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## Assessing contagion risks from the CDS market

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This paper summarises the work of the ESRB's Expert Group on CDSs, which was chaired by M. Brunnermeier and L. Clerc.

# Contents

# Executive summary

The purpose of this Occasional Paper is to assess the potential systemic and contagion risks arising from a credit event for a major credit default swap (CDS) reference entity or from the default of a key player in the CDS market. The main findings can be summarised as follows:

### Structure of the European CDS market

- The gross notional outstanding amount of CDSs on European (EU) reference entities was USD 4.6 trillion in 2012 (the global gross notional outstanding amount is about USD 23 trillion according to the Depository Trust & Clearing Corporation (DTCC)). It has risen by roughly USD 1 trillion since summer 2010.

- Over the same horizon, the total net amount of protection bought (or equivalently sold) on EU reference entities amounted to around USD 500 billion. Non-financials account for more than half of the total net notional outstanding amount, sovereigns for less than 40% and financials for around 10%. Since September 2008 there has been a shift in market activity from financials and non-financials to sovereigns. More recently (since summer 2012), market activity in sovereign CDSs has declined again. Hedge funds represented 40% of the total number of buyers in 2012, asset managers 33%, and banks only 18%. The remaining 10% is made up of financial services companies, pension plans or insurance companies. On the sell side, it is again hedge funds, asset managers and banks that dominate the market, each with a share of around 30%.

- The CDS market is highly concentrated at the level of counterparties, but less so at the level of reference entities. The top-ten most active traders account for more than 70% of gross protection bought or sold and are active in more than half of sovereign and financial reference entities. The top-ten names account for less than half of the aggregate exposure.

- In aggregate, major traders sell and smaller traders buy (net) CDS protection. This is consistent with the finding, verified for some national interbank markets, that smaller banks tend to lend to bigger, "money-centre" banks. The network of bilateral CDS exposures resembles a "core-periphery" structure. There is however significant heterogeneity in the structure of networks at the level of reference entities.

### Assessment of contagion potential in the CDS market

- With around 800 market participants and more than 3,500 bilateral links in January 2012, the EU CDS network is large and complex.

- The EU CDS market is centred around the G14 (or G15 from 2011) bank global derivatives dealers. The analysis of various network centrality indicators, however, allows to identify a larger number of very interconnected firms, which we refer to as potential "super-spreaders" in reference to Haldane's (2009) terminology.[1] These firms fall into three categories: (i) banks from the Financial Stability Board's list of global systemically important banks (G-SIBs); (ii) other banks; and (iii) non-bank super-spreaders, e.g. asset managers and hedge funds. Smaller counterparties are typically only active in a few reference entities and trade with a few major counterparties.

- Contagion arising from a sovereign credit event works through banks' sovereign bond exposures rather than their sovereign CDS exposures. Domestic banks typically have sizeable direct sovereign bond exposures. For foreign banks, generally correlated losses on

[1] Haldane (2009) emphasises the similarity between the potential of high-risk, high-infection individuals for the spread of epidemics and that of the most interconnected financial institutions for the spread of financial contagion. In allusion to this similarity, we refer to the most central CDS market participants as potential *super-spreaders*.

sovereign bond exposures are more important. A key vulnerability stems from collateral to be posted on multiple correlated positions (cf. AIG).

- The high amount of gross (and net) exposures for major market participants relative to their capital implies that in some scenarios there can be significant domino-type contagion effects. From our sample based on data from the European Securities and Markets Authority (ESMA), several banks have net exposures exceeding by far 30% of their core common equity as at 31 December 2011.

### Some policy implications

- The scope and channels for contagion seem to arise mostly from direct rather than CDS exposures and predominantly from non-contractual links. As a consequence, regulation should not only encourage financial institutions to manage their first-order/direct exposures, but also their second-order risks (e.g. from correlation between assets).

- From a systemic perspective, the analysis of the CDS market in isolation limits the range of possible policy conclusions. In particular, the multi-faceted nature of interconnectedness is difficult to capture in existing analytical frameworks. First, to better understand risk transfer and risk-bearing capacity, it would be necessary to know whether CDS exposures stem from proprietary trading, market-making or hedging. Second, counterparty credit risk is also material in other over-the-counter (OTC) derivatives markets, where the share of transactions cleared by central counterparties (CCPs) is still relatively small.

- Overall, the complex nature of interconnectedness provides significant challenges. Hence, from an ESRB perspective, a holistic view of the exposures map is required.

- At the current juncture, the role and contribution to systemic risk of non-bank super-spreaders identified is unclear. On the one hand, diversity in the form of different types of market participants makes the system more robust. On the other hand, there is very little information about the trading strategies and stress resilience of non-banks.

- Widespread CCP use should mitigate counterparty credit risk to the extent that most CDS are centrally clearable. The vital role of CCPs as circuit-breakers also puts particular emphasis on the quality of their risk modelling/policy and their collateral management.

- Credit events in the CDS market have proceeded smoothly so far. This was specifically illustrated by the market's resilience after the Greek credit event. Hence, one of the lessons of this specific event is that the threat of contagion can be reduced by means of transparency, as seen with the EBA's EU 2011 Capital Exercise. Moreover, the auction process and closing-out of CDS contracts are pivotal to the resilience of the CDS market.

- In sum, the contagion assessment for the CDS market is in line with findings for the interbank market where the somewhat mechanical scenario analysis usually produces low estimates of the systemic impact of default cascades. Despite these modest contagion estimates, interconnectedness in the interbank market is usually perceived as an important element of the financial system's risk-bearing capacity as behavioural effects or confidence channels may play an adverse role in an episode of systemic stress.

- Other regulatory initiatives may provide additional tools to mitigate contagion risk (such as the large exposures regime in Basel III). In this respect, it is important to factor in the network characteristics and properties of interbank exposures so as to strike the right balance between mitigating contagion risk and preserving banks' dealer role in the CDS market.

# Introduction

Over the past few years the CDS market's role has evolved from mostly providing default protection towards credit risk trading. The first-ever credit event in a developed country's sovereign CDS has further highlighted the importance of the CDS market from a macro-prudential perspective. Developments in the European sovereign CDS market are a part of the major structural shift in euro sovereign debt: in the market's view, there has been a significant shift from sovereign debt as a (default-free) risk-free benchmark (i.e. bearing interest rate risk only) to sovereign debt as a credit risk asset. Therefore, a significant repricing of the entire asset category has taken place, with major implications ranging from asset allocation to risk management. This implies that some policy issues are not necessarily and exclusively related to the CDS market, but are part of broader developments in the EU financial system.

This Occasional Paper aims to provide a comprehensive analysis of the CDS market from a macro-prudential perspective. In order to so, a wide range of analytical approaches is applied:

- Structural analysis of the EU CDS market: description of the market structure, key segments, concentration and evolution over time.
- Network analysis of bilateral CDS exposures: description of the structure and resilience of the network at an aggregate level as well as of sub-samples. In particular, analysis is conducted on: (i) the aggregated CDS network; (ii) various sub-networks, such as the sovereign CDS network; and (iii) networks for particular CDS reference entities. In order to carry out this analysis, we applied the established literature on interbank and payment systems networks to the CDS exposures network.
- "Super-spreader" analysis: identification of key "too interconnected to fail" market participants, their activities in the CDS market and their risk-bearing capacity.
- Scenario analysis of sovereign credit risk: the impact of sovereign credit events on the EU banking system and their potential spillovers.
- Domino effects in the CDS market: estimation of default chain scenarios for major participants in the CDS market; again, following the literature on interbank networks, we analysed the network impact of the collapse of a major market participant.
- Comparison of market- and exposure-based assessments of contagion: systemic risk rankings based on market price estimates (e.g. CoVaR) are compared with the rankings obtained using confidential DTCC exposure data in order to understand to what extent market participants are aware of who is a systemically relevant trader in the CDS market and whether these measures of systemic risk are consistent.

This paper provides a summary of the key results and the corresponding policy issues. Section 1 discusses data issues, section 2 gives a brief description of the EU CDS market, section 3 summarises the contagion analysis, section 4 discusses some regulatory topics related to the CDS market and section 5 concludes and presents the policy assessment.

# 1. Data issues

The main and most detailed source of granular CDS gross and net exposure data available for a comprehensive analysis of potential systemic risks related to a credit event for a major CDS reference entity is the Depository Trust & Clearing Corporation.[2,3] Its global trade repository, the Trade Information Warehouse (TIW), covers nearly all[4] cleared and bilateral CDS transactions, based on information reported by market participants (buy-side and sell-side) since November 2008.

There are three sets of data in the warehouse: the most granular level contains transaction-level data, including individual trade details. The next level is position-level data (net or gross), which includes aggregate position data for individual trading counterparties. The last level is aggregate notional data, which do not provide counterparty details, and are made publicly available every week. Information at transaction and position levels is not publicly disclosed.

Monitoring the CDS market necessarily requires access to granular exposure data. In the event of a reference entity default, position-level data allow analysis of first-round effects (i.e. the net notional exposure of a market participant). Transaction-level data are the only data source that allows for a comprehensive estimation of second-round effects (i.e. the propagation of a shock to other market participants via CDS exposures).

DTCC data are more granular and have wider coverage and higher frequency than Bank for International Settlements (BIS) data on CDS, which are collected as part of a broader semi-annual survey on OTC derivatives. However, in contrast with BIS statistics, they lack market values, which are key for a full assessment of risks. To partially overcome this limitation, market values for DTCC notional data have been approximated using Bloomberg and Datastream databases. Moreover, DTCC data do not have information on collateral yet; work to collect collateral data is currently ongoing at DTCC, but the information crucial for the assessment of the net credit risk exposures among CDS market participants was not available on time for our empirical analysis.

DTCC has established a regulatory portal to provide global regulators with access to the information required to perform their oversight functions and governmental responsibilities, in line with the guidelines set forth by the OTC Derivatives Regulators Forum (ODRF) in June 2010.[5] These guidelines categorise eligible authorities as follows: market regulators (e.g. ESMA), central banks with supervisory powers, prudential supervisors and authorities responsible for facilitating resolution of failed institutions, systemic risk regulators and law enforcement authorities. As for the scope of the data, the guidelines foresee that: eligible authorities should have “unfettered access to the relevant data, irrespective of the location of the trade repository”; “data access should be comparable for similarly situated authorities”; and even the primary regulator of the trade repository “would not generally access participant specific data for trades where both counterparties are outside of its supervisory jurisdictions”. According to the latter guiding principle, none of the authorities, including the Federal Reserve which has oversight over DTCC, has access to a global perspective of the CDS market.

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[2] Other potential sources of exposure data are the BIS survey on OTC derivatives, the British Bankers’ Association’s Credit Derivatives Survey and the International Swaps and Derivatives Association (ISDA) market survey.

[3] Net notional amounts in the DTCC statistics are calculated with respect to any single reference entity as the sum of the net protection bought by net buyers (or equivalently net protection sold by net sellers).

[4] According to DTCC, about 98% of all global derivative transactions are registered in the TIW’s trade repository.

[5] The scope of access to the DTCC data by type of regulator is available at: http://www.dtcc.com/downloads/products/derivserv/ODRF_guidelines.pdf.

At the time of writing, the most comprehensive dataset, covering all sectors within the European Economic Area, is available to ESMA, but with significant confidentiality restrictions. DTCC position data available to ESMA cover weekly bilateral CDS exposures between all (European and non-European) counterparties for each European reference entity from November 2006 on. The relevant variables included in the dataset are: (i) party and counterparty names; (ii) gross and net exposures (value and volume); (iii) reference type (financial, corporate and sovereign) and counterparty type (bank, asset manager, hedge fund, central clearing counterparty, pension fund, insurance company, custodian and financial services company); and (iv) the home country of the counterparties and of the reference entity.

To complement the information available to ESMA and due to ESMA's confidentiality restrictions, we also obtained an anonymised snapshot (as at end-2011) of DTCC data, which has a global rather than EU coverage, thus allowing for a broader analysis of the CDS markets across different sectors and geographical regions. The sample is composed of 40 sovereigns (EU + G20) and all global financial reference entities. The snapshot was used to perform a network analysis, with the aim of describing the data and understanding the network structure, market concentration and potentially also the propagation of shocks across the network. For the super-spreader analysis, the risk-bearing analysis and the comparison of market- and exposure-based systemic risk rankings, the ESMA sample was used.

In addition to the DTCC data, we also used the publicly available data collected by the EBA on sovereign exposures. Furthermore, bank balance sheet data, which are used to assess the potential scope for contagion due to CDS exposures, were obtained from Bloomberg.

## 2. Stylised facts about the EU CDS market

ESMA data as well as public data provided by DTCC allow for a detailed description of the CDS market in the EU.

The gross notional outstanding amount of CDSs on EU reference entities has grown strongly since 2008 to USD 4.6 trillion in the opening weeks of 2012 (the gross notional outstanding amount of all deals stood at USD 23 trillion at end-2011, according to DTCC). The net notional outstanding amount stabilised after October 2009 and weakly declined in the course of 2011. These developments were driven by the decrease of net positions against EU non-financials, which more than offset the sustained increase in EU sovereigns.

**Box 1: CDSs versus other OTC-traded derivatives**

In order to put the CDS market into perspective, this box reports the BIS data to illustrate notional values of OTC derivatives (June 2012, USD billions).

| | Notional amounts outstanding Jun.2012 | Gross market values Jun.2012 |
|---|---|---|
| Foreign exchange contracts | 66645.077 | 2217.318 |
| Interest rate swaps | 379401.183 | 17214.11 |
| Options | 50314.217 | 1847.896 |
| Equity-linked contracts | 6313.331 | 644.514 |
| Commodity contracts | 2993.013 | 390.024 |
| Credit default swaps | 26930.572 | 1187.333 |
| Total contracts | 638927.914 | 25392.24 |

Source: BIS

Hence, in a comparison of notional values the CDS market is by far outsized by the interest rate derivatives market. Furthermore, the ratio between interest rate swaps and CDSs both in terms of notional and of market values amounts to around 14.

