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Credit Default Swaps: A Survey

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Abstract

Credit default swaps (CDS) have been growing in importance in the global financial markets. However, their role has been hotly debated, in industry and academia, particularly since the credit crisis of 2007–2009. We review the extant literature on CDS that has accumulated over the past two decades. We divide our survey into seven topics after providing a broad overview in the introduction. The second section traces the historical development of CDS markets and provides an introduction to CDS contract definitions and conventions. The third section discusses the pricing of CDS, from the perspective of no-arbitrage principles, structural, and reduced-form credit risk models. It also summarizes the literature on the determinants of CDS spreads, with a focus on the role of fundamental credit risk factors, liquidity and counterparty risk. The fourth section discusses how the development of the CDS market has affected the characteristics of the bond and equity markets, with an emphasis on market efficiency, price discovery, information flow, and liquidity. Attention is also paid to the CDS-bond basis, the wedge between the pricing of the CDS and its reference bond, and the mispricing between the CDS and the equity market. The fifth section examines the effect of CDS trading on firms' credit and bankruptcy risk, and how it affects corporate financial policy, including bond issuance, capital structure, liquidity management, and corporate governance. The sixth section analyzes how CDS impact the economic incentives of financial intermediaries. The seventh section reviews the growing literature on sovereign CDS and highlights the major differences between the sovereign and corporate CDS markets. In the eight section, we discuss CDS indices, especially the role of synthetic CDS index products backed by residential mortgage-backed securities during the financial crisis. We close with our suggestions for promising future research directions on CDS contracts and markets.

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1

Introduction

Two decades have passed since the first *credit default swap* (CDS) contract was traded in 1994 [Tett, 2009]. The market has grown spectacularly, especially since 2000. It went through a boom in 2001–2007, followed by a bust after the 2008 Lehman bankruptcy. Most importantly though, the market has proved resilient in the face of several major shocks and corrections. The Russian default in 1998, the Conseco Finance restructuring in 2000, the 2008 AIG bailout, and the 2012 Greek default all contributed to shaping the formalization of CDS contracts and their trading procedures as we know them today. The seminal study by Longstaff et al. [2005], which used CDS as a tool to disentangle credit from liquidity risk in corporate yield spreads, is by far the most cited paper on CDS, and it provides an excellent introduction to the CDS contract and its market. Since the publication of their paper, the CDS literature has blossomed. Accordingly, our survey mostly covers studies in the last decade.

Our attention is first dedicated to the structure of the CDS market. In particular, we explain the many colorful subtleties of CDS contracts and we document the development of the contract templates. We also describe the *over-the-counter* (OTC) nature of the CDS market, and the controversies surrounding contract settlements via CDS auctions, which is one of the many emerging research debates that the CDS literature has stimulated. The CDS market has likely faced its toughest test with the 2007–2009 credit crisis, as it was heavily criticized for facilitating the creation of synthetic mortgage-backed securities (MBS). However, the role of CDS was also controversial during the sovereign default episodes of Greece and Argentina, as "naked" CDS buyers in particular were blamed for speculating on government defaults and artificially driving up their borrowing costs. Another scandalous landmark in the CDS history is the 2012 J.P. Morgan "London Whale" CDS trading loss. In the post-crisis period, a regulatory overhaul has been implemented both in the United States (U.S.) and in the European Union (E.U.). First came the CDS "Big Bang" and "Small Bang" in 2009, which pushed for further standardization of the CDS contract; then came the temporary ban on naked CDS in Germany, made permanent by the E.U. in 2011. CDS have become the subject of many financial regulations, including the Basel III bank regulations and the Dodd-Frank Act.

Participants in the U.S. CDS market have arguably seen the biggest structural change in CDS history in 2013, with new rules forcing the use of central counterparties (CCPs) and new trading platforms. Central clearing for index CDS was introduced in 2013 with the mandatory use of a swap execution facility (SEF) for some contracts. Also, 2014 marks a new era for CDS trading, as contracts designated as "made available to trade" (MAT) have had to be traded on SEFs or Designated Contract Markets (DCMs) since February 26, 2014. The new ISDA 2014 Credit Derivatives Definitions were announced to go live in September 2014. However, the default of Argentina in July 2014 complicated the matter and forced existing sovereign contracts to comply with the older 2003 Definitions.

The pricing of CDS is by far the most understood issue in the literature, which is partly due to the tight relationship between CDS and corporate bonds and a vast literature on the determinants of bond spreads. Early works used to view the CDS spread as a pure measure of credit risk, although it is today understood that many other factors are important in capturing both time-series and cross-sectional variation in

CDS spreads and their changes. A separate literature has emerged on the role of liquidity in CDS spreads, and how liquidity can affect price discovery. We discuss both the structural and reduced-form credit risk models that are used for CDS pricing and we discuss their predictions for the determinants of spreads that have been tested in the empirical literature. Other frictions such as counterparty risk are also discussed.

The relationship between the CDS and related markets, in particular the bond and equity markets, is intriguing and important. Even though theory predicts an accounting identity between CDS and bond spreads and a relationship between CDS and equity markets, investors saw significant price discrepancies during the financial crisis that appeared as great arbitrage opportunities. Price discrepancies were particularly strong between the CDS and bond markets, giving rise to the so-called negative CDS-bond basis. Understanding the basis requires a thorough analysis of the market differences. While the literature has made progress in understanding why the basis became negative, we are still far from understanding why it remained persistently negative for an extended period of time. In addition to pricing discrepancies, we also discuss the literature on information flow between CDS and related markets, and the related concept of price discovery. Finally, we examine how the inception of CDS has affected the pricing, efficiency and liquidity of closely related markets.

With the inception of CDS trading, market participants, both creditors and the firms themselves, have received access to credit risk transfer mechanisms. The ability to purchase CDS protection can change creditors' incentives and permits the creation of tough "empty creditors," enabled through the separation of cash flow from voting rights. The "empty creditor" debate is yet another important research issue that has gathered a lot of steam over the last years. We discuss it in detail, along with other implications of CDS trading for corporate finance and corporate governance. The CDS-induced changes in the debtor–creditor landscape affect credit supply, credit risk, and corporate policy.

We further focus our attention on the role of CDS for financial intermediaries, both banks and other financial institutions. In particular, we look at how the existence of CDS may change the risk-taking behavior of lenders or their credit supply. Alternatively, we show how banks may potentially exploit their informational advantage from customer relationships and how this can be reflected in CDS spreads. In general, it is interesting to observe that, although CDS were originally used by banks to hedge their loan risk, the use by banks nowadays is still rather limited, with CDS primarily used for trading purposes, and concentrated among a few dominant dealers.

We also dedicate an entire section to sovereign CDS. The interest in sovereign credit risk has been revived with the series of sovereign defaults in both emerging and developed countries during the last two decades. In particular, the European sovereign debt crisis was a major catalyst in generating many contributions to the literature. Sovereign CDS were no less controversial than corporate CDS during the 2008 meltdown. The fact that they technically allow speculation on a government default has led to important political debates with an effective ban on "naked" CDS in the E.U. Various dimensions of this default episode have opened up research questions that are starting to be addressed in the finance, economics, and legal literature. We attempt to patch the various angles of analysis together with the goal of providing a coherent and comprehensive picture of the existing results.

Many of the existing studies are on single-name CDS; we also review the literature on CDS index products. It is probably not surprising that the bulk of this literature has focused on the role of index products or collateralized debt obligations tied to the performance of mortgage-backed securities. CDS were particularly controversial during the financial crisis as they facilitated the creation of synthetic mortgage-backed securities. On the other hand, we will also discuss how CDS index products allowed the aggregation of information about toxic assets in the system and how this may have created a panic in the financial markets. The number of different products tied to CDS is growing and it is an exciting market to follow. J.P. Morgan even designed an exchange-traded fund (ETF) based on CDS contracts in August 2014.

