in days)



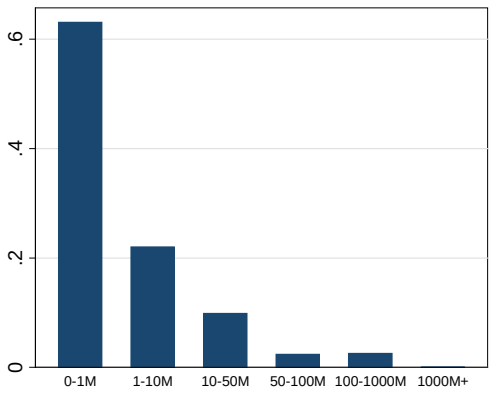
Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report). Truncated at 400 days.

Another sense in which foreign exchange derivatives differ from interest rate derivatives is in their average gross notional. Chart 35 shows that about 85% of FX forwards have a gross notional of less than €10m – similar, in fact, to credit derivatives. By contrast, recall that the modal notional category for interest rate derivatives is €10-50m.

Charts 36 plots the ratio of the contractual exchange rate to the Bloomberg benchmark rate prevailing on the execution date. There is considerable dispersion around the average, reflecting intraday volatility in exchange rates as well as price discrimination across different clients. Indeed, the significant presence of relatively less sophisticated non-financial firms in the FX derivatives market, combined with the over-the-counter structure of that market, enhances the scope for price discrimination.

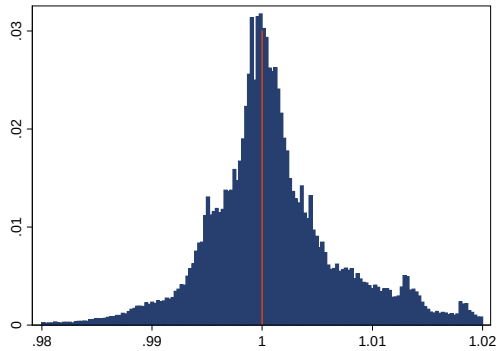
Chart 35
Frequency distribution of gross notional across trades

(in euros)



Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report). Horizontal axis is given in millions of euros.

Chart 36
Distribution of contractual rate over Bloomberg benchmark rate



Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report). For visual clarity the histogram is truncated at 0.98 and 1.02.

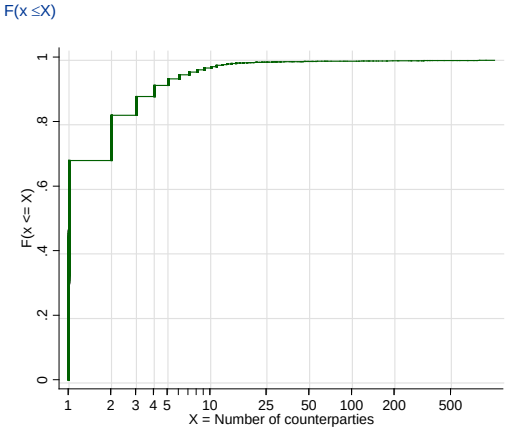
4.3 Network properties of outstanding foreign exchange forward contracts

Chart 37 presents the degree distribution off the EUR/USD forwards network. The network is more sparse than the CDS network, but similar to that of the IRD network: 90% of market participants have five or fewer unique counterparties. As with IRD, there is also a long tail of market participants with many unique counterparties, but in the case of FXD this tail is thinner.

Table 11 sheds further light on “who trades with whom” based on Orbis’s sector classifications. The role of dealers in the FX forwards market is smaller as a proportion of the overall market than it is for IRDs and, especially, CDSs. On the other hand, other financial and non-financial firms are relatively more important. Moreover, when we count trades (rather than weight them by notional), the relative significance of non-financial firms is even more apparent: as of 02/11/15, they have 132,556 outstanding EUR/USD forward contracts, compared with 258,053 for the G16 dealers, 268,602 for banks, and 160,048 for other financial firms. Insurance and pension funds are relatively less important in the FX derivatives market: they had just 4,841 outstanding EUR/USD trades on 02/11/15, compared with 7,324 interest rate derivative transactions.

Chart 37

Degree distribution of the FX network



Note: This chart does not show the 10 institutions with the largest number of counterparties (for presentational clarity).
Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report).

We conclude the analysis of the FX forwards market by visualising the network of outstanding contracts. This is shown in Chart 38. To construct the visualisation, we count outstanding contracts between any two given counterparties. The width of each link corresponds to the total gross notional outstanding between those two counterparties, while the size of each node corresponds to that counterparty's gross notional outstanding across all other counterparties.

The lack of central clearing in the FX forwards market results in a complex network of connections, with a core of about 15 banks at the centre of the network. The network is therefore more similar to that of CDSs, as both correspond to a core-periphery structure with banks at the core. However, the composition of the periphery is somewhat different in the FX forwards market: as we saw earlier, non-financial firms are relatively more important.

Table 12

Matrix of share of interactions between market participants, weighted by notional

Buy \ Sell	G16 Dealers	Banks	Other financials	ICPFs	Non-financial	Other	Total
G16 Dealers	11.3%	13.5%	8.0%	0.5%	3.2%	0.9%	37.4%
Banks	14.6%	9.6%	3.5%	0.3%	2.2%	0.6%	30.8%
Other financials	9.0%	6.2%	2.8%	0.7%	0.3%	0.1%	19.0%
ICPFs	1.3%	1.0%	2.4%	0.0%	0.0%	0.0%	4.8%
Non-financial	3.5%	2.8%	0.5%	0.0%	0.1%	0.0%	7.0%
Other	0.7%	0.4%	0.1%	0.0%	0.0%	0.0%	1.1%
Total	40.4%	33.6%	17.3%	1.5%	5.7%	1.6%	100.0%

Note: This table includes only trades which are not centrally cleared.
Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report).

Chart 38

Network of gross notional links between counterparties in a subset of the FXD market

(based on EUR/USD FX forwards)

Note: Undirected unweighted network representation of EUR/USD forward contracts. Source: DTCC OTC foreign exchange derivatives dataset (based on the 02/11/15 trade state report).

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