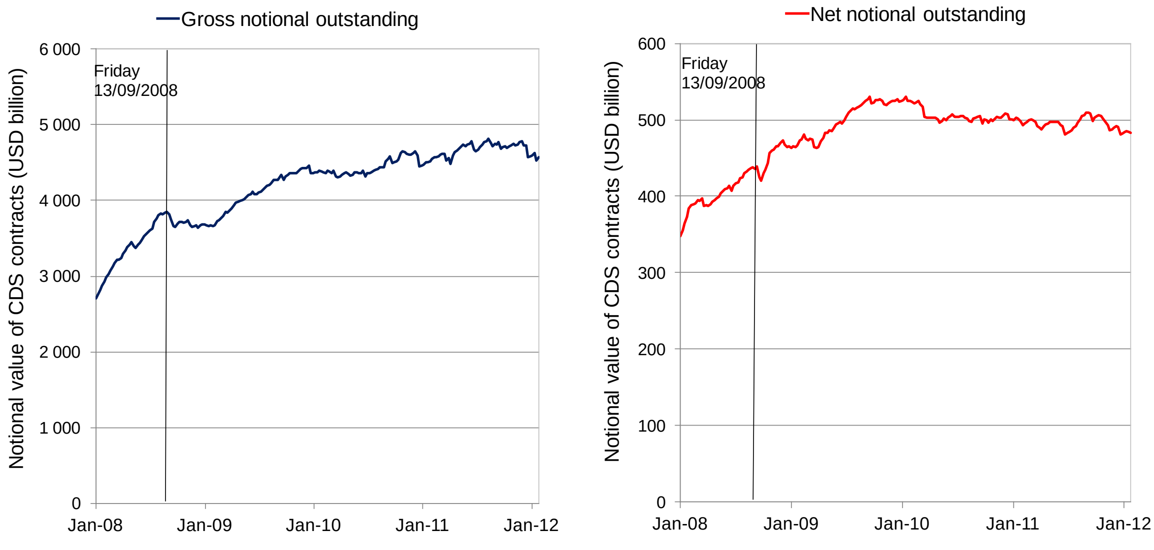
Over the same horizon, the total net amount of protection bought (or equivalently sold) on EU reference entities amounted to around USD 500 billion[6] (see Figure 1.a below). Non-financials account for more than half of total net notional, sovereigns for less than 40% and financials therefore for around 10%. Since September 2008 there has been a shift in market activity from financials and non-financials to sovereigns (see Figure 1.b). More recently (since summer 2012), however, market activity in sovereign CDSs has declined again.

Figure 1.c shows that hedge funds represented 40% of the total number of buyers in 2012, asset managers 33% and banks 18%. The remaining 10% is made up of financial services companies, pension funds and insurance companies. On the sell side, it is again hedge funds, asset managers and banks that dominate the market, each with a share of 30%.

However, the numerous hedge funds and asset managers selling CDSs account for a mere 2.1% of the total notional outstanding amount. Banks (Figure 1.d; red area, left-hand scale) accounted for more than 96% of gross CDS sales until end-2009, and about 88% in 2012. This sharp decline follows the regulatory move to centralised clearing for standardised OTC derivatives: as a consequence, CCPs' share increased from less than 1% in January 2010 to almost 10% in 2012.

Figure 1: Evolution of the CDS market since 2008[7]

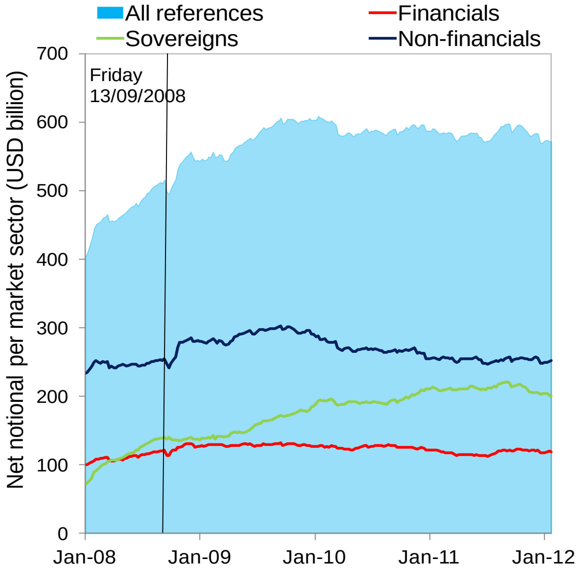
**Figure 1.a: Gross and net outstanding amounts on EU reference entities (USD billions)**




6 For example, in the anonymised global dataset, total gross notional amounts to EUR 4,280 billion and total net notional is EUR 349 billion. Hence, if all entities were to default with a loss of 100%, the total payout to protection buyers would be EUR 349 billion.

7 The TIW went live in November 2006. However, a process of backloading of firms' derivatives portfolios into the warehouse continued throughout 2007, which could affect the notional amounts of CDS positions recorded for that year. For this reason, we decided to report market developments starting from January 2008.

**Figure 1.b: Net notional outstanding and market share by sector**



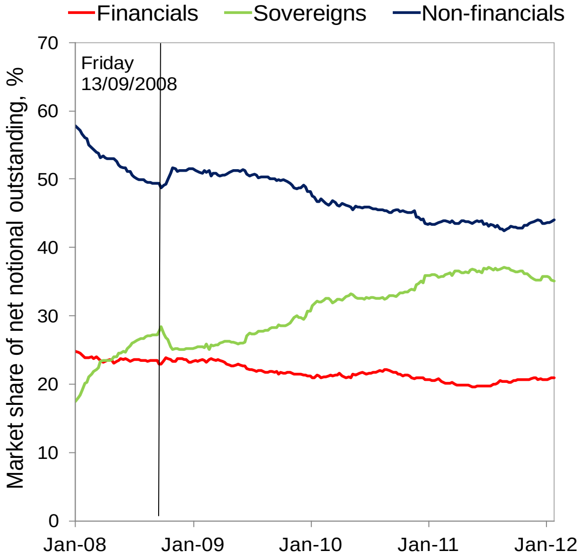
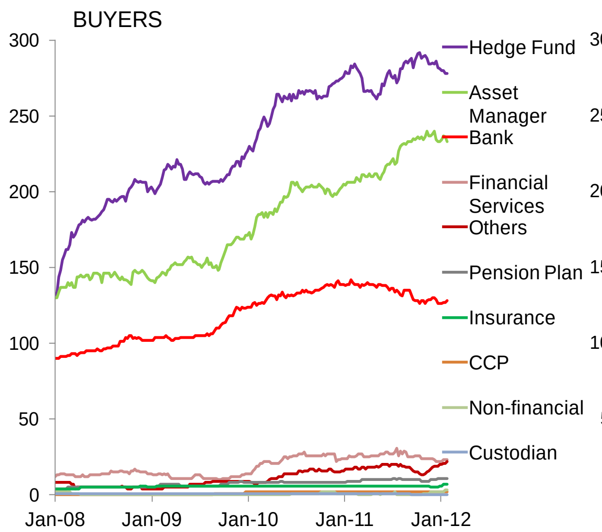




**Figure 1.c: Market participants: number by type (buy and sell sides)**



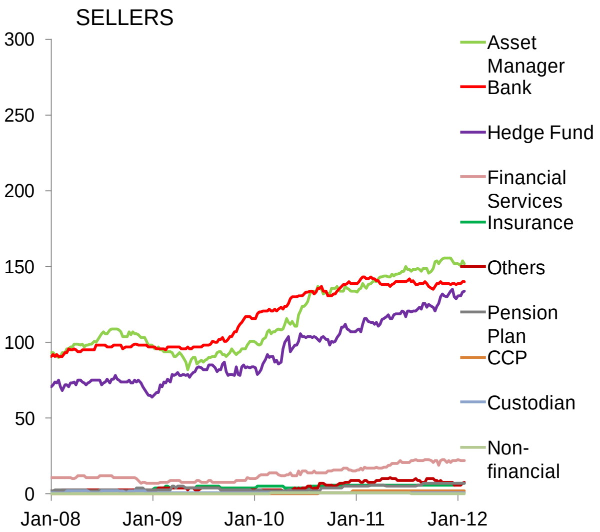
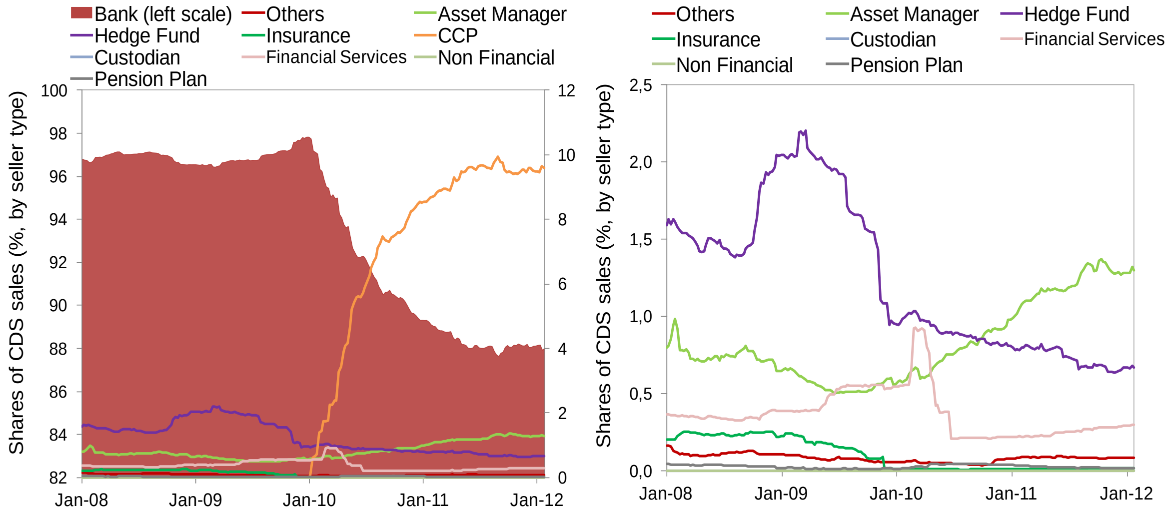



**Figure 1.d: Market participants: market share by type (%)**




Additional insights can be gained from the analysis of the anonymised global sample provided by DTCC. This global sample covers 642 reference entities, including 18 G20 sovereign, 22 EU sovereign and 602 global financial entities (see Peltonen et al., 2013, for more details).

Overall, 946 counterparties have been active in these reference entities. The dataset contains the names of reference entities, but the identity of the counterparties is anonymised. The total gross notional in this sample equals EUR 4.28 trillion. The net notional exposure at the aggregated level, however, is significantly smaller and equal to EUR 349 billion, leading to a net-over-gross notional ratio of 8.2%. This ratio is relatively stable across reference entities. The average market participant is trading 18.7 reference entities and is linked to 9.6 counterparties, even though the distribution of links is highly skewed. We observe 592,083 transactions that have an average notional value of EUR 7.2 million. There are virtually no transactions with a low notional amount, as standardised amounts (or multiples of them) are typically traded. Each exposure in a particular reference entity network on average results from 10.3 (potentially offsetting) transactions. The high number of transactions and the low net-over-gross notional ratio indicate that net CDS exposures between any two traders on a particular reference entity are frequently adjusted and that an exposure opened at some date is typically not kept unchanged until the maturity of the CDS contract (typically a five-year horizon).

Concentration among counterparties is quite high. In order to analyse the trading activity of groups of market participants, we measure the concentration of activity as the share of the gross CDSs sold by the ten most active institutions, relative to the total gross CDS market notional. The ten most active traders account for 73% of the gross sales of CDSs, implying that the CDS market is highly concentrated among a few major dealers, as also observed by Mengle (2010). At a more granular level, we investigate whether the aggregate net position of a particular trader, either as a net buyer or as a net seller of CDSs, depends on its level of activity. Given that counterparties are anonymised in the dataset, we can only distinguish them according to their overall level of activity (in percentiles).

We note that a large number of the active market participants act as net protection buyers. In the aggregated CDS market, only 18% of the institutions are net CDS sellers overall (even though they may be net buyers of particular reference entities).

## Box 2: Trading activity in the CDS market

This box briefly describes the types of transactions that occur in the CDS market, the reasons why they occur and how they can influence the lifecycle of a CDS contract.

There are four different types of transactions in the CDS market:

+ New trades: These are new CDS contracts that are initiated between two counterparties.

+ Terminations: These are instances where the two counterparties mutually agree to terminate an outstanding position in a CDS contract. The termination may be full (i.e. it covers the full notional amount of the CDS contract) or partial (i.e. it covers a fraction of the notional amount of the CDS contract).

+ Amendments: The two counterparties to a CDS contract mutually agree to change one or more of the contract parameters (i.e. to amend the contract). This could involve for example increasing the notional amount or extending the maturity of the contract.

+ Assignments: One of the two counterparties to a CDS contract steps out of the contract and is replaced by another counterparty. As with the terminations, assignments can also be full or partial.

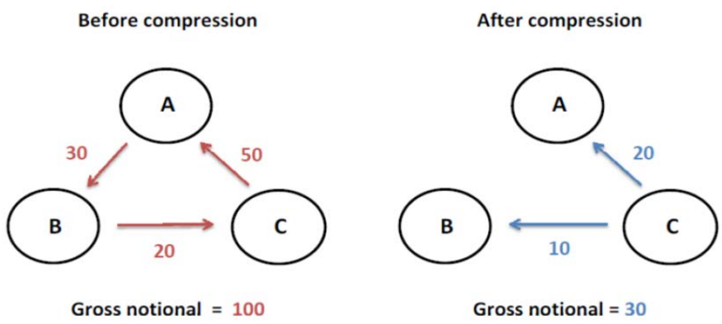
Transactions in the CDS market may have a number of origins:

+ New market activity: This is genuinely new activity occurring as a result of the bilateral negotiation of two counterparties. It may involve any of the transaction types described above.

+ Market-wide trade compressions: This activity aims to reduce the gross notional amounts outstanding of a number of market participants without changing their aggregate net exposures.

Figure 2 illustrates the hypothetical exposures of three market participants before and after a compression cycle. The purpose of market-wide compressions is to reduce counterparty risk that arises as a result of bilateral contractual obligations, without affecting the overall exposure to reference entity risk of the market participants. Compressions typically involve multiple contract terminations and a few new trades that replace the terminated contracts. Compressions may therefore cause the gross notional amounts outstanding to rapidly decline within a day. Understandably, compressions require some coordination across market participants and this is facilitated by commercial providers such as Tri-Optima.

**Figure 2: A hypothetical CDS compression cycle**

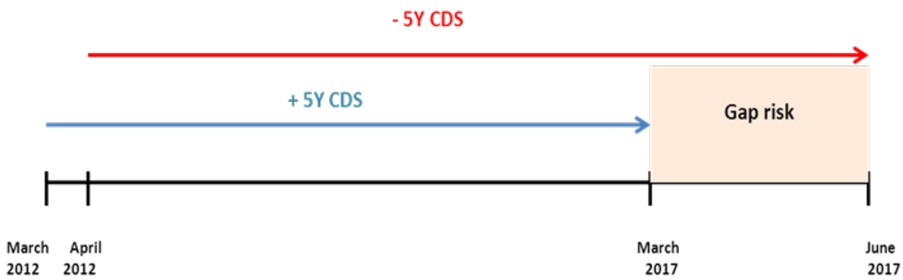



Note: in the chart above, the starting point is the protection seller.