There are several prior articles providing survey discussions about CDS. Das and Hanouna [2006] provide the first synthesis of the CDS literature with a focus on pricing. Stulz [2010] gives a great account of the role of CDS during the financial crisis. The focus of Bolton and Oehmke [2013] is on how CDS may affect the incentives of individual market participants, including end-users, debtors and creditors. Jarrow [2011] draws parallels between the CDS and actuarial insurance markets, and Augustin [2014] concentrates on the sovereign CDS literature. Griffin [2014] discusses research in accounting. However, previous reviews typically focus on only one specific aspect of the CDS market. This manuscript is more comprehensive in scope and covers all major research domains involving CDS.

2

The CDS Contract and Market Structure

CDS contracts were engineered in the early nineties by J.P. Morgan to accommodate the increasing demand for transferring credit risk. The first such instance was in 1994, when J.P. Morgan off-loaded its credit risk exposure to Exxon by paying a fee to the European Bank for Reconstruction and Development, which was willing to sell protection.[1] CDSs represent the simplest ("plain vanilla") instrument among the broad class of credit derivatives. Nevertheless, they remain, to date, the most widely used, and yet most controversial, among these products. While their proponents defend them as efficient vehicles with which to transfer and manage credit risk as well as means to widen the investment opportunity set, opponents denounce them as "poisonous," "toxic," "time bombs," "financial hydrogen bombs," or speculative bets that influence government default.[2] For the sake of this review, we

[1]There is some ambiguity about the precise date of the introduction, although the year of introduction of CDS contracts is generally taken as 1994, as noted by Tett [2009].

[2]See Soros [2009] and also Felix Rohatyn, a Wall Street banker employed at Lazard Frères, quoted in Tett [2009]. Warren Buffett refers to OTC derivatives more generally as "weapons of mass destruction" (see Berkshire Hathaway Annual Report for 2002, p.13, on-line at http://www.berkshirehathaway.com/2002ar/2002ar.pdf).

eschew such characterizations and stick to the factual definition of what they really are — insurance contracts offering protection against the default of a referenced sovereign government, corporation, or structured entity — and skirt around the polemics of the popular discussion of these products.

2.1 CDS contract

CDS are part of the OTC market and not traded on an organized exchange. Guidance on the legal and institutional details of CDS contracts is given by the International Swaps and Derivatives Association (ISDA).[3] ISDA also acts as a non-voting secretary for the various regional *Credit Derivatives Determination Committees* (DC), which deliberate over issues involving *Credit Events*, *CDS Auctions*, *Succession Events* and other related matters. ISDA has played a significant role in the growth of the CDS market by providing a standardized contract in 1992, the *ISDA Master Agreement*, which was updated in 2002, in order to provide OTC counterparties with a fully documented, yet flexible, contract as a basis for negotiating their derivatives transactions. Credit derivatives agreements are further guided by the 2003 *ISDA Credit Derivatives Definitions* ("The 2003 Definitions") and the July 2009 Supplement, and, going forward, the 2014 *ISDA Credit Derivatives Definitions* ("The 2014 Definitions").

Technically speaking, a CDS is a fixed income derivative instrument, which allows a protection buyer to purchase insurance against a contingent *credit event* on an underlying *reference entity*, by paying an annuity premium to the protection seller, generally referred to as the *CDS spread*, over the life of the contract. This premium is usually defined as a percentage of the *notional amount* insured (or in basis points), and can be paid in quarterly or semi-annual installments. The concept of a CDS is very much analogous to a widely used financial product, insurance on a car or a home. In the case of car insurance, the true analogy would be that the contingent event could be based on theft, accident or malfunction. In other words, different types of

[3]See www.isda.org

incidents would lead to an insurance payout. Further, the insurance contract could be based on several cars belonging to the same brand, rather than on an individual basis, where a contingency for any of the vehicles would trigger an insurance payment. Even if no such event occurred over the life of the contract, the insurance premium would still have to be paid periodically, as specified in the contract. Similarly, in the language of credit derivatives, you would purchase CDS protection on a company, the reference entity, for example, and if that company failed to meet its obligations for any of a predetermined set of its debt claims, default would be triggered and the payout would occur. More specifically, the CDS contract usually comprises a specific class of the firm's capital structure, such as the senior, unsecured, or junior debt obligations of the company, and references a particular amount of the insured debt, defined as the notional amount.

In general, the failure of an entity to meet its debt obligations is labeled a credit event. Consequently, a credit event triggers a payment by the protection seller to the buyer equal to the difference between the notional principal and the value of the underlying reference obligation, also called the *loss given default* (LGD). In practice, the occurrence of a credit event must be documented by public notice and notified to the investor by the protection buyer. Amid the class of qualifying credit events are bankruptcy, failure to pay, obligation default or acceleration, repudiation or moratorium (for sovereign entities), and restructuring, and thus they represent a broader definition of distress than the more general form of Chapter 7 or Chapter 11 bankruptcy in the U.S.[4]

The settlement of CDS contracts may occur in two ways: *cash settlement* or *physical delivery* of one among a set of deliverable *reference obligations*. In the case of a cash settlement, the monetary exchange involves only the actual incurred losses and the claimant continues to hold on to the debt claim on the underlying reference entity's balance sheet. On the other hand, if the settlement is by physical delivery, the claimant transfers the obligation referenced in the contractual agreement to the insurer, and receives the full notional amount of the

[4]DCs of the ISDA are the final arbiters of whether a credit event has occurred or not.

underlying contract in return. The protection seller can then try to maximize the resale value of the debt claim received or continue to hold on to it. Conceptually, this is no different than with any put option seller, who is delivered the underlying asset upon exercise. This right implies that the claimant literally holds a *cheapest-to-deliver* (CTD) option, as he may deliver the least valuable bond among the defined set of eligible reference obligations.[5] This option is particularly relevant in the case of corporate restructuring, which is why the restructuring credit event is most critical in the pricing of CDS contracts. As a consequence, the contractual clauses attached to the restructuring credit event have been modified numerous times by ISDA, and there exist nowadays different types of restructuring clauses that can be defined in a CDS contract.

The CTD option is most severe in the so-called *Full Restructuring* (CR) credit event clause, which stipulates that any obligation with a maturity of up to 30 years can be delivered to settle a triggered CDS commitment. The reason is that long-dated bonds tend to be less liquid than comparable short-dated bonds and often contain a liquidity discount. An illustration of this CTD option was provided by the restructuring of Conseco Finance on September 22, 2000. At the time, CR was the only type of restructuring credit event available in the initial 1999 ISDA *Credit Derivatives Definitions* ("The Definitions"). The bank debt of Conseco Finance was restructured to the benefit of the debt holders. Yet, the restructuring event still triggered payments from outstanding CDS contracts. Protection buyers exploited this situation and made use of the CTD option created by the broad definition of deliverable obligations in order to obtain additional benefits by delivering the least valuable bond in the settlement. To address this issue, ISDA modified the CDS contract structure to include the *Modified Restructuring* (MR) credit event clause, which was introduced in the 2001 *Restructuring Supplement* to the 1999 ISDA Credit Derivatives Definitions ("The Restructuring Supplement"). Under MR, any restructuring is still defined as a credit event. However, the deliverable

[5] See Jankowitsch et al. [2008] for empirical evidence on the CTD option implicit in corporate CDS, and Ammer and Cai [2011] for similar evidence on sovereign CDS.

obligations are limited to those with maturities within 30 months of the CDS contract's remaining maturity. In March 2003, ISDA made another change and introduced the *Modified-Modified Restructuring* (MMR) clause into CDS contracts to relax the limitation on deliverable obligations to some extent. Under MMR, the deliverable obligations are restricted to bonds with maturities of up to 60 months within the CDS contract's remaining maturity for restructured debt, and 30 months for other obligations. Contracting parties may also agree to eliminate the restructuring credit event altogether from a CDS contract, in which case it is labeled *No Restructuring* (XR). Berndt et al. [2007] discuss the restructuring clauses and find a restructuring premium of about 6% to 8% of the CDS spread without restructuring.[6] Packer and Zhu [2005], on the other hand, find little evidence of pricing discrepancies across different restructuring specifications in their sample.