+ Delta-neutral auctions: Because standardised contracts have quarterly expiration cycles (March, June, September, December), it is often difficult for market participants to run books whose long and short positions are perfectly balanced in terms of their maturities. For example, while a five-year CDS contract bought in March 2012 will expire in March 2017, a five-year CDS contract sold in April 2012 will expire in June 2017. Thus, a dealer who did these trades will have an imbalanced book between March and June 2017. This is referred to as "gap risk" and is illustrated in Figure 2. In the above example, to eliminate this book imbalance in April 2012, the dealer would have to sell the five-year March contract and replace it with a contract that expires in June 2017. However, following a given expiration cycle, no new contracts of that date can be traded, so the dealer would not be able to sell a five-year March contract in April to offset his/her position. For this reason, various providers (such as Creditex) facilitate electronic auctions whereby dealers submit their imbalances for every contract maturity (the "curve") and also the prices at which they are willing to trade in order to balance their books. A sophisticated algorithm then matches the dealers' bids and generates trades that allow them to reduce the imbalances in their books.

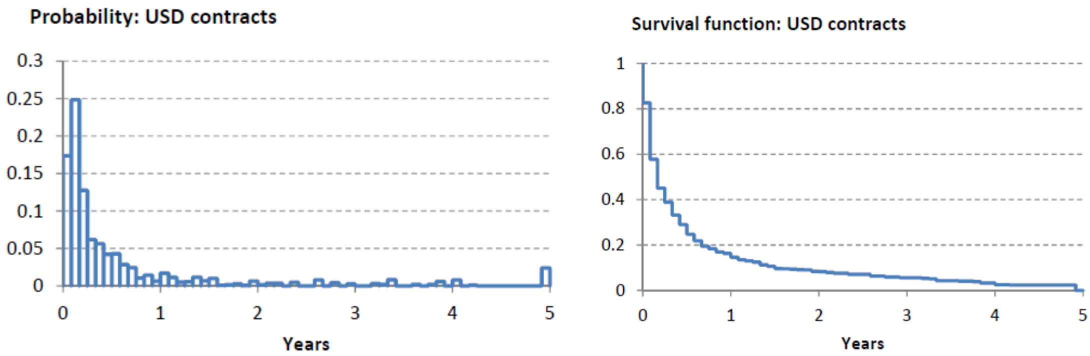
+ Novated trades: An existing contract between two counterparties can also be novated to a clearing house. This means that the original contract is terminated and is replaced by two new contracts, between the clearing house and each of the counterparties. Novations are therefore different than assignments: whereas in an assignment the original contract always remains valid and one of the counterparties is just replaced by another one, in a novation the original contract is cancelled and replaced with two new contracts. This means that, following a novation, there is a total of three counterparties (the original two counterparties plus the clearing house).

**Figure 3: Illustration of gap risk**




The typical CDS contract experiences multiple events throughout its lifetime: assignments, amendments and ultimately partial or full terminations. For this reason, only a few contracts mature naturally. As an example, the charts in Figure 3 show lifecycle statistics for the USD-denominated CDS contracts written on a major euro area sovereign. The charts are based on a subset of actual transactions data for 2007-11. The first chart shows the distribution of the lifespan of the five-year CDS contracts. The chart shows that the vast majority of contracts are terminated within a year of their initiation and only a small fraction matures naturally. The second chart shows the survival function of the CDS contracts, i.e. the probability that a contract will survive beyond a specified time, conditional on the contract having survived up until that time. The chart shows for instance that a five-year CDS contract has a 20% chance of surviving beyond one year and only a 10% chance of surviving beyond two years.

**Figure 4: The lifecycle of a USD-denominated five-year CDS contract written on a euro area sovereign (2007-11)**



# 3. Contagion assessment

## a. A theoretical overview of contagion channels

In general, contagion can be defined as the process of transmission of (positive or negative) shocks across components in the financial system. A more restrictive concept of contagion is the propagation of shocks in excess of that which can be explained by fundamentals, that is, excess co-movement. Most of the contagion analysis is based on the Forbes and Rigobon (2000a and 2000b) framework in which contagion is defined as a change in how shocks are propagated between relatively normal periods and crisis periods.

As Brunnermeier and Oehmke (2012) argue, the literature on financial networks is still in its infancy. A number of papers start with a given financial network and highlight spillovers and amplification mechanisms within this network. In some papers, these spillovers occur via direct domino effects, while other papers embed amplification via prices or bank runs into a network structure. Network models are also central to the literature on payment systems and settlement risk.

In order to develop the empirical analysis, we have considered a general theoretical framework for potential mechanisms of contagion in the financial system (i.e. not specific to CDS markets). Overall, "rational" channels of contagion (e.g. driven by fundamentals) need to be distinguished from "behavioural or psychological" channels. This leads to the following general structure of contagion channels:

**1. Rational channels of contagion**

1.1 Within the financial sector

- A) Direct spillover effects due to contractual links and/or default (domino effects); network risks (see for instance Brunnermeier et al., 2013)
- B) Indirect spillover effects due to:
  - price effects (loss spiral and wealth effects combined with fire-sale externalities)
  - funding effects (margin/haircut spiral, leverage cycle)
  - information spillovers (herding, which is also related to the behavioural channel, learning about correlation structure)

1.2 Feedback loop between banking and sovereign risk

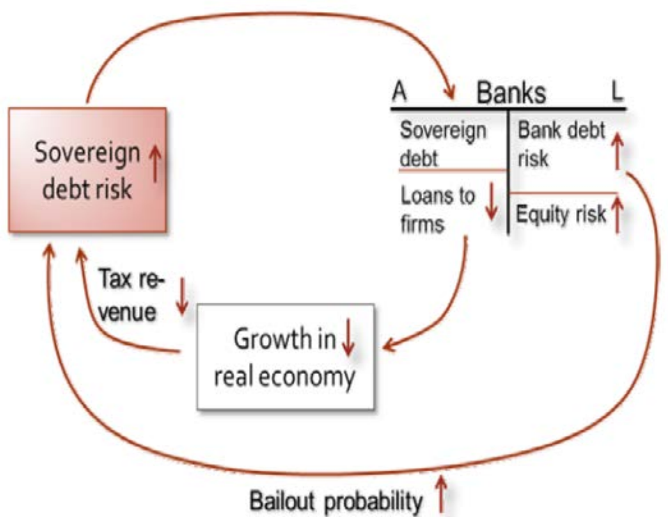
**2. Psychological channels of contagion**

- Panic behaviour
- Information processing cost channels

More specifically applying this general structure to the context of the European sovereign debt crisis, the pernicious feedback loop between banks and sovereigns, depicted in Figure 5, has played a unique role. When, as in Europe, financial institutions rely on sovereign debt for risk and liquidity management purposes, this introduces an interdependence between sovereign and financial sector risk, which works through two main channels. First, an increase in the riskiness of government debt impairs financial institutions that have large exposures to sovereign risk, which increases the probability that the sovereign will have to bail out the banking sector. This further compromises the fiscal position of the sovereign by increasing yields on its own debt, making sovereign refinancing more challenging. Second, banks that suffer losses on their holdings of sovereign debt may reduce their lending to the real economy. The resulting decrease in credit slows down economic growth and thus reduces the sovereign's tax revenue, which again increases the riskiness of sovereign debt.

In the context of the European debt crisis, this feedback mechanism has been referred to as the "diabolic loop" between sovereign risk and banking risk (Brunnermeier et al., 2011).

Figure 5: Feedback loop between bank and sovereign risks




Source: Brunnermeier and Oehmke (2012).

Box 3 below draws some conclusions from the Greek credit event, which was perceived as a major threat to euro area financial stability by policy-makers. However, fears of contagion, following the channels described above, did not materialise, illustrating the resilience of the CDS market and in particular the effectiveness of both the auction process and close-out netting of CDS contracts.

### Box 3: The Greek credit event

On 9 March 2012, ISDA announced that the triggering of the collective action clauses in domestic-law bonds represented a "restructuring" credit event for the CDS contracts on the Hellenic Republic. The auction on 19 March led to a recovery rate of 21.5%, which was in line with bond price-based estimates before the auction. In late March, DTCC reported that settlement of the Greek CDS auction generated net flows of USD 2.89 billion. The gross amount of Greek CDSs settled amounted to USD 80.1 billion. The potential systemic risk arising from the credit event is illustrated by the fact that gross exposure to the Hellenic Republic exceeds net exposure by a factor of more than 20: gross exposure currently amounts to USD 69 billion. One reason for this sizeable wedge between net and gross exposure is the fact that CDS contracts are typically closed by entering into offsetting contracts with the opposite sign, thereby artificially increasing the total gross outstanding notional.

To put the Greek credit event into perspective, a comparison with the Lehman Brothers credit event is useful. Compared with the settlement of the Lehman event where all protection sellers paid out their liabilities, the triggering of CDS contracts on the Hellenic Republic was smoother for a number of reasons:

- There was more time to plan for the credit event: Market pricing had already for some time accounted for the increasingly likely credit event whereas there was a "jump-to-default" for Lehman.

- Market participants had exited Greek CDS contracts quite some time earlier; hence the Greek credit event involved a smaller volume of CDSs outstanding.

- Ex ante, the recovery payment from the CDS triggering was expected to be bigger: Lehman's recovery rate was 9%, whereas for Greece bond price-based estimates before the auction indicated that it would be around 20-30%.

- There was more collateral in place to mitigate counterparty risk in the CDS exposure due to the improvements in risk management since the aftermath of the Lehman collapse.

- EU banks' exposure to Greek CDSs was modest. As the September 2011 EBA data on banks' exposures to sovereign CDSs indicate, exposure of the three biggest net protection sellers amounted to between around EUR 100 million and EUR 300 million per institution.

Overall, the combination of these factors meant that the credit event itself was no surprise to market participants and had no noticeable impact on the financial system. As the CDS payout was very close to the loss on bonds, market participants considered the credit event to have delivered the desired outcome. CDSs provided the market hedge, allowing investors to hedge their bond positions. Hence, the process clearly demonstrated the effectiveness of CDSs as hedging instruments, at least for this specific credit event.

In terms of **lessons from a macro-prudential perspective**, an important factor in the limited impact of the Greek credit event was the widespread clarity about exposures of major banks. In particular, the EBA Capital Exercise had provided detailed disclosures on banks' exposures to sovereign CDSs and the underlying debt. Hence, transparency for CDS positions mitigated concerns about fragile players (e.g. the potential for a "new AIG") and subsequent contagion.

### b. Analysis of the network structure of the CDS market

Network analysis is the main tool to analyse contagion in the CDS market. It makes it possible to identify: (i) key institutions and concentration of counterparty risks (e.g. who bears the ultimate risk in case of a credit event of the reference entity); (ii) the network structure and resilience; and (iii) how it is changing over time. The literature on financial networks is surveyed by Allen and Babus (2009) or

Upper (2011). Some relevant empirical contributions are Bech and Atalay (2008) on the topological properties of payment systems or Boss et al. (2004), Iori et al. (2008) and Langfield et al. (2012) on interbank networks. These papers typically describe financial interconnections using network metrics such as indicators of density, degree estimates, centrality or clustering.

In contrast to the interbank literature, analysis of contagion in the CDS exposure network so far is scarce principally due to the lack of data. Markose et al. (2010) reconstruct the network of CDS exposures in the US banking system and their analysis reveals the presence of "super-spreaders". Super-spreaders are large protection sellers who are highly "central" in the market in terms of clustering and connectivity measures, and whose capital bases – although comfortably fulfilling regulatory requirements – could be considered low when account is taken of the system-wide capital loss they may impose if they are assumed to fail in these simulation exercises. Shachar (2012) provides empirical evidence that counterparty risk, measured by the level of exposure in the inter-dealer market, affects the ability of CDS dealers to provide liquidity. The more "congested" the inter-dealer market becomes from a build-up of bilateral credit exposure, the more averse dealers become towards inventory risk. The consequence is that dealers' desire to hedge counterparty risk effectively leads to limited intermediation in the CDS market. All these studies support the idea that the CDS market might have a destabilising potential and therefore might be a source of systemic risk for the financial system.

In the next sub-sections, methodologies developed for the interbank market are applied to the DTCC data. Of particular interest are the identification of possible super-spreaders and the structure and resilience of the network. For the latter, a "domino"-type analysis is conducted. The advantage of the network analysis is that it sheds light on the structure and mechanics of the links of the main participants. However, this focus on direct spillover effects may lead to an underestimation of the overall contagion effects as the indirect spillover effects outlined above are not captured. To assess indirect spillovers, the leverage and liquidity mismatch of the super-spreaders are crucial since they determine how they will react to a shock. If they are well-funded, they can absorb shocks, thereby stabilising the system. On the other hand, if they have a large liquidity mismatch, they will contribute to further fire sales, thereby propagating shocks. For this purpose, we also analyse the capital positions of major institutions.

### c. Super-spreader analysis[8]

The analysis carried out on the time series of centrality metrics computed over 426 weekly directed and weighted networks – from 4 January 2008 to 27 January 2012 – using an anonymised dataset provided by ESMA (DTCC data on European reference entities) delivers the following results (see also Figure 1 above).

Institutions participating in the market for CDS on EU reference entities increased from an average of 480 in 2008 to an average of 803 at the start of 2012. Since September 2008 the trend has been mostly driven by CDSs on EU sovereigns and their growth was faster after November 2009.

With 803 nodes and 3,730 links (net buyer-net seller ordered pairs) in the first weeks of 2012, the overall CDS network stands as a large and complex system. For all reference networks, connectivity averaged around 1% over the sample period. Thus, networks are highly sparse, with participants typically being directly exposed to a small pool of other firms: in 2012 most were holding net positions only vis-à-vis three or four other firms. Connectivity is strongly negatively correlated with net value

8 This section draws heavily on Clerc et al. (2013). Results refer to the networks for all European reference entities, i.e. the links (net bilateral exposures) are computed bundling together all CDS positions outstanding on EU reference entities.

outstanding, reflecting an increasing level of concentration. However, this trend stopped in the first quarter of 2010 and concentration decreased slightly in the last months of 2011.