Irrespective of the type of settlement, the prices of the defaulted bonds usually suffer from wide market fluctuations, especially after default, and this makes it challenging to determine the precise value of the insurance settlement.[7] Over time, markets have converged to a practice where the mid-market value is obtained through a dealer poll conducted by ISDA soon after the credit event. Whether this pricing mechanism is efficient remains unclear, and this is discussed in detail in Section 2.4.

The contractual details of the 2003 Definitions are crucial, and as usual the devil lies in the details, as was recently proved in the case of the restructuring of Greek government debt. European officials pushed heavily toward a voluntary restructuring, in which case the restructuring would not have been binding on all bond holders with uncertainty about whether such an agreement would have triggered payments under existing CDS contracts.[8] We discuss in Section 7 why the CDS

[6] The restructuring premium is also illustrated using a case study of Ford Motor Company.

[7] This is similar to futures contracts, such as the Treasury bond futures contract, where the investor with the short position in the futures contract has the right to deliver the bond that is cheapest, after considering its conversion factor. See Jankowitsch et al. [2014] for an analysis of the recovery rates, or equivalently the LGD values for different credit events. See also Han and Wang [2014].

[8] See Greek Sovereign Debt Q&A, October 31, 2011, www.isda.org.

contracts did ultimately pay out. The landscape for CDS has further altered with the implementation of the *CDS Big Bang* and *CDS Small Bang* protocols on April 8, and June 20, 2009 for the American and European CDS markets respectively. The primary goal of these market changes, which brought about significant alterations in the contract and trading conventions, was to improve the efficiency and transparency of the CDS market. One of the major changes brought about by the new conventions was a standardization of the coupon payments. Thus, henceforth, the fixed coupon payments for U.S. single-name CDS were defined to be either 100 or 500 basis points, whereby any difference relative to the running par spread would be settled through an upfront payment. An important change in the U.S. CDS market has been the exclusion of restructuring as a standard credit event in the contractual CDS clauses. Another aspect of the Big and Small Bang Protocols was the hardwiring of the auction settlement mechanism into the standard CDS documentation. In addition, the responsibility for deciding upon the formal trigger of a credit event was fully attributed to the DCs. All market participants were heavily encouraged to sign up to the Big Bang protocol so that these changes could be applied to existing CDS contracts.

In 2014, ISDA proposed the most important changes to the CDS contract design in a decade [see Mahadevan et al., 2014], and published the 2014 Definitions in February 2014. The changes mainly related to European financial and global sovereign CDS. One of the key changes was a new credit event applicable to financial entities, i.e., governmental intervention to bail out the financial entity. Another important change is related to asset package delivery, so that any proceeds (deliverable or non-deliverable) received after a restructuring can now be delivered to settle a financial/sovereign CDS contract, if the original bond was deliverable. Moreover, under the new definition, senior CDS will be triggered based solely on whether the senior bonds of the entity are restructured. There were many other amendments made to the existing trading terms, including bond exchanges, succession and substitution events, among others. For instance, bond exchanges may be considered a credit event. At times, anecdotal evidence has suggested that CDS contracts have become worthless following corporate reorganizations, corporate takeovers, or initial public offerings. Such CDS contracts have become known as *orphaned* CDS. To reduce the risk of orphaned CDS following a merger, initial public offering or other corporate reorganization, ISDA has also introduced a set of changes relating to succession events. The concept of *universal successor* has been introduced to recognize the succession event when debt is transferred but identified outside the 90-day succession backstop window. To capture successions that occur gradually in stages, the 2014 Definitions have introduced a "Steps Plan" to determine successors based on a series of successions to reference entities or their obligations that may occur over a period of time.[9]

An interesting feature to highlight is that CDS contracts, along with other derivatives, enjoy special treatment in bankruptcy. While creditors are subject to *automatic stay* when firms file for bankruptcy, derivative counterparties have the right to terminate the contract and collect payment by seizing and selling collateral. Netting privileges and the treatment of "eve-of-bankruptcy" payments futher strengthen the position of the derivative counterparty with a positive credit balance.[10] Therefore, derivative counterparties are in a much stronger position than other claims under U.S. bankruptcy law. Bolton and Oehmke [2014] discuss the economic consequences of the super-senior treatment of CDS in bankruptcy. They analyze the problem in the incomplete contracts framework in corporate finance. In their three-period model, firms raise funds by issuing debt and hedge their exposure by purchasing derivatives. If there is no default at an interim date, firms obtain the continuation value at the final date. The super-senior treatment of derivatives transfers default risk from derivative counterparties to creditors. The priority ranking of derivative contracts matters because the counterparty that is providing hedging services necessarily has to post collateral, which is costly. Bolton and Oehmke [2014] show that, unless

[9]See Mahadevan et al. [2014] for a detailed discussion of these changes.

[10]As discussed in Bolton and Oehmke [2014], derivative counterparties can net offsetting positions and avoid payments to a bankrupt firm. Moreover, they have stronger rights regarding eve-of-bankruptcy payments. For example, derivative counterparties can keep any collateral posted to them at the time of bankruptcy filing.

counterparties receive large cross-netting benefits from being senior, the seniority of derivatives in default increases collateral requirements for counterparties that provide hedging services, and is, therefore, inefficient. In addition, the seniority of derivatives may induce the firm to speculate (rather than hedge) and can result in inefficient collateral calls by the derivative counterparty. Hence, firms must promise higher payments to the debt holders to compensate for this decrease in the value of the underlying assets of the firm. As a result, firms may, ex ante, have an incentive to rely on funding sources that benefit from this super-senior treatment, which is comparatively cheaper.

2.2 CDS market

The CDS market was relatively modest in 1997 with gross notional amounts outstanding in the order of $180 billion. Figure 2.1 provides a time-line of the major developments in the CDS market over the last two decades. The plot starts with the creation of CDS by J.P. Morgan in 1994. It shows the year of the publication of the first ISDA standardized CDS contract in 1999, with the subsequent Restructuring Supplement in 2001, as well as the Conseco restructuring event that we discussed previously. The CDS market experienced exponential growth from the early 2000s up to the financial crisis. The primary reasons behind this rapid increase in trading are likely twofold. On the one hand, ISDA published a new set of standardized CDS contract definitions in 2003. On the other hand, 2004 witnessed the onset of trading in a broader class of credit derivative index products, including synthetic collateralized debt obligations (CDO), for which CDS contracts are a crucial element. At the end of 2004, the total gross notional amount of CDS outstanding was roughly $6 trillion, as can be seen in Panel A of Figure 2.2.[11] The market witnessed three-digit growth rates in the following

[11] The gross notional amount outstanding may inflate the net outstanding amount substantially, and should be interpreted with caution. For example, in one prominent example of the default of Lehman Brothers Holdings Inc. in September 2008, a firm had about $72 billion in CDS written on it as obligor. However, when these were settled in October 2008 (with payoffs of $0.92 per $1 of principal), only about $5.6 billion actually exchanged hands.

years to reach about $60 trillion just prior to the onset of the financial crisis in 2007.

The size of the CDS market in terms of gross notional amounts of CDS outstanding dropped considerably after the 2008 crisis, in particular after the Lehman default, partly due to the fact that CDS contracts were central to the credit crisis.[12] Another major determinant of the drop of CDS market size was the regulators' concerns about central clearing and counterparty risk, following the Lehman bankruptcy, which led to significant portfolio compressions with the associated netting of counterparty risk exposures.[13] However, a similar decline was also witnessed in other derivative markets, although it was not as sharp. Panels B and C in Figure 2.2 further dissect the CDS market statistics by contract type and credit rating. Notional amounts for single-name CDS have also fallen from the record level of $33 trillion during the financial crisis to about $13 trillion in 2013. The trend for multi-name CDS, including index products, has been similar, although the decline has not been as strong as for single-name CDS. As a consequence, the market was almost equally divided between single-name and multi-name products in 2013, while single-name products made up the bulk of all transactions back in 2004, when multi-name CDS represented slightly less than 20% of the CDS market. This number had increased to 46% by 2013.[14] Panel C illustrates that most CDS contracts reference assets with credit ratings ranging between A and BBB, according to the statistics available from the Bank for International Settlements. The smallest category is comprised of rating categories AAA to AA.

Overall, the CDS market remains highly sizeable and proves to be robust to the financial crisis. According to the semiannual survey of the Bank for International Settlements, the gross notional amount of outstanding CDS contracts as of December 2013 is $21 trillion (with

[12]See also Burne and Henning [2014] for a recent discussion on the rise and fall of the CDS market and a "new setback" related to Deutsche Banks's intentions to reduce its single-name CDS trading activities.

[13]Portfolio compression refers to the process through which two counterparties cancel their existing contracts so as to replace them with new ones such that they reduce the number of contracts and gross notional value amounts outstanding, while maintaining the same net exposure and risk profile.

[14]We discuss multi-name CDS in detail in Section 8.

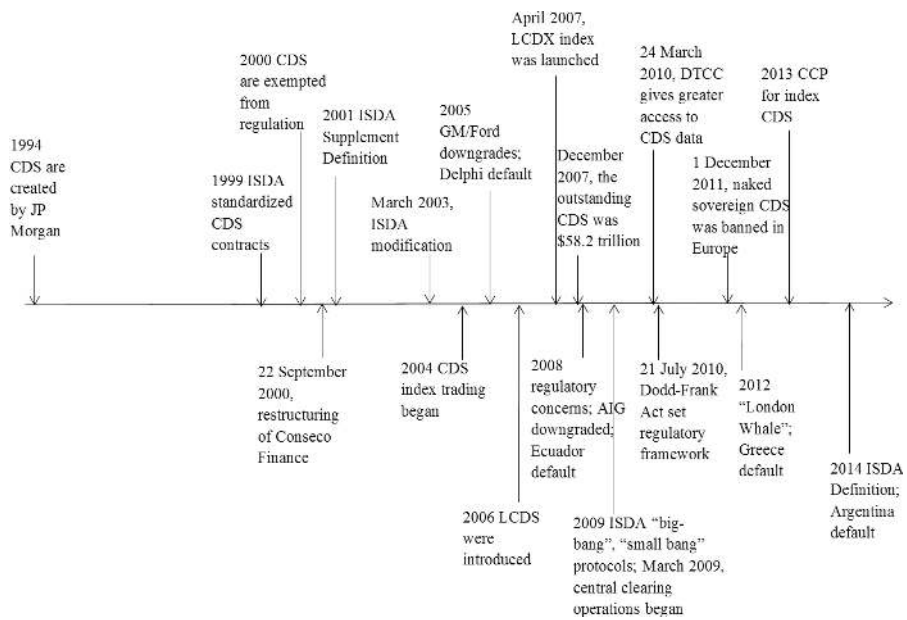
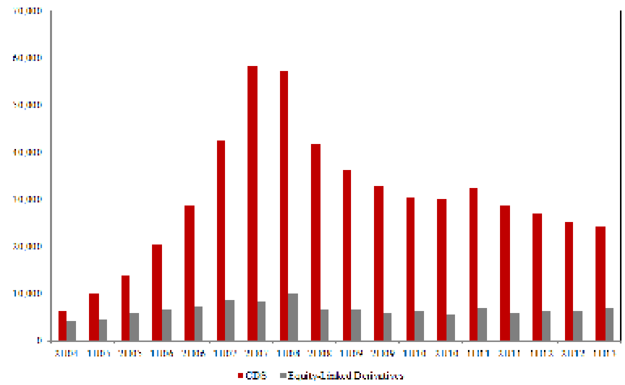
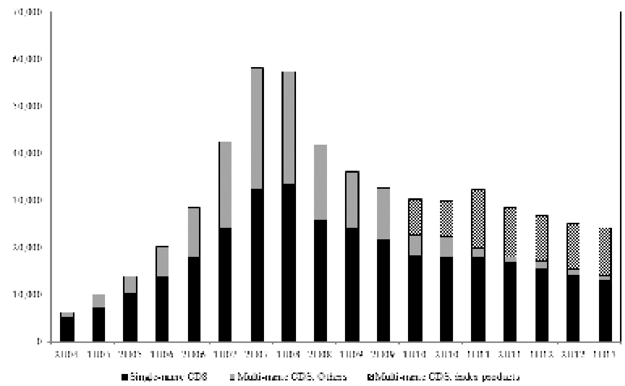


Figure 2.1: Timeline for the CDS market.
This figure presents a timeline of major developments in the CDS market from 1994 to 2014.

Panel A: All CDS



Panel B: Single-name and Multi-name CDS



Panel C: All CDS by Credit Ratings

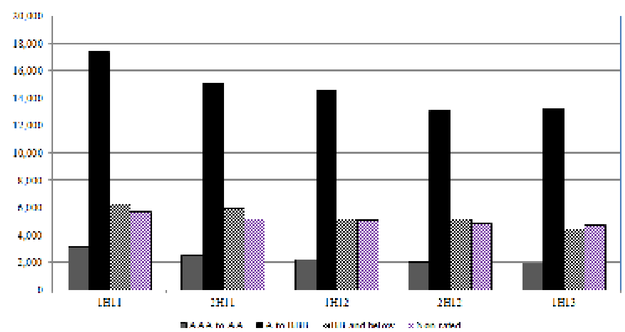


Figure 2.2: Global gross notional amount outstanding in the CDS market.
This figure presents the global gross notional amount outstanding in the CDS market in billions of U.S. dollars. The data are from the Bank for International Settlements (www.bis.org). Panel A presents the gross notional amount outstanding for all CDS contracts, as well as for all equity-linked derivatives. Panel B separates the gross notional amount outstanding of CDS for single-name and multi-name CDS. Panel C separates the gross notional amount outstanding of CDS by credit ratings.

gross market value of $653 billion and net market value of $139 billion), of which $11.3 trillion are single-name contracts and $8.7 trillion are index products. The recent central clearing practices have reduced the inter-dealer transactions and increased direct transactions of end-users with central counterparties. Central counterparties count for $5.5 trillion of the total market as of December 2013. Furthermore, the 2014 Definitions, introduced in September 2014, negatively impacted the size of the market. However, as we discuss later, the sector for sovereign CDS seems to have become more active in recent years. There are $2.6 trillion sovereign CDS outstanding, most of them are single-name, as of December 2013.

Initially, insurance companies were the main CDS protection sellers while commercial banks were the main buyers. However, hedge funds have increased their participation in the market. Several hedge funds, most notably, Saba Capital Management and BlueMountain Capital Management, use CDS as their main strategy. Recently, activist Carl Icahn disclosed that his investment firm traded CDS on high yield bonds.[15] Bond mutual funds such as PIMCO also started using CDS more aggressively in recent years. Some hedge funds (e.g., BlueMountain Capital Management, D.E. Shaw, Citadel, and Elliott Management) are even represented in the ISDA Determination Committee. One interesting trend is that insurance companies have started to buy CDS for bond portfolio management along with selling CDS as providing insurance (about two-thirds are multi-name CDS), but overall they are net CDS buyers as of December 2013 according to BIS survey results. At the same time, hedge funds are net protection sellers with

[15] http://www.reuters.com/article/2014/10/21/us-investing-icahn-junkbonds-idUSKCN0IA2NR20141021

aggregate positions that are five times of insurance companies' positions. The rise of hedge funds in the CDS market may have generated some controversial incidents which we discuss later.