CDS network topology shows a power law distribution[9] of the largest net multilateral CDS exposures. The degree distribution and the distribution of net selling or net buying positions are highly heavy tailed. Very few nodes sell (buy) protection to (from) many counterparties, most nodes being linked to only a few others; only a few participants sell (buy) a net value of CDS protection much larger than the average.

The analysis shows that the most interconnected nodes in the networks in terms of the number of counterparties that they deal with (on the buy and/or on the sell side) and of their aggregate net bilateral selling or buying positions are the "fourteen families" (i.e. bank-type global derivatives dealers).[10] However, the G14 (or G15 from 2011) are not necessarily the top-15 most interconnected firms in terms of their net multilateral selling position, nor in terms of more complex centrality indices (see Table 1 below).

**Box 4: Network centrality measures to assess contagion risks**

In order to assess the scope for contagion through the networks of CDS exposures, several metrics are computed and presented in Table 1 below. Besides aggregate net selling and buying positions based on bilateral positions and aggregate net multilateral exposures, Table 1 reports three additional measures: net strength, eigenvector centrality and betweenness centrality. In each network, net bilateral sellers or buyers of CDS protection represent the *nodes* of the networks; a *link* is considered to exist if an institution is a net buyer of protection from another. Links are weighted based on net bilateral exposures (denoted by $w_{ij}$).

Net strength

In-strength is defined by the sum of the net bilateral *selling* positions of node *i* (i.e. the sum of the bilateral positions, *j*, where node *i* is a net seller):

$$in\_strength_i = \sum_j w_{ji}^{netsold}$$

Out-strength represents the sum of the net bilateral *buying* positions of node *i* (i.e. the sum of the bilateral positions, *j*, where node *i* is a net buyer):

$$out\_strength_i = \sum_j w_{ij}^{netbought}$$

Net strength is then the difference between its in-strength and out-strength:

$$Net\_Strenght_i = \sum_j w_{ji}^{netsold} - \sum_j w_{ij}^{netbought}$$

Net strength represents the net multilateral position of institution (or node) *i.*

[9] Power distribution is indicative of a "scale-free" network. The scale-free property strongly correlates with the network's robustness to failure (see also the sub-section f). Scale-free networks are characterised by major nodes, called "hubs", closely followed by smaller ones. If failures occur randomly, and the vast majority of nodes are those with small degree, then the scope for contagion to hubs is negligible.

[10] The term "fourteen families" was coined already in 2005 in a meeting held at the Federal Reserve Bank of New York, see: http://www.newyorkfed.org/markets/otc_derivatives_supervisors_group.html

Betweenness centrality

This measure provides an indication of the "exclusivity" of the position of a node *i* in the overall network by counting the number of paths between any originating and any terminating node that pass through node *i*. It could be important for identifying the nodes whose removal could affect network resilience the most. Normalised betweenness is computed as follows:

$$btw_i^* = \frac{\sum_{j,l} \frac{a_{jl,i}}{a_{jl}}}{(n-1)(n-2)}$$

where $a_{jl,i}$ denotes the number of paths between *j* and *l* through *i*, $a_{jl}$ is the total number of shortest paths between *j* and *l*, and *n* is the number of nodes.

Eigenvector centrality

In the context of assessing contagion due to CDS exposures, this measure could provide an indication of which nodes would be more important in the propagation of a shock if one could take into account the knock-on effects that may follow a shock. Mathematically, eigenvector centrality is defined as the principal eigenvector of the adjacency matrix that represents the (internally connected) network, i.e. which indicates whether there is a link or not between two nodes. The defining equation of an eigenvector is:

$$\lambda v = Gv$$

where *G* is the adjacency matrix of the graph, *λ* is a constant (the eigenvalue), and *v* is the eigenvector. The equation lends itself to the interpretation that a node has a high eigenvector score if it is adjacent to nodes that are themselves high scorers. This measure correlates best with the capacity of a financial institution to cause the others to suffer the largest contagion losses.

Table 1 shows that the G-SIBs, as identified by the Financial Stability Board (FSB), play a pivotal role in the CDS market. In particular, columns 1 and 2 show that these large global banks (*) tend to act primarily as dealers. As a result, they tend to perform more netting of their short and long contracts. With a few exceptions, their net multilateral exposures tend to be relatively lower (column 3), especially when compared with their common equity (column 4).

By contrast, some non-bank institutions tend to hold large net exposures (in particular some asset managers and hedge funds). Column 4 also reveals the very high multilateral net exposure of some other banks relative to their capital. While network metrics (columns 5 and 6) confirm the potential of bank-type dealers as super-spreaders of financial contagion in CDS networks, a significant variety of other non-bank/non-dealer market participants with super-spreader potential also emerge (in particular, some asset managers and hedge funds).

**Table 1: Top-20 market participants in the CDS market for European reference entities in 2011**

| Rank 2011 | Net selling position | Net buying position | Net multilateral position | Net multilateral expo./ TCE | Eigenvector centrality | Betweeness centrality |
|---|---|---|---|---|---|---|
| 1 | Bank 312* | Bank 497* | Bank 312* | 44% | Bank 497* | Bank 148* |
| 2 | Bank 622* | Bank 356* | AM 860 | N.A. | Bank 356* | Bank 1172* |
| 3 | Bank 765* | Bank 317* | Bank 821 | 66% | Bank 1045* | Bank 622* |
| 4 | Bank 497* | Bank 765* | Bank 186* | 17% | Bank 276* | Bank 497* |
| 5 | Bank 1045* | Bank 622* | Bank 622* | 8% | Bank 148* | AM 538 |
| 6 | Bank 1172* | Bank 148* | HF 508 | N.A. | Bank 954* | Bank 765* |
| 7 | Bank 186* | Bank 276* | Bank 656 | 65% | Bank 317* | Bank 356* |
| 8 | Bank 148* | Bank 136* | Bank 389 | 90% | HF 304 | Bank 317* |
| 9 | Bank 317* | Bank 1172* | Bank 1045* | 12% | Bank 136* | Bank 276* |
| 10 | Bank 136* | Bank 1045* | Bank 627 | N.A. | Bank 1172* | HF 673 |
| 11 | AM 860 | Bank 954* | AM 104 | N.A. | Bank 765* | Bank 136* |
| 12 | Bank 356* | CCP 565 | Bank 1176* | 12% | Bank 782 | Bank 186* |
| 13 | Bank 821 | Bank 553* | Bank 412 | 18% | Bank 289 | AM 937 |
| 14 | Bank 553* | Bank 289 | Bank 553* | 1% | AM 873 | Bank 954* |
| 15 | Bank 276* | Bank 186* | Bank 804 | 8% | Bank 622* | FS 373 |
| 16 | CCP 565 | Bank 1176* | FS 920 | N.A. | CCP 565 | AM 541 |
| 17 | Bank 954* | Bank 782 | HF 1075 | N.A. | Bank 804 | Bank 553* |
| 18 | HF 508 | Bank 804 | Bank 765* | 3% | HF 509 | Bank 1045* |
| 19 | Bank 1176* | Bank 304 | Bank 1172* | 3% | HF 401 | AM 621 |
| 20 | Bank 656 | AM 873 | Bank 628 | N.A. | Bank 553* | AM 467 |

Source: Clerc et al. (2013).

Notes: AM stands for asset manager; HF for hedge fund; FS for financial services company; CCP for central clearing counterparty; N.A. for not available; * signals that the bank is a G-SIB identified by the FSB.

Table 2 reports the pair-wise Pearson and Spearman (rank) correlation coefficients for various centrality indicators. The correlation between more complex indicators (like betweenness and eigenvector centrality), possibly more suited for capturing the extent of feedback effects following a shock at one market participant, and the other most common centrality measures points to the potentially key role played in the spread of contagion by: (i) net sellers to many counterparties, since they indirectly connect many participants which are not otherwise directly exposed to each other; and (ii) large net bilateral buyers which, because of their links to large net sellers, pose a greater risk that a shock hitting one of the key players could rapidly reach more key players, thus endangering the connectedness of the whole network.

In fact, the table reveals that over the sample period, in-degree displayed the strongest positive (linear) correlation with betweenness centrality, while out-strength displayed the highest (linear) correlation with eigenvector centrality.

**Table 2: Pearson's/Spearman's correlation coefficients between different centrality measures (averages for 2008-12)**

| | In-strength | Out-strength | Net strength | In-degree | Out-degree | Eigenvector |
|---|---|---|---|---|---|---|
| **In-strength** | | | | | | |
| **Out-strength** | 80% / 14% | | | | | |
| **Net strength** | 37% / 26% | -26%/-76% | | | | |
| **In-degree** | **87% / 98%** | 95% / 9% | -6% / 29% | | | |
| **Out-degree** | 83% / 16% | **92% / 81%** | -10%/-60% | 94%/14% | | |
| **Eigenvector** | 61% / 12% | **89% / 96%** | -39%/-76% | 78% / 7% | 79%/79% | |
| **Betweenness** | 74% / 60% | 83% / 30% | -10% / 1% | **88%/64%** | 85%/47% | 66%/29% |

The analysis of the (linear and rank) correlation between network centrality and selected balance sheet items indicates the following (Tables 3 to 5): (i) banks with the largest aggregate net bilateral selling and buying positions in 2011 tended to be bigger institutions (in terms of their total assets); (ii) the largest net bilateral buyers tended to hold more common equity and cash items, which is not the case for the largest net bilateral sellers; (iii) banks selling net protection to a higher number of participants tended to have a higher market value; and (iv) the largest bank dealers tended to be perceived as safer by the market (a lower CDS spread).

This descriptive analysis suggests that banks with larger net multilateral exposures, which we refer to as potential super-spreaders – tended to perform worse in the stock market in 2011 and to be less well capitalised (see Table 5). As discussed in more detail below, from 2008 to 2010 their core capital-to-assets ratio was on average 20% lower compared with other non-super-spreader banks, but the difference decreased in 2011.

**Table 3: Correlation between in-strength and selected balance sheet items**

| Year 2011 | CDS aggregate net bilateral selling position (in-strength) | Number of counterparties to which net protection is sold (in-degree) |
|---|---|---|
| **Total common equity** | 45% | 45% |
| **Total assets** | **55%** | 48% |
| **Cash and near cash items** | 41% | 45% |
| **Last stock price** (as at 31/12/2011) | 37% | **54%** |
| **Last CDS spread** (as at 31/12/2011) | **-19%** | **-19%** |
| **Leverage** (common equity/assets) | -4% | 5% |

**Table 4: Correlation between out-strength and selected balance sheet items**

| **Year 2011** | **CDS aggregate net bilateral buying position** (out-strength) | **Number of counterparties from which net protection is bought** (out-degree) |
|---|---|---|
| **Total common equity** | 38% | **51%** |
| **Total assets** | **45%** | **58%** |
| **Cash and near cash items** | 42% | **54%** |
| **Last stock price** (as at 31/12/2011) | **54%** | 41% |
| **Last CDS spread** (as at 31/12/2011) | **-20%** | **-26%** |
| **Leverage** (common equity/assets) | 0% | 0% |

**Table 5: Correlation between net strength and selected balance sheet items**

| **Year 2011** | **CDS net multilateral selling position** (net strength) | **Number of counterparties** (degree) |
|---|---|---|
| **Total common equity** | 7% | **48%** |
| **Total assets** | 11% | **52%** |
| **Cash and near cash items** | -4% | 49% |
| **Last stock price** (as at 31/12/2011) | **-25%** | **50%** |
| **Last CDS spread** (as at 31/12/2011) | 2% | **-22%** |
| **Leverage** (common equity/assets) | **-5%** | 3% |

By computing the ratio of super-spreaders' (average) net bilateral selling or buying exposure in 2011 to the level of their total common equity[11] we explore the risk-bearing capacity of these firms in the "Armageddon" (highly implausible) scenario where all their counterparties default. We find that some ratios are alarmingly high, especially for some non-dealer banks (Table 6).

11 Differences between US and EU accounting standards may affect the assessment of risk-bearing capacity.

**Table 6: Financial soundness of the 2011 largest net bilateral sellers and buyers**

| Rank 2011 | Largest net bilateral CDS sellers | | Largest net bilateral CDS buyers | |
|---|---|---|---|---|
| | *Participant* | *Net selling exposure/TCE* | *Participant* | *Net buying exposure/TCE* |
| 1 | Bank 312* | 45% | Bank 497* | 67% |
| 2 | Bank 622* | 23% | Bank 356* | 63% |
| 3 | Bank 765* | 56% | Bank 317* | 94% |
| 4 | Bank 497* | 41% | Bank 765* | 53% |
| 5 | Bank 1045* | 48% | Bank 622* | 15% |
| 6 | Bank 1172* | 41% | Bank 148* | 28% |
| 7 | Bank 186* | 26% | Bank 276* | 13% |
| 8 | Bank 148* | 23% | Bank 136* | 10% |
| 9 | Bank 317* | 55% | Bank 1172* | 38% |
| 10 | Bank 136* | 9% | Bank 1045* | 36% |
| 11 | AM 860 | N.A. | Bank 954* | 13% |
| 12 | Bank 356* | 24% | CCP 565 | N.A. |
| 13 | Bank 821 | 66% | Bank 553* | 7% |
| 14 | Bank 553* | 8% | Bank 289 | 32% |
| 15 | Bank 276* | 7% | Bank 186* | 9% |
| 16 | CCP 565 | N.A. | Bank 1176* | 20% |
| 17 | Bank 954* | 10% | Bank 782 | 19% |
| 18 | HF 508 | N.A. | Bank 804 | 15% |
| 19 | Bank 1176* | 32% | Bank 304 | N.A. |
| 20 | Bank 656 | 67% | AM 873 | N.A. |

Source: Clerc et al. (2013).

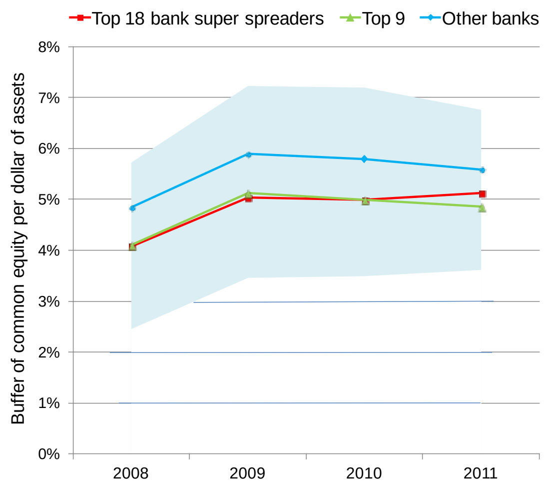
Notes: For the banks belonging to the 20 largest net bilateral CDS sellers (buyers) in 2011, the table reports the ratio of their aggregate net bilateral selling (buying) position to their total common equity. TCE stands for total common equity; N.A. for not available; * signals that the bank is a G-SIB identified by the FSB.