While the global CDS market has matured, it is still relatively nascent in some regions of the world. For example, China launched its first CDS product, called *Credit Risk Mitigation Agreement* (CRMA), on November 5, 2010, with a total of 20 transactions on the first trading day. A total of 17 financial firms (12 domestic and 5 foreign) have been approved as market dealers. *Credit Risk Mitigation Warrants* (CRMW) started to trade on November 24, 2010. In contrast to CRMAs, CRMWs are more standardized and transferrable in the market. As an example, HSBC China was the first foreign bank in China to issue a CRMW, with a five-year bond issued by Petro China Company Limited as the underlying reference entity.[16] Similar to CDS products' influence in the U.S., it is commonly believed that Chinese CDS products will equip banks with an effective mechanism through which to transfer credit risk. The hope is that the ability of banks to hedge their credit risk exposures through CDS products will allow them to expand their loan portfolios and increase bank lending. Compared with the U.S. CDS market, Chinese CDS products are significantly simpler and come under much greater regulatory scrutiny. For example, while a CRMA is a non-tradable bilateral agreement between two parties, a CRMA product needs to be simple and standardized. The underlying reference entity is restricted to be a particular loan or bond, the amount of leverage is limited, and market participants are classified into key dealers, dealers, and non-dealer participants who can use CRMAs only for hedging purposes.

[16]Before the launch of this product, China had deployed cautious efforts to set the scene for the introduction of credit derivatives. In 2007, the People's Bank of China formed the National Association of Financial Market Institutional Investors (NAFMII) to help develop the OTC markets. A test run of the CDS pilot project started on July 13, 2010, under the name Optional CBIC 1. At the end of October, in 2010, NAFMII unveiled the Guidance of the Pilot Business for Credit Risk Mitigation Instruments in the interbank market.

2.3 Regulatory development of CDS

Regulations and regulators played an important role in the initial expansion and subsequent contraction of the CDS market. CDS are part of the OTC market and were to a large extent unregulated. The reason for this is a provision inserted in 2000 in the Commodity Futures Modernization Act by Senator Phil Gramm, who from 1995 to 2000 presided over the Senate Banking Committee, exempting CDS from regulation by the Commodity Futures Trading Commission (CFTC).[17] CDS are often used by banks to manage regulatory capital ratios. As discussed by Shan et al. [2014b], CDS provide banks an additional tool for risk management that is recognized by regulators. When banks buy CDS protection, either through single-name CDS or CDS index, they may reduce their risk-weighted assets and raise their regulatory capital ratios. Since J. P. Morgan first used it for that purpose in 1998, many other banks followed suit. The regulatory role of CDS has also contributed to the fast growth of the CDS market. The insurance company AIG, which was a focal point of the 2008 U.S. government bailout, disclosed that a majority of its CDS protections sold to banks were used for regulatory capital relief.[18]

Prior to the recent financial crisis, CDS were generally viewed as having positively contributed to the development of financial markets. CDS spreads were considered to be a precise measure of firms' credit quality, widely used by practitioners and by academics.[19] Many also pictured CDS contracts as a simple and reliable way to trade credit risk, as was similarly argued by many academic papers [Bolton and Oehmke, 2013]. For example, former Federal Reserve Chairman Alan Greenspan argued that "these increasingly complex financial instruments have

[17] See Roubini and Mihm [2011], pp. 199.

[18] See Hu [2009], for an opinion on how "empty creditor analysis" may help explain otherwise puzzling actions and statements from banks, such as Goldman Sachs, vis-à-vis AIG at the height of the crisis.

[19] For example, when GM and Ford were downgraded on May 5, 2005, the CDS spreads on the two companies had already been increasing since October 2004, and they exhibited a substantial run-up prior to the downgrade [Acharya et al., 2014b]. Similarly, WorldCom's CDS spread had been creeping up in anticipation of its bankruptcy on July 21, 2002 [Jorion and Zhang, 2007].

contributed, especially over the recent stressful period, to the development of a far more flexible, efficient, and hence resilient financial system than existed just a quarter-century ago".[20] Such rhetoric has likely contributed to the fact that CDS contracts were essentially exempted from regulation and excluded from the surveillance responsibility of the U.S. Securities and Exchange Commission (SEC) and the CFTC, institutionalized through the Commodity Futures Modernization Act of 2000, as we previously pointed out. While some see CDS contracts as an effective tool for credit risk transfer, there have been increasing concerns that "naked" CDS may help speculators destabilize the debt market.[21] For example, in a striking case, when Delphi Corporation filed for bankruptcy on October 8, 2005, the total amount of CDS contracts outstanding was roughly thirty times the face value of its bonds outstanding. Protection buyers who did not own Delphi's bonds scrambled to acquire the Delphi bonds to settle their CDS contracts through physical delivery, driving the price of these bonds up quite substantially. The concern was particularly striking during the European debt crisis, which led to a ban on naked CDS for European sovereign debt in 2011. The naked CDS positions on Greek debt also raised concerns about market manipulation by a group of hedge funds that attempted to precipitate a Greek default.

The financial crisis has highlighted some shortcomings in the existing CDS market, some of which may be due to the current structure of the CDS market. A primary concern is that there is little transparency in the CDS market because transactions in OTC markets are typically bilateral trades. For example, using data from OCC's Quarterly Report on Bank Trading and Derivatives Activities, Atkeson et al. [2014] find that the CDS market is highly concentrated, with only a small number of financial institutions acting as market makers, including HSBC, Bank of America, Citigroup, Morgan Stanley, Goldman Sachs, and J.P. Morgan Chase. The authors model the CDS market as a matching

[20] See "Economic Flexibility," Alan Greespan, Speech given to Her Majesty's Treasury Enterprise Conference, London, January 26, 2004.

[21] A naked position refers to having a position in the CDS without having any exposure to the underlying reference entity. The position is said to be uncovered, or naked.

market with free entry of buyers and sellers. They find that fixed entry costs, trading frictions, and the benefits of netting explain the high concentration in this market, whereby large banks act as dealers, and medium-sized banks act as customers. This endogenously leads to heterogeneity in trading patterns, whereby dealers play a socially useful role as they mitigate OTC market frictions. However, the same large dealers are also more inclined to exit the market if they are hit by negative shocks. Peltonen et al. [2014] test the network structure of the CDS market using recently available Depository Trust and Clearing Corporation (DTCC) data on bilateral CDS exposures on 642 sovereign and financial reference entities in 2011. They find that the CDS market is highly concentrated around 14 dealers, which suggests that the market is "robust but fragile." The failure of any one single dealer may impose significant contagion effects and create systemic risk. The authors further document that CDS contracts are used for both hedging and trading purposes, and that end-users typically trade through dealers. Getmansky et al. [2014] also study the interconnectedness in the CDS market using DTCC data from 2012. Consistent with previous studies, they find that CDS trading activities are concentrated among a select number of counterparties. Compared to single-name CDS, trading in sovereign CDS appears to be comparatively more concentrated.

There is a related concern with the counterparty risk in the CDS market.[22] Zawadowski [2013] shows that unhedged counterparty risk in the OTC market may lead to a systemic run of lenders in the case of the idiosyncratic failure of a bank. As discussed in Acharya et al. [2009], CDS and other OTC contracts deal with counterparty credit risk by requiring collateral to be posted by both parties to the transaction. However, the terms are not standardized and no account is taken of the substantial risk externality imposed by one transaction on the risk exposures of other market players. In this vein, the massive CDS exposure of AIG around the time of the Lehman default also raised concerns about the collateral call risk and the lack of transparency, including

[22]For a thorough discussion on counterparty risk, see Gregory [2010].

the counterparties' overall exposure.[23] AIG managed to avoid posting a substantial amount of collateral because of its AAA rating. However, when its credit rating was downgraded later in 2008, it was required to post additional collateral, which drove it into serious trouble, as described by Stulz [2010]. Thompson [2010] formally investigates counterparty risk when the protection buyer is better informed, taking the perspective of a protection seller. The protection seller has an incentive to impose higher counterparty risk on the protection buyers by holding less liquid capital. Otherwise, the protection seller may charge a higher insurance fee. However, Thompson shows that there exists a mitigating factor if the protection buyer is better informed. Thus, the protection buyer faces a tradeoff between the cost of insurance and counterparty risk. There will be a separating equilibrium where buyers with high risk exposure will buy CDS with lower counterparty risk, and vice versa. Biais et al. [2014] investigate the effect of derivatives on the risk-taking behavior of protection sellers. They develop a three-period model with a risk-averse protection buyer and a risk-neutral protection seller with limited liability. A negative signal regarding the value of the reference assets observed at the interim date increases the chance of an insurance payment. Observing the bad signal, the protection seller may choose to gamble. This risk-taking behavior of protection sellers accentuates the endogenous counterparty risk for protection buyers. This deterioration in counterparty risk could be mitigated by a margin call after the bad signal, which would improve the protection seller's incentive.

The discussions that derived from the uncovered shortcomings of the existing CDS contracts during the financial crisis were useful in the sense that they promoted substantial changes in the CDS market. One of the key debates that has emerged from the turmoil surrounds the central clearing of CDS contracts through clearing houses, known as central counterparties (CCPs). Central clearing operations began in March 2009. In July 2010, the Dodd-Frank Act set the regulatory framework for derivative markets, substantially expanding their clearing role. In 2013, CDS indices were the first to implement the mandates, driven

[23] The London unit of AIG Financial Products sold CDS protection on a massive scale, with a huge net exposure of $441 billion by mid-2008.

mainly by the CFTC. By the end of 2013, CDS contracts with *central clearing* accounted for 26% of all gross notional amounts of CDS outstanding.[24] The *netting* of contracts has been more popular for CDS contracts cleared through central counterparties. The Inter-continental Exchange (ICE), a subsidiary of the NYSE, is already recording a growing market share in the clearing process, and both academic and political voices are calling for a move toward organized exchanges, more transparency and more orderly price dissemination.[25] The Dodd-Frank-mandated central clearing, electronic trading and trade reporting are already providing a boost to market transparency, and the benefits of this improvement will be evident in the coming years.[26]

A number of papers examine how the introduction of CCPs affects risk in the CDS market. Acharya et al. [2009] propose three different types of central clearing, each offering a different level of market integration and transparency. Acharya and Bisin [2014] argue that the lack of transparency in the OTC market can create a *counterparty risk externality*. Insurance sellers may excessively take short positions that lead to an increased counterparty risk to all trades. A model shows that the existence of a CCP can eliminate this externality. Biais et al. [2012] examine the costs and benefits of bilaterally settled OTC markets relative to centrally cleared markets using a CCP. They conclude that a market structure with an *optimally* designed CCP dominates. However, there are doubts as to whether the currently proposed CCPs are optimally designed.[27] Loon and Zhong [2014b] document a reduction of counterparty and systemic risk following central clearing using a sample of single-name CDS that voluntarily selected to be centrally cleared.

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[24]See the Derivatives Statistics published by the Bank for International Settlements on www.bis.org.

[25]Another growing CCP for CDS is provided by the Chicago Mercantile Exchange (CME).

[26]Loon and Zhong [2014a] investigate how CDS market liquidity is affected by different aspects of the Dodd-Frank reforms, including central clearing, the SEF, non-financial hedgers (“end-users”), bespoke contracts, and block trades. The results from the univariate and regression analysis suggest that the various Dodd-Frank reforms have improved liquidity, and had distinct and incremental effects on trading costs.

[27]See also Pirrong [2009], Singh [2010b], Hull [2010], and Jones and Pérignon [2013] for a discussion on the clearing of derivative markets using CCPs.

Regulators seem to actively push CDS toward centralized clearing, although there exist a few notable exemptions. Within this context, a number of papers debate an apparent tradeoff that arises through changing collateral demands linked to central clearing.[28] On the one hand, a CCP leads to *multilateral netting* gains among market participants across a *single class* of derivatives. On the other hand, clearing through a CCP results in a loss of *bilateral netting* benefits across different contract types, for example CDS and interest rate derivatives. Therefore, for a CCP to be valuable, the benefits from *multilateral netting* need to be sufficiently large. Duffie and Zhu [2011] provide a detailed discussion of this tradeoff. They find that a CCP may not reduce counterparty risk exposure if there are multiple central counterparties for different classes of derivatives, or if the loss in bilateral cross-asset netting is substantial. However, Cont and Kokholm [2014], using a similar framework, find that the gains from multilateral netting outweigh the losses of bilateral netting if they account for the correlations and heterogeneous risk characteristics of cleared assets. Anderson et al. [2013] compare the default exposures and netting efficiencies of linked and unlinked CCP configurations. They suggest that establishing a link between a small domestic CCP and a larger global CCP might not be desirable. Sidanius and Zikes [2012] and Heller and Vause [2012] empirically investigate the same tradeoff and find evidence of increasing collateral demands following central clearing through a CCP. In contrast to this evidence, Duffie et al. [2014] find that central clearing does not increase collateral demand using a comprehensive dataset of CDS bilateral exposures from the DTCC, covering about 31.5% of the global single-name CDS market.

2.4 CDS auctions

In the early days of CDS, market participants had the choice of settling “physically” or in “cash” upon the occurrence of a valid credit event. With the introduction of the Big Bang and Small Bang protocols, cash

[28] Singh [2010a] expresses concerns about collateral demand under CCP. See also Fontaine et al. [2014] on this topic.

settlements became hardwired into the contractual CDS agreements, whereby the final settlement price would be determined through an auction mechanism. Prior to April 2009, the decision to participate in these credit event auctions was optional. One of the key reasons for moving toward a systematic cash settlement was the risk of occasional "market squeezes," when the net notional amount outstanding would exceed the quantity of deliverable cash bonds. This happened, for example, in the famous bankruptcy of Delphi Corporation in 2005, mentioned earlier. Delphi, which had an estimated $28 billion in CDS notional outstanding traded, had only $2 billion in deliverable cash bonds afloat in the secondary market.[29]

The CDS auction process was designed jointly by ISDA, Markit, and CreditEx, which administers the auctions. Data on each bankruptcy event and the related auctions since 2005 have been publicly available on the CreditEx's webpage.[30] At a broad level, CDS auctions are two-stage auctions, whereby an *initial market midpoint* and the *net open interest* are determined in the first round of the auction. Participating dealer banks submit indicative bid and ask prices and physical settlement requests to buy or sell bonds on behalf of themselves and their clients. The submitted bid-ask spreads are required to stay within a predetermined maximum, typically 2% of par value, and the predefined quotation size is usually in the range of $2 million. In addition, the physical settlement requests must be in the same direction as the submitting party's market position, but cannot exceed it. Submitting dealers are further bound to be on the "right" side of the market, or will be required to pay an *adjustment amount* as a penalty, which will become due if a bid and ask quote cross and the submitted bid (ask) is higher (lower) than the initial market midpoint in the presence of a net open interest to sell (buy).

In the second stage of the Dutch auction, the *final price*, which can deviate by no more than a pre-specified quantity from the initial market midpoint, is determined based on the first-stage market orders, the new limit orders submitted by the dealers, and the net open interest

[29] See Summe and Mengle [2006, September 29], and Choudhry [2006].
[30] See http://www.creditfixings.com/CreditEventAuctions/fixings.jsp

determined in the first stage of the auction. In the case of the net open interest being positive, submitting dealers are only allowed to submit buy limit orders, while they can only submit sell limit orders if the net open interest is negative. Two unusual features of the CDS auction mechanism may be worth pointing out. First, investors with a net CDS exposure have the option to submit physical settlement requests. This could potentially create an imbalance and the need to allocate excess bond demand and supply in the auction. Second, as the bidding agents in the auctions may themselves have outstanding positions in the CDS market, they could have an incentive to manipulate the outcome of the auction. The two-stage auction process has been designed precisely to address the above two challenges.