Finally, we consider the level of leverage (total common equity divided by total assets) of the top-nine or top-18 bank super-spreaders identified as largest net multilateral sellers relative to a set of another 81 banks.

Figure 6 shows that the 18 super-spreader banks tended to hold on average a lower buffer of equity per dollar of assets than the other banks. While the top-18 bank net sellers increased their equity-to-assets ratio over time (the average grew from 4% in 2008 to 5.1% in 2011), it remained lower than the equity buffer of the other banks in the sample. It is also interesting to note that the nine largest net sellers of CDS protection (all of which are G14 dealers) typically held a slightly higher equity ratio than the top-18. This changed however at end-2011 when the top nine reported an average ratio 0.3% below the equity ratio of the top 18 banks.

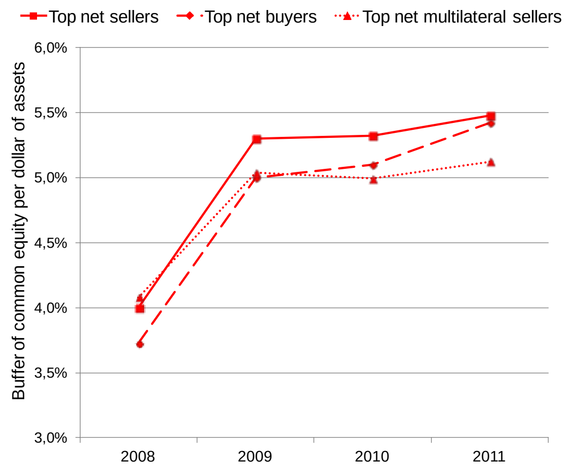
If we now consider the average ratio across the different types of potential super-spreaders identified (Figure 7) – largest net bilateral sellers, largest net bilateral buyers and largest net multilateral sellers – we can see that the top bilateral sellers and buyers of CDS protection were on average less capitalised than the top multilateral sellers in 2008, but became better capitalised in 2009, 2010 and 2011. The higher equity buffer of the top sellers and top buyers in 2011 (5.5% against 5% for the top multilateral sellers) seems to be driven by the presence in those rankings of some other big bank dealers that are missing in the list of participants with the largest net multilateral exposures.[12]

Figure 6: Buffer of common equity per USD of assets: bank super-spreaders versus other banks




The bank super spreaders identified are the largest net multilateral sellers. The shaded area represents the interquartile range for the entire sample of banks.

Figure 7: Buffer of common equity per USD of assets: top-30 net bilateral sellers, top-30 net bilateral buyers and top-30 net multilateral sellers




**Overall, the analysis shows that the "fourteen families" (G14), i.e. bank-type global derivatives dealers, are more interconnected in the networks in terms of the number of counterparties and of their aggregate net bilateral selling or buying positions. However, the G14 (or G15 from 2011) are not necessarily the top-15 most interconnected firms in terms of their net multilateral selling position, nor in terms of more complex centrality indices. The ten largest net bilateral CDS sellers and buyers are all in the FSB's G-SIBs list.**

### d. Estimation of domino effects in the CDS market from a single bank's default

As a next step of the analysis, a domino or round-by-round algorithm is applied to CDS exposures. This approach, which was developed for the interbank market, aims to investigate how far the failure of one bank spreads to other banks. Hence, the aim is to analyse the CDS market as a potential channel of direct contagion – direct contagion similar to the analysis of counterparty credit risk due to the interbank linkages rather than for instance the risk arising from common exposures.

The algorithm works as follows: one bank is assumed to get into distress as a result of an exogenous event. Each bank which has exposures to this bank suffers losses and – in the event that its capital

12 The top-30 largest net bilateral sellers include 22 banks, while the top-30 largest net bilateral buyers include 20 banks.

cushion is not sufficient – may fail as well, thereby spreading and amplifying the original shock. This process comes to an end when a new equilibrium is reached, i.e. when there is a round with no additional failures. There are more sophisticated algorithms modelling the effects of a bank failure, for instance the approach by Eisenberg and Noe (2001), in which the losses due to the initial distress are simultaneously distributed among the banks, and not sequentially as in the round-by-round algorithm. However, this sequential approach has two advantages: it is established in the interbank contagion literature and it is better-suited to describing the real world than a simultaneous approach. As previously mentioned, it is nevertheless important to keep in mind that – by analogy with the interbank literature – conclusions based on domino analysis potentially underestimate the extent of contagion in the system.

The sample combines ESMA data on DTCC gross exposures with bank balance sheets (common equity and risk-weighted assets) and covers a set of 39 large banks.

We adopt the following criterion for bank distress: a bank is defined to be in distress in the event that its common capital falls below 6% of its risk-weighted assets. A threshold where the book value of assets is still higher than the liabilities (instead of complete capital depletion) is chosen here because a bank with a sharp drop in its capital ratio will no longer have any access to short-term funding at sustainable rates, thereby soon leading to the bank's default.

A different, randomly drawn loss given default (LGD) is assigned to each bilateral exposure. In the literature, there is evidence that this assumption better describes reality than e.g. the assumption of a constant or an endogenous LGD, where the LGD is determined by the borrower's balance sheet composition.

The primary aim here is to study to what extent CDS exposures among banks are a channel of contagion. The simulation study proceeds as follows: one of the 39 banks in the sample is assumed to fail for an exogenous reason. Then, the round-by-round algorithm is applied and the number of subsequent failing banks is recorded. The simulation is repeated 10,000 times to account for the stochastic nature of the LGDs. This calculation is run for each of the 39 banks, yielding 390,000 simulated initial bank failures. To analyse the time series development, the simulation is conducted for the years 2008 to 2011, keeping the sample of banks constant through this five-year period.

The main results can be summarised as follows.

- First (see table below), contagion may happen but it is a rather rare phenomenon. Even in 2008, when the CDS exposures were high and the capital ratios low, in nearly 80% of the simulation runs no contagion occurs at all. This is remarkable not least because the focus is on banks' gross exposures, assuming that netting may not be enforceable in case of stress.
- Second, the analysis confirms that the CDS market is highly concentrated among a few banks. Direct contagion only happens in case such a bank – i.e. a super-spreader – fails.
- Third, in the worst simulation runs, up to 50% of the banks in the sample get into distress due to contagion.
- Fourth, the danger of contagion seems to have decreased since 2008 as the maximum number of affected banks and assets has declined steadily since 2008. This development may be due to the banks' improved capitalisation and the decline in CDS gross exposures (as highlighted earlier).

**Table 8: Results of the contagion simulation runs (sample of 39 banks; mean LGD of 45%)**

| | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Maximum number of banks in distress | 17 | 15 | 12 | 11 |
| Maximum share of defaulted assets | 61% | 52% | 39% | 31% |

### e. Sovereign credit events and their spillovers to the European banking system

In the analysis of sovereign credit events and their spillovers to European banks, the focus is on the interplay between sovereign bond and CDS holdings (see Peltonen and Vuillemey, 2012). The analysis uses a theoretical framework to assess the potentially risk-mitigating or risk-amplifying role of the CDS market in case of a sovereign credit event. Five transmission channels from sovereign entities to banks are featured in the model: (i) direct losses on sovereign bond holdings; (ii) write-downs on other (available-for-sale and held-for-trading) sovereign exposures; (iii) direct CDS repayments triggered by the credit event; (iv) increased collateral requirements to cope with higher CDS spreads on other non-defaulted reference entities; and (v) contagious propagation of counterparty failures. Moreover, the analysis explicitly incorporates several features proper to OTC derivatives markets, including collateralisation, collateral netting agreements and close-out netting procedures in case of counterparty default.

The theoretical framework is calibrated using public data released by the EBA on 65 major European banks related to the EU 2011 Capital Exercise. The dataset includes both sovereign bond and CDS holdings at a bank level for 28 European sovereign entities, while bilateral CDS exposures are estimated and their market values simulated. Additional balance sheet data are retrieved from Bloomberg. Exogenous sovereign default scenarios are studied for four stressed euro area countries (Ireland, Italy, Portugal and Spain) for a wide range of recovery rates.

The key findings are the following (see Vuillemey and Peltonen, 2013, for a detailed analysis). First, following a sovereign credit event (i.e. the probability of default (PD) of one country is exogenously set at 100%), banks' losses due to their direct and correlated sovereign bond exposures are estimated to be significantly higher than the pure losses due to sovereign CDS exposures and to counterparty risk on the CDS market. However, the relative share of each failure channel depends on the recovery rate for the sovereign bonds (the share of banks defaulting from their sovereign bond exposure is higher when the recovery rate on the defaulted debt exposure is lower). Given the home bias in banks' portfolios, losses on direct sovereign exposures are found to be more substantial for domestic banks, whereas losses through correlated sovereign bond exposures are found to be more important for foreign banks. The number of failures is scale-dependent: for a similar level of the relative debt-to-GDP ratio, the default of larger countries tends to have a larger impact for the same exogenous PD.

Second, in the case of a sovereign credit event, CDS repayments are overall found to remain small compared with banks' capital or liquid assets. Instead, the main risk for CDS sellers is found to be sudden increases in collateral to be posted on multiple correlated exposures. This channel dominates when the recovery rate is high enough, and is more important if the pool of available collateral is correlated with the bond exposure experiencing a credit event.

Third, there are no strong redistributive effects of net CDS repayments in case of a sovereign credit event, neither from banks with low exposure to highly exposed banks nor from highly liquid banks to banks with lower liquidity. Even though the observed distribution of net protection bought through CDSs does not match the distribution of underlying sovereign bond holdings, we do not find significant failures due to the inability of some banks to honour their contractual repayments in case of a credit event.

Fourth, there is limited evidence of contagion purely due to CDS exposures. Five main explanations account for the limited extent of contagion. First, the framework only captures one type of interconnections between banks, i.e. bilateral CDS exposures, and misses other important exposures, chiefly interbank exposures and other derivatives exposures. This caveat nevertheless allows for a focus on contagion purely due to banks' European sovereign exposures, and therefore permits the isolation and quantification of the importance of this particular channel of contagion. Second, losses due to counterparty failures are of low magnitude. Third, collateralisation and close-out netting play a risk-mitigating role. The fourth reason for the low extent of the contagion is the network structure. A large share of the links in each estimated gross CDS network (between 52% and 86% depending on the reference entity and a mean of 76%) are reciprocal, implying that potentially contagious chains of financial institutions are relatively limited. Finally, we do not observe the default of one of the main dealers on the CDS market, which substantially limits the potential for contagion.

Fifth, the effectiveness of risk-mitigation mechanisms, including collateralisation, collateral netting agreements and close-out netting, is investigated. Collateral netting agreements in this setting increase the overall liquidity of the banking sector, as less cash and liquid assets have to be pledged as collateral. Such a positive role of collateral netting agreements should nonetheless be considered cautiously, as the theoretical framework does not capture strategic bank balance sheet decisions when the institutional framework changes. For example, the existence of collateral netting agreements is likely to induce a higher leverage ex ante, as larger derivative portfolios can be sustained with a given level of pledgeable assets. Instead, the level of collateralisation of each trade plays an ambiguous role in our model. On the one hand, collateralisation reduces the extent of potential contagion by decreasing the loss incurred in case of counterparty failure. On the other hand, failures from illiquidity (i.e. the inability to meet collateral calls) are more likely to occur when the required level of trade collateralisation is higher, as the pool of cash and liquid assets remains constant. Overall, there are limited effects of changes in the level of collateralisation on banks' losses due to counterparty failures. Finally, close-out netting of the whole CDS portfolio in case of counterparty failure is shown to play a major role, as contagion would affect most of the banks active on the CDS market if it were not to be implemented.

There are important caveats to the analysis. First, as there is no data for true bilateral interbank (or CDS) exposures, the interconnections of the banks are based on estimated CDS exposures. Second, market values of banks' CDS portfolios are estimated based on the simulated number and maturity of bilateral CDS contracts. Third, the losses through the correlated sovereign bond and CDS exposures are based on estimated tail dependencies for a sample that includes sovereign stress periods but only the Greek sovereign credit event. Fourth, the analysis focuses only on the banks' sovereign bond and CDS holdings and certain collateral aspects, thus it does not include any feedback effects on the macroeconomy or any other aspects of the interbank market.

### f. Determinants of the CDS network structure

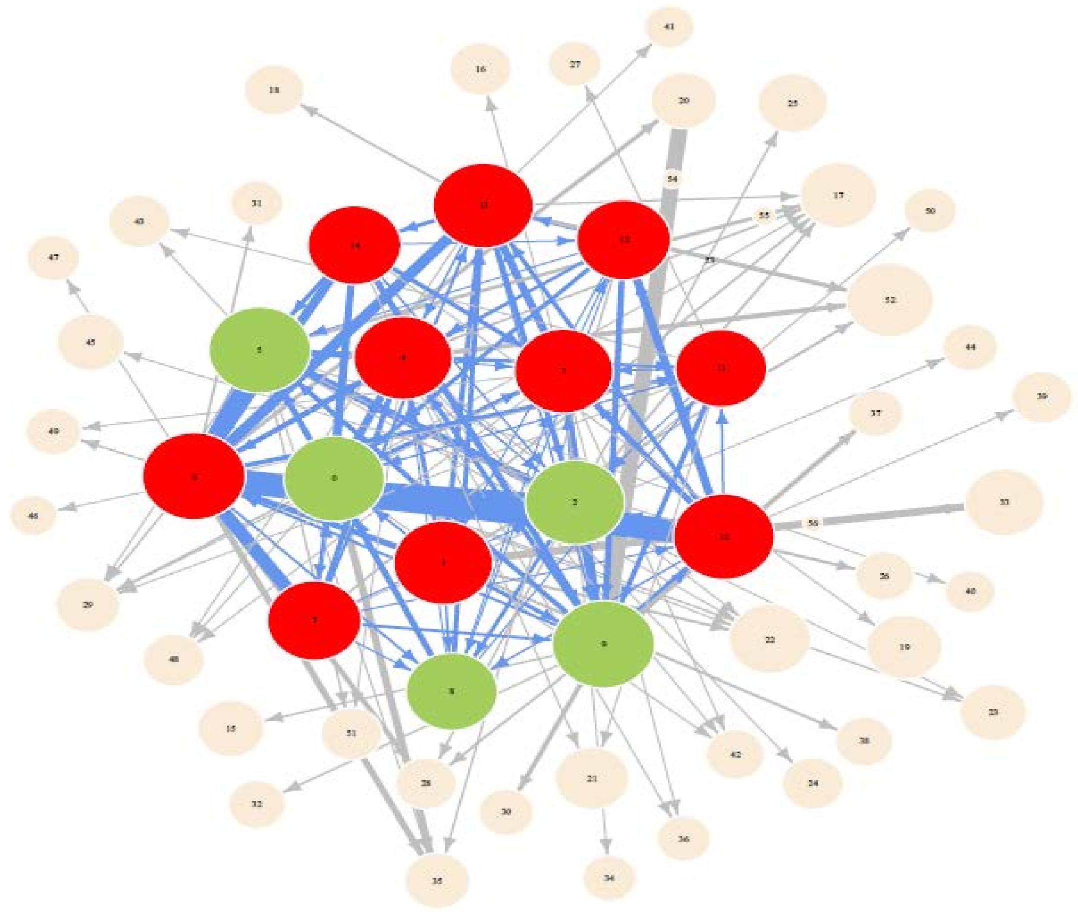
Peltonen et al. (2013) find that a number of reference entity characteristics have an important impact on the network properties. The number of active counterparties, as well as the gross and net CDS notional amounts exchanged in sub-networks, are closely linked to one another and differ substantially when we consider the categorisation based on the level of debt, the share of unsecured debt, CDS volatility and beta. For instance, whereas there are 850 active counterparties in the market for "high debt" CDS (i.e. CDSs whose underlying bond volume is above the sample median), there are only 504 active counterparties in the market for "low debt" CDSs, therefore suggesting that the underlying debt volume is an important driver of the CDS market size and activity. Similarly, sub-networks for "high unsecured debt", "low spread", "high beta" and "high volatility" CDSs are characterised by a larger number of active counterparties, as well as larger gross and net CDS exposures, even though those sub-networks are composed of roughly the same number of reference entities. In contrast, neither the sovereign versus financial distinction, nor the European versus non-European distinction, strongly affects the characteristics of the sub-networks.

Box 5: Application of the 10 x 10 x 10 approach to CDS data

In this box, we apply Duffie (2011)'s proposal to measure systemic risk exposures in a 10 by 10 by 10 approach to an anonymised dataset of global CDS exposures on sovereign and financial reference entities. In short, the first "ten" refers to the ten biggest market participants, the second "ten" to their biggest exposures and the third "ten" to a set of key risk factors, which could also capture behavioural responses such as fire sales. Figure 8 provides an illustration of the network structure of the CDS market.

The chart is constructed as follows: in order to isolate the net behaviour of systemically important institutions in the network, we focus on the top-15 counterparties and their top-ten exposures. Hence, the coloured nodes in the centre are the 15 largest counterparties in the CDS market, when counterparties are ranked by total notional exposure. Among them, red nodes are net sellers and green nodes are overall net buyers. For each of these fifteen traders, we show their ten largest bilateral net selling exposures. The size of each node is proportional to the log of the underlying gross exposure. The size of each link is proportional to the log of the net exposure it represents. Large net exposures between top-15 traders are in blue.

Figure 8: A "15 x 10" approach to identifying systemic players



Sources: DTCC, ESRB calculations.

Overall, the chart gives a concise description of the network structure, indicating that the network is quite concentrated. Among the core traders, a large majority (ten) has in aggregate a net selling position. Many of the second-tier counterparties have links to several of the top-15 entities. Furthermore, the top 15 have large net exposures among themselves (multilateral netting is considered at the reference entity level).

Overall, a key result is the significant impact of the characteristics of the underlying bond exposure (size, collateralisation) and of the risk characteristics of the CDS (volatility, commonality in returns) on the CDS market size and activity. Whereas the distinction between sovereign and financial reference entities matters for the network structure, there are almost no significant differences in structural properties between European and non-European reference entities. Concentration, on the other hand, is largely explained by proxies for a CDS contract's activity and beta.

In sum, the CDS network displays properties of a scale-free structure with a small-world characteristic.[13] The financial stability implications are the following: first, such a structure strongly correlates with network resilience to failure. In effect, if failures occur randomly and the vast majority

13 In a "small-world" network, the average number of links between any two nodes is small. "Scale-free" relates to the shape of its degree distribution.

of nodes are those with few counterparties, the probability that a hub will be affected is almost negligible. Even in the event of a hub failure, the network will remain connected thanks to remaining hubs. However, in case a shock hits a few major hubs together, the network could possibly lose its connectedness, hence its capacity to function. Consequently, ensuring the safety of the hubs or increasing their loss-absorption capacity ensures the safety of the whole system.

A key stylised fact is the existence of considerable heterogeneity in the structures of networks at the level of reference entities. In particular, entities categorised as “high debt”, “high beta” or “high volatility” have denser, more active and bigger networks. In contrast, the average number of counterparties per trader is remarkably stable across networks.

### g. Linking market- and exposure-based assessments of contagion

Finally, we complete our contagion analysis by attempting to link market- and exposure-based data. Up to now, due to scarce data on CDS exposures, the bulk of the literature has relied on econometric methods applied to high-frequency price data. The assumption is that the information extracted from stock prices or credit spreads can illustrate patterns of linkages among underlying entities. Therefore, we try to assess the extent to which the two approaches deliver consistent results.

The literature on contagion or spillover effects among CDS spreads is still in its infancy. Examples of papers analysing contagion in corporate credit markets include Jorion and Zhang (2010) or Yang and Zhou (2010). Jorion and Zhang (2010) study the transfer effects of credit events through the CDS market and find a positive correlation across CDS spreads. They find strong dominant contagion effects (positive correlations) for Chapter 11 bankruptcies and competition effects (negative correlations) for Chapter 7 bankruptcies. Yang and Zhou (2010) study the structure of credit risk networks across major financial institutions around the 2007-08 global financial crisis using CDS spreads as the credit risk measure. Their analysis enables them to identify several financial institutions as “senders” of credit risk information. Acharya, Schaefer and Zhang (2007) analyse correlation risk in credit markets in the context of the Ford and GM credit rating downgrades of May 2005 and overall find excess co-movement in fixed-income securities. Coudert and Gex (2010) also study this event.[14]

Our analysis is based on weekly data covering the period from January 2004 to August 2012. The CDS sample consists of 232 spreads; the stock returns dataset contains 571 entities, including EU and US financial institutions. Systemic risk measures, like the marginal expected shortfall (MES)[15] and capital shortfalls (Acharya et al., 2010), have been provided by Viral Acharya for the same 571 entities utilised for the computation of the contribution- and exposure-CoVaR values (Adrian and Brunnermeier, 2011). The contribution-CoVaR measure, obtained from quantile regressions of the system on all individual institutions and based on equity returns, expresses the marginal risk contribution of each firm to overall systemic risk, i.e. it answers the question to what extent does the risk of the entire financial system increase if an individual institution is in distress. The exposure-CoVaR measure switches the conditioning and addresses the question of which institutions are most exposed when the financial system as a whole is in distress, i.e. during a financial crisis. The contribution-CoCDS and exposure-CoCDS measures use the same logic as the CoVaR measures, but are based on CDS spreads instead of equity data.

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14 Related research includes Alter and Schueler (2012), Anton, Mayordomo and Rodriguez-Moreno (2012), Lahmann (2012), Acharya et al. (2011) or Ejsing and Lemke (2010).

15 The marginal expected shortfall of an institution can be defined as its expected equity loss when the market itself is in its left tail. The CoVaR represents the Value-at-Risk (VaR) of the financial system conditional on institutions being under distress.

As a first step, the exposure and the contribution measures based on equity returns (CoVaR) and on CDS spreads (CoCDS) have been estimated.

It is difficult to form expectations about the outcomes of the comparison between exposure- and market-based measures of contagion risk. The exposure-based measures capture a very specific contagion channel, emanating from the interdependence through the CDS exposures. In contrast, the measures based on CDS spreads and stock returns, i.e. reflecting the market perspective, display a broader picture, possibly including both real and informational channels. Moreover, measures based on different market prices (CDS spreads and stock returns) could display different risk transmission mechanisms due to the different information content of the market prices.

The CDS spreads directly reflect the risk of failure of the underlying entity. In contrast, stock prices reflect the discounted future stream of income from holding stock and thus do not reflect credit risk to the same extent as CDS spreads (Jorion and Zhang, 2007). Moreover, the CDS spreads are often associated with the "too big to fail" phenomenon (Voelz and Wedow, 2009). Hence, they tend to underestimate the default risk for systemically important institutions.

The comparison analysis is based on cross-sectional correlation coefficients calculated at two different points in time (see table below). The contribution CoVaR based on returns (as well as the capital shortfall) is positively correlated with all four exposure-based measures at a relatively high level (if looking at the January 2012 snapshot). The negative correlation between the CDS spreads and the exposure-based measures possibly indicates the "too big to fail" phenomenon. The correlation coefficients between the contribution CoCDS and the exposure-based measures are rather ambiguous, indicating no clear relationship. The exposure CoCDS and the exposure-based measures are negatively correlated. A comparison of the two snapshots (8 January 2010 and 6 January 2012), though, shows that the correlation structure changes over time; thus, the results should be interpreted cautiously.

**Table 9: Correlations between market-price and exposure-based measures**

| (6 Jan. 2012) | Eigenvector | Betweenness | Exposure | In-degree |
|---|---|---|---|---|
| Contrib. CoVaR | 0.542 | 0.545 | 0.688 | 0.635 |
| Expos. CoVaR | 0.031 | -0.069 | 0.106 | -0.013 |
| Contrib. CoCDS | 0.043 | -0.277 | 0.048 | -0.300 |
| Expos. CoCDS | -0.184 | -0.247 | -0.214 | -0.305 |
| CDS value | -0.237 | -0.312 | -0.204 | -0.330 |
| MES value | 0.138 | -0.089 | 0.251 | -0.013 |
| Relative capital shortfall | 0.639 | 0.583 | 0.712 | 0.643 |
| Market value | 0.107 | 0.266 | 0.202 | 0.220 |
| (8 Jan. 2010) | Eigenvector | Betweenness | Exposure | In-degree |
| Contrib. CoVaR | 0.118 | -0.086 | 0.105 | 0.016 |
| Expos. CoVaR | 0.174 | -0.088 | 0.093 | 0.030 |
| Contrib. CoCDS | 0.012 | -0.412 | -0.138 | -0.294 |
| Expos. CoCDS | -0.060 | -0.344 | -0.200 | -0.243 |
| CDS value | -0.233 | -0.220 | -0.269 | -0.266 |
| MES value | 0.130 | 0.070 | 0.076 | 0.086 |
| Relative capital shortfall | 0.579 | 0.216 | 0.704 | 0.623 |
| Market value | 0.245 | 0.273 | 0.371 | 0.369 |

All market- and exposure-based risk measures are positively (and in most cases significantly) correlated if the absolute (log) "dollar values" of the variables are taken instead of the relative measures.

### h. Discussion and summary

Overall, our analysis shows that under some circumstances the materialisation of contagion in the CDS market is likely. With around 800 market participants and more than 3,500 bilateral links in January 2012, the EU CDS market forms a large and complex network.

The core of the network is constituted by around 15 (from 2011 onwards) bank-type global derivatives dealers. Given their high level of interconnectedness in the network of net bilateral CDS exposures, we refer to them as "super-spreaders". These market participants trade in a large majority of all reference entities. The ten largest net bilateral CDS sellers/buyers are all in the FSB's G-SIBs category. In contrast, the average market participant is trading less than 20 global reference entities and is linked to around ten counterparties.

However, non-bank institutions also play an important role in the network: hedge funds, asset managers and insurance companies account for sizeable market activity. According to the network analysis, some non-bank market participants also have super-spreader potential.

Contagion arising from a sovereign credit event works through banks' direct sovereign bond exposures rather than their sovereign CDS exposures. Domestic banks typically hold sizeable direct sovereign bond exposures. For foreign banks, correlated losses on sovereign bond exposures are generally more important. A key vulnerability stems from the collateral to be posted on multiple correlated positions (cf. AIG).

The high amount of gross (and net) exposures for major market participants relative to their capital implies that in some scenarios there can be significant domino-type contagion effects. From the ESMA data, several banks have net notional exposures exceeding by far 30% of their core common equity. Though this characteristic is not specific to CDS, nor to derivative exposures, it deserves appropriate monitoring by supervisors.

## 4. Regulation and best practice

### a. Regulation

We now turn to regulatory initiatives aimed at preventing or mitigating contagion risks stemming from the CDS market.

The regulation of CDSs takes place in the broader context of OTC derivatives. The main step was initiated at the Pittsburgh G20 Summit in 2009, at which it was decided to extend the current regulatory framework of the OTC derivatives markets by: (i) requiring that all transactions should be declared to trade repositories (post-trade transparency); (ii) imposing that standardised products should be cleared through CCPs and subject to financial guarantees to limit the leverage effect and risks of contagion among financial counterparties (security); and (iii) making it compulsory to trade on organised markets (pre-trade transparency).

These reforms were to be implemented in all G20 jurisdictions by December 2012. Various attempts have been made by individual legislators to meet the obligations:

- the US passed the Dodd-Frank Act in July 2010;
- the EU issued the European Market Infrastructure Regulation (EMIR) and the Regulation on short selling and certain aspects of credit default swaps; it is also in the process of adopting

the Markets in Financial Instruments Directive (MiFID) and the Markets in Financial Instruments Regulation (MiFIR).

### Regulations covering OTC derivatives, including CDSs

#### A) In Europe

#### a) European Market Infrastructure Regulation (EMIR)

EMIR establishes rules for the central clearing of OTC derivatives and for the transactions record-keeping. The regulation, which entered into force on 16 August 2012[16], covers all types of OTC derivatives, including CDSs, and both financial firms which use OTC derivatives and non-financial firms that have large positions in OTC derivatives.[17] The objectives of the regulation are to provide the following:

- Greater transparency: trades in all derivatives (both OTC derivatives and exchange-traded derivatives) entered into by EU entities will have to be reported to trade repositories (central data centres). Regulators in the EU will have access to these repositories, enabling them to have a better overview of who owes what and to whom, and to detect early on any potential problems, such as accumulation of risk. Meanwhile, ESMA will be responsible for the surveillance of trade repositories and for granting or withdrawing their registration. In addition, trade repositories will have to publish aggregate positions by class of derivatives to give all market participants a clearer view of the OTC derivatives market.