There are several studies analyzing the various aspects of the CDS auction mechanism. Four of these are exclusively empirical (Helwege et al. [2009], Coudert and Gex [2010], Gupta and Sundaram [2014b], and Gupta and Sundaram [2014a]), one study investigates the process from a purely theoretical perspective (Du and Zhu [2013]), while Chernov et al. [2013] present both a theoretical and an empirical examination.

A major challenge to empirical work in this literature is the availability of data, as high-quality bond price data are accessible only for US companies. This explains the limited sample sizes used by researchers in this area: Chernov et al. [2013], for example, start with a sample of 117 auctions that reduces to a final set of 26 events, while Gupta and Sundaram [2014b] start out with 76 auctions and fully exploit only 22 of them, due to data limitations.[31] Another obstacle to structural estimations of CDS auctions is the unavailability of data on auction participants' CDS holdings. Overall, these empirical challenges emphasize the importance of guidance from theoretical predictions in the design of the econometric specifications for estimation.

The empirical evidence to date suggests the existence of mispricing in the final outcomes of CDS auctions, with underpricing (overpricing) in auctions with positive (negative) net open interest. The magnitude of the mispricing depends, of course, on the precise measure of fair

[31] In the companion paper, Gupta and Sundaram [2014a] use 30 auctions.

value against which the mispricing is benchmarked. In the empirical evaluation of their model, Chernov et al. [2013] find that bonds in auctions with positive net open interest have, on average, been underpriced by 6%, using the difference between the bond price in the auction and the bond price in the OTC market on the day of the auction as a conservative estimate. The authors also document a drop in bond prices of about 25% over the ten days before the auction. Gupta and Sundaram [2014a] argue that this pricing inefficiency may give rise to apparent arbitrage opportunities, which nevertheless disappear once liquidity and asymmetric information risks borne by the auction participants are controlled for.

Also, Gupta and Sundaram [2014b] conclude that the auction prices are significantly biased relative to the pre- and post-auction bond prices, and that the underpricing (in auctions with a net positive open interest) is, on average, about 20%. The conservative bidding behavior seems to be partially explained by a winner's curse, in that the magnitude of the underpricing appears positively related to the pre-auction variance in bids. It also turns out that pre-auction market variables have no ability to explain the auction prize mechanism. Nevertheless, the auction itself seems to be useful for price discovery as the final auction price, on its own, appears to be a key determinant of the post-auction price formation. This view is partly shared by Helwege et al. [2009], who conclude that "the first stage process plays an informative role in determining the final recovery price." Based on a sample of 43 credit events from 2005 through March 2009, the authors further conclude that the auction mechanism seems to be efficient, as it achieves two of its primary goals: a reduction in payments due to the netting effects obtained from offsetting long and short positions, and the establishment of a fair recovery price for the underlying debt obligation. In addition, the "recovery basis," the difference between the recovery implied by the CDS final auction price and the recovery implicit in bond prices, is typically close to zero. Similar conclusions are shared by Coudert and Gex [2010], who study 27 senior CDS auctions from 2005 to 2009. Their work uses the bankruptcies of Lehman Brothers, Washington Mutual, CIT, Thomson, Government Sponsored Entities

(GSEs), i.e. the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac), as individual case studies, to throw additional light on some oddities in the determination of the final recovery price. Overall, their sample suggests an average recovery rate of 31% throughout the 2005-2009 period (26% if the GSEs are excluded), with significant variation over time.

An important theoretical contribution on this topic is provided by Chernov et al. [2013], who theoretically model the two-stage auction process and show that strategic bidding may result in either under- or overpricing relative to the fair bond price. The model provides a number of predictions about the direction of mispricing based on auction characteristics. For example, they show that bonds in auctions with a positive net open interest have, on average, been underpriced by 6%, as we have previously explained, and that the degree of underpricing increases with the net open interest. While their model does not consider asymmetric information for the bidders, risk aversion, or other potential reasons for the mispricing, the model puts in place important groundwork for future theoretical analysis and mechanism design. Another theoretical analysis of the current auction design, which is now hardwired into CDS contracts, is conducted by Du and Zhu [2013]. They too conclude that auction price outcomes are biased and result in inefficient allocations. In contrast to the other references, their proposed model consistently results in overpricing. While such cases exist, the empirical evidence suggests that underpricing is more common. One focus of this paper is the proposal of a double auction design, in which both price biases and inefficient allocations could be restored to their fair values. According to this analysis, bidders should, thus, be able to submit quotes in both directions in the second stage of the auction, regardless of their open interest determined in the first step.

3

CDS Pricing

CDS are essentially insurance contracts that allow a protection buyer to purchase insurance against a contingent credit event on an underlying reference entity by paying an annual premium to the protection seller, generally referred to as the CDS spread. As with other swap contracts, at the initiation of a CDS contract there is no exchange of cash flows between the two parties to the transaction.[1] If a credit event occurs, the CDS protection seller pays the CDS protection buyer the difference between the face value and market value of the underlying reference obligation. The settlement of this obligation can be made either through a cash payment or through physical delivery of the underlying bond. The periodic spread payments in exchange for the credit protection purchased occur typically until the earlier of the maturity of the CDS contract or the occurrence of a credit event. If a credit event occurs between two payment dates, the CDS protection buyer is in addition obliged to pay the accrued premium since the last coupon payment. In general, like other traded derivative contracts, CDS are assets in

[1] We stress that this description is no longer entirely accurate, since the Big and Small Bang protocols have introduced standardized coupon payments with *upfront* payments.

zero net supply, i.e., they are side bets, with protection buyers and sellers having identical numbers of contracts outstanding. Thus, the premium and protection legs must be priced equally at inception, using the principles of arbitrage-free derivatives pricing, in order for the buyer and seller to reach agreement. In this section, we review the literature relating to alternative approaches to CDS pricing.

3.1 Basic arbitrage pricing

The pricing framework for credit derivatives was first discussed in Das [1995]. Duffie [1999] presents a simple arbitrage-free pricing model for CDS by making a correspondence with a portfolio comprising a default-free and defaultable floating-rate bond.[2] He shows that a protection buyer's cash flows on a CDS contract can be replicated by purchasing a par default-free floating-rate note, and simultaneously shorting the underlying par floating-rate note. An investor with the replicating portfolio receives a floating interest rate from the default-free note and pays a floating interest rate plus spread on the defaultable bond. The net payment corresponds to the credit spread. In the absence of any credit event, both notes mature at par and there is no additional cash flow at maturity. In the case of a credit event occurring before maturity, the investor liquidates his position and receives the difference between the market value of the default-free floating-rate note (which is par on a coupon date) and the market value of the underlying par defaultable floating-rate note. Since the payoff of this portfolio is the same as that obtained from buying protection with a CDS contract, the absence of arbitrage implies that the CDS spread must equal the spread over a risk-free rate on the underlying floating-rate note issued by the reference entity, i.e., the par floating-rate spread.

This no-arbitrage relationship is, however, only an approximation, as several frictions may prevent the relationship from holding perfectly. In such cases, appropriate adjustments are needed to value CDS

[2] Other early works on CDS pricing that are directly related to this approach include Lando [2004] and Hull and White [2000].

spreads through the no-arbitrage approach. The most important friction is the difficulty in shorting corporate bonds, which may complicate the no-arbitrage argument. In practice, investors may short bonds through a combination of a reverse repurchase agreement and a cash sale. Through a reverse repurchase, the investor can obtain the reference note as collateral on a loan made to the repo counterparty. The investor can simultaneously sell the collateral notes in the market, thereby creating a short position in the reference bond. At the maturity date of the repurchase agreement, the investor will purchase the bond in the market in order to return it to the repo counterparty. The repo counterparty will repay the previously borrowed funds plus an interest rate on the loan, which corresponds to the repo rate. The *term repo specialness* refers to the difference between the term general collateral rate (which is the general interest rate for such loans prevailing in the market) and the term repo rate. The term repo specialness is positive especially when the liquidity of the reference note is poor. The positive term repo specialness represents an extra annuity payment when the arbitrage portfolio is created. In other words, if bonds are *special*, then the absence of arbitrage implies that the CDS spread must equal the sum of the par floating-rate bond spread and the term repo specialness.