- Greater safety by reducing counterparty risks: all standardised OTC derivatives will have to be cleared through CCPs. If a contract is not eligible and therefore not cleared by a CCP, it will be subject to margin requirements. As CCPs are to take on additional risks, they will be subject to stringent business conduct rules and harmonised organisational and prudential requirements to ensure their safety (such as internal governance rules, audit checks, greater capital requirements, etc.).

- Reduced operational risk: market participants will have to measure, monitor and mitigate this risk (mainly based on flexibility in defining the economic and legal terms of contracts), for example by using electronic means for confirming the terms of OTC derivative contracts.

- The EMIR Technical Standards were published in the Official Journal of the European Union on 23 February 2013 and came into force in March 2013.

#### b) Regulation on short selling and certain aspects of credit default swaps

The main objectives of the Regulation on short selling and certain aspects of credit default swaps are to create a harmonised framework for coordinated action at the European level, increase transparency and reduce the risks that certain short selling and CDS trading practices pose on the markets. The regulation, which came into force on 1 November 2012, covers shares, sovereign bonds and certain aspects of sovereign CDSs. Concerning sovereign debt, the regulation has introduced the following measures:

- Greater transparency: significant net short positions in EU sovereign bonds will have to be reported to regulators. This also includes notification of significant short positions taken through sovereign CDSs. The regulation provides for information to be disclosed to regulators only, as

16 On 19 December 2012 the European Commission adopted the relevant regulatory and implementing technical standards.
17 However, non-financial firms (such as manufacturers), which use OTC derivatives to mitigate risk arising from their core business activities ("commercial hedging" used to protect against exchange rate variations for example), are exempt from the CCP clearing requirements.

public disclosure could have negative consequences for the operation of sovereign bond markets, notably in terms of liquidity. Market-making activities and primary market operations are under certain conditions exempted from this restriction.

- Restrictions on uncovered short selling of sovereign debt: in order to reduce the risks of settlement failure and increased price volatility associated with naked short selling, certain restrictions are introduced. To enter into a short sale of sovereign debt, an investor must have borrowed the instrument concerned, entered into an agreement to borrow it, or have an arrangement with a third party to locate the sovereign debt or otherwise have a reasonable expectation of settlement when it is due. Market-making activities and primary market operations are under certain conditions exempted from this restriction.

- Restrictions on uncovered sovereign CDSs: to reduce any adverse impact on the stability of sovereign debt markets, the regulation prohibits investors from entering into uncovered CDS positions. Uncovered (or "naked") sovereign CDS positions refer to such positions that do not serve to hedge exposures to the underlying debt or other correlated assets or liabilities. Market-making activities and primary market operations are under certain conditions exempted from this restriction.

- Powers for regulators and a coordinated European framework: in exceptional situations, competent authorities (i.e. financial regulators) are given powers to impose temporary measures such as requiring further transparency or to ban short selling and sovereign CDS transactions. These powers extend to a wide range of financial instruments, and are subject to coordination by ESMA. In addition, competent authorities are given the power to impose a short-term restriction on short selling of a financial instrument in the case of a significant price fall of that instrument on a trading venue. Such a "circuit-breaker" would enable competent authorities to intervene to ensure that short selling does not contribute to a disorderly fall in the price of the instrument concerned. Competent authorities may temporarily lift the restrictions on uncovered short sales in sovereign debt when the liquidity of the sovereign debt falls below a certain threshold, and they may also temporarily lift the restrictions on uncovered CDSs when these restrictions negatively impact the functioning of the sovereign debt market.

### c) Revision of the Markets in Financial Instruments Directive (MiFID)

MiFID establishes a regulatory framework for the provision of investment services in financial instruments (such as brokerage, operating trading venues, dealing, advice, portfolio management, underwriting, etc.) by banks and investment firms and for the operation of regulated markets by market operators. It also establishes the powers and duties of national competent authorities in relation to these activities. MiFID/R will improve the organisation, transparency and oversight of various market segments, especially in those instruments mostly traded OTC. MiFID/R complements the legislative framework on OTC derivatives, CCPs and trade repositories.

It is mainly the provisions concerning transparency and trading in the regulation (MiFIR) that may affect the CDS market. MiFID/R will impose pre- and post-trade transparency requirements on all financial instruments, notably bonds and derivatives which are traded on organised venues. These requirements will be calibrated by instrument and trading model. For standardised liquid derivatives, there will be a requirement to trade them on organised venues.

The proposal is currently under discussion in the European Council and Parliament.

### B) In the United States

Title VII of the Dodd-Frank Act sets out a comprehensive reform of the OTC derivatives market. It aims to fulfil the G20 commitments that all standardised OTC derivatives should be cleared through

CCPs by end-2012 and that OTC derivative contracts should be reported to trade repositories (TRs). In a nutshell, the new framework requires:

- registration of OTC derivatives dealers and adherence to business conduct rules;
- a clearing obligation for derivatives: the regulators have to determine which OTC derivatives are subject to the clearing obligation;
- a reporting obligation: any swap must be reported to a registered TR;
- risk-mitigation measures for uncleared trades (capital and margin requirements on swap dealers);
- a regulatory framework for CCPs;
- a regulatory framework for TRs.

The effective date for implementation of rules in these areas is 360 days after enactment of the Dodd-Frank Act or 60 days after publication of the final rule if rule-making by regulatory bodies is required (see below). Therefore, certain provisions of the Dodd-Frank Act took effect on 16 July 2011 (360 days after enactment), but most provisions will be effective once the required rules have been made by federal regulators. The federal regulators responsible for issuing the application rules of the Dodd-Frank Act provisions regarding OTC derivatives are the Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CFTC). The SEC is in charge of the regulation of swaps on single names or a narrow-based index of securities (e.g. a derivative of nine or fewer securities), while the CFTC is in charge of the regulation of swaps on non-securities (e.g. currencies, interest rates) or a broad-based index of securities. Some mixed swaps (swaps that share characteristics of both) may be under shared regulation by both agencies. A lot of work in the US has been dedicated to the definition of swaps in order to distinguish swaps under the regulation of the SEC from swaps under the regulation of the CFTC.

The SEC issued a complete set of proposals in May 2011, which are still under discussion. The CFTC adopted on 13 January 2012 a final rule on swap data recordkeeping (SDR) and reporting requirements, which applies to swap data recordkeeping and reporting requirements for swap data repositories (SDRs), derivatives clearing organisations, designated contract markets, swap execution facilities, swap dealers, major swap participants, and swap counterparties which are neither swap dealers nor major swap participants. The recordkeeping and reporting requirements of this rule meet the goals of the Dodd-Frank Act to reduce systemic risk, increase transparency and promote market integrity within the financial system. The fundamental goal is to ensure that complete data concerning all swaps subject to the CFTC's jurisdiction are maintained in SDRs, where it would be available to the regulators. For that purpose, records relating to swaps should be registered throughout the existence of each swap and kept for five years following final termination or expiration of the swap. Three "unique identifiers" have been created in connection with swap data reporting at the time a swap is executed: a unique swap identifier (USI); a unique counterparty identifier (UCI); and a unique product identifier (UPI). These identifiers will be crucial regulatory tools for linking data together and for mitigating systemic risk and preventing market manipulation. A similar approach is foreseen for the EU under EMIR.

### C) Other countries

Along with the United States, Japan is the only other jurisdiction that has adopted legislation mandating disclosure (use of an electronic trading platform for OTC derivatives markets), trade reporting and central clearing of standardised OTC derivatives, although such legislation does not apply to all standardised OTC derivatives, as required by the G20 commitments. Brazil, Japan and the US already have legislation in place requiring reporting of OTC derivatives to a TR. Other jurisdictions, including Argentina, China and India, have rules in place requiring reporting of certain derivatives to a TR-like platform. At the time of writing, most small jurisdictions have indicated that they are waiting for the frameworks in the US and the EU, the two largest OTC derivatives markets, to be fully in place before they finalise their own systems.

Both the Dodd-Frank Act and EMIR seek to implement the commitments made by G20 leaders with regard to the standardisation and clearing of all OTC derivatives contracts. It is worth noting that unlike in the US, many aspects of OTC derivatives trading, advice and dealing were already regulated in Europe. In addition, a certain number of EU reforms in relation to OTC derivatives, including an exchange trading requirement for standardised OTC derivatives, will be implemented through a set of amendments to the Markets in Financial Instruments Directive (Directive 2004/39/EC, "MiFID"), generally referred to as MiFID II. Finally, the EU Short Selling Regulation regulates certain aspects of sovereign CDSs.

All in all, there is significant commonality in the approaches adopted by the proposed EU Regulation and the Dodd-Frank Act in relation to the regulation of OTC derivatives markets, but there are also some significant differences. Both the US and EU measures have some degree of extraterritorial application; however, non-US CCPs do not benefit from a mutual recognition regime. In the absence of agreement between the US and EU regulators, extraterritoriality has the potential to have undesirable impacts on the derivatives industry.

### Working group initiatives

In May 2011 the Committee on Payment and Settlement Systems and the International Organization of Securities Commissions (CPSS-IOSCO) issued two consultative reports containing guidance to promote consistent interpretation and implementation of their recommendations when they apply to OTC derivatives (one report for CCPs that clear OTC derivatives and one for TRs for OTC derivatives).

In April 2012 CPSS-IOSCO published Principles for Financial Market Infrastructures, which set international standards for the risk management of CCPs, central securities depositories and payment systems, and in July 2012 a consultative report on the recovery and resolution of financial market infrastructures.

Earlier, in January 2012, they published the final report on the OTC derivatives data that should be collected, stored and disseminated by TRs. The report reflects recent international developments in data reporting and aggregation requirements (stemming from the Legal Entity Identifier (LEI) workshop in September 2011) and other efforts under the auspices of the FSB.[18] The requirements and data formats will apply both to market participants reporting to TRs and to TRs reporting to the public and to regulators. The report also finds that certain information currently not supported by TRs would be helpful in assessing systemic risk and financial stability, and discusses options for bridging these gaps. It finally covers the mechanisms and tools that the authorities will need for the purpose of aggregating OTC derivatives data.

The standard-setting bodies (the Basel Committee on Banking Supervision (BCBS), the Committee on the Global Financial System (CGFS), the CPSS and IOSCO) have recently issued several reports dealing with central clearing and TRs. Following the Cannes G20 Summit, IOSCO published an overview of the CDS market, which was submitted to the G20 Summit on 18-19 June 2012 in Los

18 As the report indicates, some questions remain regarding how best to address current data gaps and define authorities' access to TRs. As requested by the G20, two internationally coordinated working groups will address these questions in the coming year. The FSB has established an ad hoc group of experts to further consider means of filling current data gaps, while the CPSS and IOSCO have established a joint group to examine authorities' access to trade repositories.

Cabos, Mexico, and published afterwards.[19] In addition, the BCBS/IOSCO joint Working Group on Margining Requirements (WGMR) published a consultative document, which presents initial policy proposals aimed at establishing minimum standards for margin requirements for non-centrally-cleared derivatives. These proposals were developed in consultation with, and with the active participation of, the CPSS and the CGFS.

### b. Current industry practices

Hedging credit exposures with CDSs within a bank's balance sheet is a common practice. But this can be disruptive for the market, especially when considering that:

- potential imbalances between market participants' supply and demand may eventually lead to a feedback loop: CVA (Credit Valuation Adjustment) desks have a large impact on the relatively small CDS market;

- hedging practices are not always rigorously related to the underlying risk (macro hedging).

Furthermore, the experience with JPMorgan's trading of CDS index instruments has also highlighted a few challenges.

#### Two-way Credit Support Annex contracts reduce the need for hedging counterparty risk

According to market participants, OTC transactions are in general covered by a Credit Support Annex (CSA), which is a contract governing collateral arrangements between counterparties. Between frequent users, these contracts are two-way agreements, i.e. each entity is required to post collateral to the other to match the net exposures that arise as a consequence of a derivative position.

However, the majority of sovereigns do not post collateral (one-way contract) to support their use of OTC derivatives (e.g. swap arrangements), while their counterparties (the banks) have to. It is also noteworthy that, according to bank dealers, big corporate accounts do not sign CSAs either and therefore do not post collateral. As a consequence, when a derivative's mark-to-market position is in favour of the bank, the sovereign or the corporate does not have to pledge any collateral, which gives rise to a credit exposure for the bank. The remaining counterparty exposure can be significant due to the notional size of the market and most of the big dealers have established CVA desks to manage that position on a daily basis.

19 "The credit default swap market", OICV-IOSCO, June 2012.

### Box 6: Credit Valuation Adjustment and the CVA-CDS feedback loop

When a bank enters into any contract with a counterparty, it becomes exposed to counterparty credit risk arising from the failure of the latter to perform on the contract. The Credit Valuation Adjustment (CVA) is the market value of this counterparty credit risk. Banks currently calculate and manage CVA risks according to different business models and subject to different accounting regimes. Various large banks manage their CVA risks as part of their trading books, through daily marking to market, active hedging, enforced market risk limits and transfer-out of CVA risks. Some banks have opted for a central CVA desk. Others have opted for a CVA desk deployed in their main business units.

Banks that mark CVA to market are subject to the volatility of market prices. Consequently, these banks may want to hedge CVA risks beyond the events of counterparty default. But some hedges are not risk free and the recent crisis showed that CVA-related losses can be large, in some cases larger than the default losses that they tried to hedge.

Basel III will introduce a capital charge for CVA. It allows two methods to calculate the CVA requirement, one internal model-based (advanced) and the other non-internal model-based (standardised). The advanced method requires that the CVA requirement be modelled by using, among other inputs, market-observed CDS spreads to calculate counterparty risks. It also allows banks to mitigate the capital requirement by buying CDS protection. The standardised method is implicitly ratings-based. Based on the EBA's Basel III monitoring data, only nine banks in the EU have permission to use the advanced method. These are the biggest banks and their resultant CVA requirement under the advanced method covers less than half of the CVA capital requirement for the EU banking sector (hence, less than half of sovereign derivative exposures are dealt with by the advanced method).

The relationship between the CVA and CDSs has been named the “CVA-CDS feedback loop”. The loop arises on uncollateralised trades with the nine big banks that use the advanced method, where the counterparty exposure (and consequently the associated capital charge) is the highest. Corporate and sovereign counterparties for instance typically cannot or will not post collateral. In such a case, the only way for these banks to reduce the CVA capital charge on trades with those counterparties is to buy CDS protection. However, since the CVA charge is partly based on the volatility of CDS spreads, a surge in demand for protection may drive their capital charge up, leading banks to buy more CDS protection, and so on and so forth.

The CVA-CDS feedback loop, though it is difficult to measure accurately, is thought to be a product of mark-to-market practices. There are, however, a couple of points that suggest that this feedback loop may not be so strong:

- the jump in demand for CDSs may not be immediate and steep, because the same large banks that use the advanced CVA method already buy sovereign CDSs to mitigate the CVA risk in their own internal risk management;

- to the extent that demand will increase, it does not mean that the CDS market will not be able to grow and accommodate it. Calculations by IMF staff show that sovereign CDS open interest grew markedly from 2008 to 2011, though it seems to have been stable over the recent quarters.

National treasuries sometimes enter into large derivative contracts, which may lead their counterparties (the banks) to take offsetting positions in CDS contracts. The dealer banks have been requesting the signature of two-way CSAs for some time. The need to hedge CVA risk with CDSs will become less pronounced as more sovereigns move to two-way CSAs, which reduce the exposure and hence the CVA charge. So far, very few public entities (a few Member States such as Hungary, Ireland, Portugal, Sweden and the United Kingdom, government agencies, central banks, public companies, etc.) have agreed to sign such two-way CSAs and committed to posting collateral. Some other Member States are considering using them.

A survey carried out by the International Swaps and Derivatives Association and the Association for Financial Markets in Europe on the largest derivatives dealers (G14) found that one-way CSAs relating to European sovereign derivatives may drain as much as USD 70 billion from the financial system. The total exposure is partially hedged as banks do not usually buy CDSs on their own sovereign. However, it is difficult for supervisors and regulators to reconcile these figures. A mandatory two-way CSA may solve the alleged problems and may also increase the transparency of the transfer cost of these transactions between dealers and users.

### A (too) easy recourse to macro hedging/sovereign CDSs

A specific credit exposure can be hedged either with a single-name CDS (e.g. an exposure towards a bank being covered by the same-name CDS) or with a CDS highly correlated to the underlying asset. These "proxy hedging" techniques allow a specific asset exposure to be covered by a single-name CDS of another asset (i.e. hedging the exposure to a bank with the CDS of another bank), to be covered by an index CDS or the related sovereign CDS.

This practice is known among market participants as "macro hedging." Dealers and CVA desks may be using sovereign CDSs as their main tool for hedging their risks, as other alternatives – single-name and index CDSs – are currently highly correlated with the sovereign. Although hedging counterparty risk with a sovereign CDS does not generate a perfect offsetting position, macro hedging is widely used for several reasons:

- not only national treasuries, but also many public institutions and companies, have no CSA or only a one-way CSA and no CDS on their name. A sovereign CDS is then considered a good proxy hedge by market participants;

- hedging a risk on a financial counterparty with a sovereign CDS can be a close proxy hedge if those banks have close links to their state (too big to fail);
- sovereign CDSs are often more liquid than single-name or index CDSs (narrower bid-offer spread and/or larger tradable sizes) and have the largest trade size;
- if a sovereign CDS lacks liquidity, markets participants may use another sovereign CDS, when correlation between countries is high. It cannot be excluded that such cross-country hedging may partially contribute to cross-border contagion effects. Going forward, this risk should be reduced by the new Regulation on short selling which limits the cases where the use of cross-country hedging is not considered to give rise to an uncovered sovereign CDS position and hence is allowed.

It seems that the risk management of banks exerts no constraints on hedging a specific risk with a CDS that hedges another specific risk, as long as the two risks are correlated. This practice may explain part of the growing usage of sovereign CDSs and this practice may contribute to feedback loops of contagion and potential imbalances in the market.

Whereas the protection buyers cover many different risks with a sovereign CDS (corporate, financial, another sovereign), CDS issuers only focus on the risk attached to the sovereign debt. Consequently, the demand may overshoot the supply on this market and the price of the hedge will thus increase, generating a market signal of growing risk of a sovereign. The interaction between the sovereign CDS and the underlying sovereign bond is difficult to assess as there is no data repository, such as DTCC, for EU sovereign bonds.

Box 7 below draws additional lessons from JPMorgan's 2012 CDS losses from a risk management perspective.

**Box 7: JPMorgan's CDS losses and lessons for CDS risk management**

In May 2012 JPMorgan surprised markets by announcing that it was facing significant mark-to-market losses in the synthetic credit portfolio managed by its Chief Investment Office (CIO). This box briefly summarises the facts known so far and discusses some possible risk management lessons.[20]

**Background on the investment strategy**

In the first quarter of 2012 JPMorgan Chase & Co. had USD 1,100 billion in deposits and USD 720 billion in loans, with the bulk of the USD 0.4 trillion difference driving its USD 375 billion CIO securities portfolio. Investments were in high-grade, low-risk securities. In addition to hedging interest rate, FX, basis or convexity risk, the CIO had entered into positions to mitigate a significant credit stress event. Specifically, the aim of the synthetic credit portfolio was to hedge some of the credit risk in JPMorgan's CIO investment portfolio. For this purpose, the CIO entered into long and short positions in CDS indices, tranches and related instruments. These synthetic positions were taken by means of buying/selling protection on US CDX indices (investment-grade and high-yield pools) or the European iTraxx index. Hence, the CIO's strategy was to trade portfolio credit risk via index products, e.g. via a long position in investment grade, which partly funded a short position in high yield. The net notional size of these synthetic positions amounted to USD 51 billion (for comparison, shareholders' equity amounted to around USD 180 billion). As this size estimate is based on the assumption that all netting arrangements function as designed, it indicates the risks incurred simply due to the magnitude of the positions.

By late December 2011 the CIO was revising its strategy because it had a more positive view of the economic outlook, and because JPMorgan overall had started to reduce its risk-weighted assets. For this repositioning, traders significantly increased both the overall notional size and the long exposure of the portfolio. In late March the Head of the CIO suspended trading in the portfolio as losses had started to materialise.

In early April the Wall Street Journal and Bloomberg were starting to report about the CIO's trading and specifically about one trader, who due to the size of his positions was referred to as the "London Whale".

In May JPMorgan publicly revealed that the synthetic credit portfolio had significant mark-to-market losses, and that the portfolio had proven to be riskier, more volatile and less effective as an economic hedge than it had previously believed. On 13 July JPMorgan announced that it would be restating its first-quarter net income, to lower it by USD 459 million. At the same time, the firm also announced that cumulative year-to-date losses in the portfolio through 30 June 2012 amounted to USD 5.8 billion.

**Tentative lessons from a risk management perspective**

From the perspective of firm-level risk management, valuation of the synthetic portfolio was a key issue. Overall, the CIO had built up sizeable positions without the proper tools and framework in place. Hence it ultimately proved unable to properly monitor, control and manage the sizeable risks it faced. Specifically, in terms of its risk management approach, the modelling of the portfolio's VaR as well as the valuation of positions proved to be highly problematic. For example, price quotes for valuing the positions were sometimes too optimistic and the valuation process also relied on the use of error-prone spreadsheets. As regards its VaR model, several deficiencies came to light in the course of early 2012. These related to the model's description of liquidity, default and correlation risks.

In addition to these specific firm-level issues, the incident also highlighted broader challenges in monitoring the activity in the CDS market. One issue is the necessity for a comprehensive analysis of position data by the competent supervisory authorities. In particular, according to analysis of the publicly available DTCC data, the build-up of positions in certain index instruments was visible in the evolution of notionals.

20 JPMorgan's report, which was published on 16 January 2013, is available at: http://files.shareholder.com/downloads/ONE/2272984969x0x628656/4cb574a0-0bf5-4728-9582-625e4519b5ab/Task_Force_Report.pdf

### c. Financial stability issues related to netting

#### Close-out netting and worldwide monitoring of derivatives payable for any single party

As discussed earlier in the context of the EBA sample analysis, an important risk-mitigation mechanism is bilateral or even multilateral netting. According to the ISDA Master Agreement, all transactions with a party should be netted down to a single amount in the event of a default of that counterparty (close-out netting). This means that counterparty risk can be measured by the net derivatives receivable less any collateral posted. This is the case for each individual party vis-à-vis its counterparties, but also for the whole system vis-à-vis any individual party.

From a systemic risk perspective, the counterparty risk is the risk to others in the global system if an individual financial institution defaults on its obligations. This can be measured by the total derivatives payable by any individual market party.[21] It may be advisable for supervisors to cooperate to monitor this risk worldwide. In this respect, the lack of comprehensive information about collateral related to CDSs places a serious limitation on the ability of supervisors to effectively monitor this risk.[22] On the other hand, close-out netting may incur general systemic risk and cause uncertainty within the financial markets. Close-out netting contains contagion through the CDS channel, but interacts with the seniority of other debtors in the event of a bank default. Consequently, if a bank is perceived to be near default, there is an incentive to trade with this institution via derivatives, rather than providing any kind of funding. This may increase the cost of funding dramatically and drive the institution towards insolvency. In that case, senior bondholders, deposit guarantee schemes and uncovered depositors will all face a situation where there are fewer assets to repay their claims. If these senior bondholders are other financial institutions, it may also generate unintended contagion, financial instability and uncertainty as the rate of recovery on any investment is unclear.

#### Despite close-out netting, there will be asymmetry when a default is near

Despite close-out netting, there may still be some sort of asymmetry between derivatives payable and receivable. Already when market participants are in distress, their counterparties will tend to try to terminate the contracts that are in their favour and will leave the other contracts in place. This means that when there is serious market stress or when there is a significant decrease of creditworthiness of a single party, derivatives payable may underestimate the true risks.

## 5. Policy assessment

#### Monitoring contagion risk

Macro-prudential analysis of the CDS market requires granular data on bilateral exposures at a timely frequency, as they are currently provided by DTCC. The upcoming availability of information on collateral will allow for a better appreciation of credit risk.

From a systemic perspective, the analysis of the CDS market in isolation limits the range of possible policy conclusions. In particular, the multifaceted nature of interconnectedness is difficult to capture in existing analytical frameworks. First, to better understand risk transfer and risk-bearing capacity, it would be necessary to know whether CDS exposures arise from proprietary trading, market-making or hedging. In the latter case, positions in other assets with opposite risk profiles could be offsetting the risk incurred in the CDS positions. Second, counterparty credit risk is also material in other OTC derivatives markets, where the share of CCP-cleared transactions is still relatively small. For instance, a variety of related contagion channels (e.g. bond exposures or collateral mechanisms in

[21] For example, total derivatives payable for AIG in 2008 amounted to about USD 31 billion.

[22] However, pursuant to the EMIR implementing technical standards on the minimum details of the data to be reported to trade repositories recently adopted by the European Commission, market participants will, in the future, have to report detailed information on collateral to trade repositories.

the case of sovereign CDSs) are of relevance, but difficult to capture with currently available disclosures.

Importantly, indirect contagion channels through price and funding effects further amplify direct domino effects captured by network models. The funding position of market participants, especially their liquidity mismatch, is important. Market participants with a large liquidity mismatch amplify the initial shock as their response to a negative shock is to fire-sell assets. On the other hand, market participants with a low liquidity mismatch hold on to their assets and hence absorb shocks. In the medium term, it is therefore important to extend the analysis along the lines of the risk topography outlined in Brunnermeier, Gorton and Krishnamurthy (2012).

Overall, the complex nature of interconnectedness provides significant challenges. Hence, from a systemic risk perspective, a holistic view of the exposure map is required.

### Mitigating contagion risk

Network analysis of the DTCC data shows that the EU CDS market is centred around fifteen super-spreaders which fall into three categories: (i) banks from the FSB's G-SIBs list; (ii) other banks; and (iii) non-bank super-spreaders, e.g. asset managers. Smaller counterparties are typically only active in a few reference entities and trade with a few major counterparties.

A comprehensive assessment of the risk-bearing capacity of super-spreaders poses a number of difficulties. First, the high amount of net (and even more so gross) exposures for these market participants relative to their capital suggests significant risks incurred by their CDS trading. Second, the future G-SIB surcharge, which will be applied to some of the bank super-spreaders, is likely to capture not only the size of exposures but also the degree of interconnectedness, thereby eventually mitigating related risks. Third, the systemic nature of G-SIBs provides them with an added level of implicit protection, which may be difficult to assess quantitatively.

At the current juncture, the role and contribution to systemic risk of non-bank super-spreaders is unclear. On the one hand, diversity in the form of different types of market participants makes the system more robust. On the other hand, there is very little information about the trading strategies and stress resilience of non-banks.

Widespread CCP use should mitigate counterparty credit risk to the extent that most CDSs are centrally clearable. The vital role of CCPs as circuit-breakers also puts particular emphasis on the quality of their risk modelling/policy and their collateral management.

A credit event in the CDS market can proceed quite smoothly. This was specifically illustrated by the market's resilience after the Greek credit event. Hence, one lesson of the Greek credit event is that the threat of contagion can be reduced by means of transparency, as seen with the EBA Capital Exercise. Moreover, the auction process and closing-out of CDS contracts are pivotal to the resilience of the CDS markets.

Overall, however, significant contagion in/from the CDS market cannot be ruled out. One the one hand, contagion risk is potentially kept low by the usually limited level of net exposures relative to capital. Thus, unless a major sovereign reference entity is affected, it is difficult to trigger widespread contagion. On the other hand, super-spreader institutions are heavily exposed to counterparty risk and linked by a complex network structure, making them vulnerable to contagion risk.

In sum, the contagion assessment for the CDS market is consistent with findings for the interbank market where the somewhat mechanical scenario analysis usually produces low estimates of the systemic impact of default cascades. Despite these modest contagion estimates, interconnectedness in the interbank market is usually perceived as an important element of the financial system's risk-bearing capacity as behavioural effects or confidence channels may play an adverse role in an episode of systemic stress.

Other regulatory initiatives may provide additional tools to mitigate contagion risk (such as the large exposures regime in Basel III). In this respect, it is important to factor in the network characteristics and properties of interbank exposures so as to strike the right balance between mitigating contagion risk and preserving banks' dealer role in the CDS market. In particular, for scale-free networks to be sustainable, connectivity needs to preserved in times of stress.

There are also some policy issues related to hedge effectiveness (e.g. ISDA credit event definition). Additional risk may also stem from "macro" or "proxy" hedging, which may call for developing the CDS market so as to increase the number of reference entities.

## Annex: List of Members of Expert Group on CDS

The report has benefited from the input of the entire team listed below, with the authors being marked with an asterisk

| | |
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