Duffie [1999] discusses other cases where adjustments are needed, including the payment of accrued CDS premia, the accrued interest on the underlying notes, the difference between floating-rate notes and fixed-rate notes, bonds priced away from par, and so forth. He finally suggests that "the model-based pricing may be useful because it adds discipline to the measurement and use of default probabilities and recoveries."[3]

3.2 Structural approaches

The structural approach to credit risk pricing is influenced by the Black and Scholes [1973] and Merton [1974] arbitrage pricing framework. In

[3] Also Adler and Song [2010], following Duffie [1999], correct for such biases in a CDS pricing framework, including for example bonds that are priced away from their par value, or accrued spread and coupon payments.

models of this type, the value of a firm's assets is assumed to evolve randomly over time, and is typically modeled by a stochastic process such as a geometric Brownian motion. A firm is assumed to default when its asset value falls below the default boundary. In structural models, credit spreads are determined mostly by leverage, asset volatility, and market conditions such as interest rates, which are suggested by the underlying theory.[4,5]

The structural approach is widely used in credit risk modeling. However, several papers find that structural models do a poor job in empirically explaining the magnitude of credit spreads, a result commonly referred to as the *credit spread puzzle*.[6] Huang and Zhou [2008] test the structural model using CDS spreads for 93 firms during 2002–2004. They conduct GMM-based specification tests of five structural models including Merton [1974], Black and Cox [1976], Longstaff and Schwartz [1995], Collin-Dufresne and Goldstein [2001], and Huang and Huang [2012]. They find that the first three models are strongly rejected by the specification test, while the model in Collin-Dufresne and Goldstein [2001] gives the best fit. However, they show that these structural models still fail to predict CDS spreads accurately and that they cannot accurately capture their time-series changes. Recent work identifies

[4]Various extensions and modifications have been proposed, such as random default at any time, time-varying default boundaries, or more complex asset dynamics with jumps and/or stochastic volatility. See, for example, Black and Cox [1976], Leland and Toft [1996], Mella-Barral and Perraudin [1997], and Acharya et al. [2006]. More recently, Bhamra et al. [2010], Chen et al. [2009], and Chen [2010] have extended structural credit risk models into a general equilibrium framework.

[5]The accounting-based approach, along the lines of Altman [1968] and Ohlson [1980], has also been used for credit risk modeling. Das et al. [2009] find that a hybrid model of accounting-based (e.g., Altman [1968] and its extensions) and market-based models (e.g., Merton [1974] and its extensions) of CDS spreads is best in capturing the level of the CDS spread.

[6]A number of papers investigate the credit spread puzzle using bond spreads. For example, Eom et al. [2004] test the performance of five different structural models in a sample of bond prices from 1986 to 1997. The results indicate that structural models tend to overestimate the credit risk of riskier firms, and underestimate the credit risk of safer firms. They conclude that the accuracy of the structural models needs to be improved. See also Huang and Huang [2012] for evidence on the credit spread puzzle based on structural credit risk models.

other factors that affect CDS spreads and credit spreads, in general. Gamba and Saretto [2013] find that CDS spreads are affected by corporate financial policies, especially investment decisions, endogenously. Gamba et al. [2013] document that the debt-equity agency conflict, in particular the "agency credit spread," contributes a significant part to the credit spread.[7]

In parallel with the direct pricing of credit spreads using a formal model, several academics have attempted to explain credit spreads empirically using observable variables suggested by structural models.[8] Zhang et al. [2009] attempt to explain CDS spreads using volatility and jump risk measures computed based on high-frequency equity returns. Their sample covers five-year CDS contracts with MR clauses for 307 distinct U.S. entities over the period spanning 2001 to 2003. The authors' approach to using high-frequency return data to explain CDS spreads differs significantly from previous research that relied on long-run equity volatility or traditional jump risk measures such as historical skewness and kurtosis to explain credit spreads. The regression of CDS spreads on volatility and jump risk measures yields an R^2 of 53%, which can be increased to 73% if other standard structural factors are controlled for. This evidence suggests that high-frequency return-based volatility and jump risk measures have significant explanatory power for the *levels* of CDS spreads. While short-term realized volatility, as measured by one-week realized volatility, also helps to explain the *changes* in CDS spreads, the authors confirm the findings of Collin-Dufresne et al. [2001] that structural factors have limited explanatory power to fully explain credit spread changes. In other words, in difference regressions, a substantial fraction of the variation cannot be explained, judging by the rather low R-squares of such specifications. Cao et al. [2010] investigate the explanatory power of option-implied volatility for CDS spreads, rather than historical volatility. Additional calibration results of structural models also point toward the added

[7]Other tests of structural models are carried out by Hull et al. [2004] and Chen et al. [2006], among others.

[8]For similar empirical studies of the determinants of bond spreads see Collin-Dufresne et al. [2001], Campbell and Taksler [2003], and Cremers et al. [2008].

value of incorporating stochastic volatility and jumps into such a framework in order to better explain the level and time-series variation of CDS spreads, in particular for highly rated firms.

Ericsson et al. [2009] investigate the explanatory power of structural variables for credit spreads in a linear regression framework using a sample of CDS rather than bond spreads. Their analysis suggests that structural covariates such as volatility and leverage do, in fact, explain a great fraction of the CDS spread variation. A principal component analysis of the residuals further confirms that there is little evidence of the existence of an additional omitted common factor, a finding emphasized for corporate bond spreads by Collin-Dufresne et al. [2001].[9] Bharath and Shumway [2008] find that the distance-to-default measure from Merton [1974] is insufficient in predicting CDS spreads. Bai and Wu [2013] examine the cross-sectional variation in CDS spreads by combining distance-to-default with a long list of firm fundamental characteristics. Their approach raises the average explanatory power by a significant amount, up to 77%. Colonnello et al. [2014] document that executive compensation structure affects asset risk choice, which plays a non-trivial role in determining CDS spreads. A number of recent papers investigate the determinants of the credit spreads of financial firms, focusing on the unique character of such entities as regulated companies. Annaert et al. [2013] explain the CDS spread changes of Euro-zone banks using credit risk, liquidity, and other industry and market variables. Alternatively, Gonzalez and Naranjo [2014] find that equity volatility is a major determinant of CDS spreads for U.S. and European insurance companies.

There is also a growing literature in accounting empirically analyzing the determinants of CDS spreads, guided by the structural pricing framework. Callen et al. [2009] and Das et al. [2009] find that accounting earnings are priced into the levels of and changes in CDS spreads, whereas Franco et al. [2009] show that CDS prices are responsive to debt analysts' reports. Lok and Richardson [2011] provide a method to calculate the credit return by considering the carry component of a

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[9] A related reference is Fabozzi et al. [2007], who also examine the explanatory power of fundamental credit risk factors for the pricing of CDS spreads.

CDS contract and its duration. Shivakumar et al. [2011] demonstrate that CDS pricing reacts significantly to management forecast news and that the reaction to forecast news is stronger than to actual earnings news. Batta [2011] examines the direct relevance of accounting information for CDS pricing. Correia et al. [2012] find that a modified structural model with accounting and market inputs is best able to explain cross-sectional variation in CDS spreads, which react to fundamental information with a delay. Kim et al. [2013] find that greater financial statement comparability is associated with lower CDS spreads. Zhang and Zhang [2013] find that CDS spreads anticipate earnings surprises, but do not show post-earnings drift, supporting the notion of CDS pricing efficiency. Elkamhi et al. [2012] show that accounting information releases cause CDS spreads to jump. Tang et al. [2014] find that CDS spreads increase in the material weaknesses of internal controls, suggesting that financial reporting quality is priced in CDS spreads. Finally, Arora et al. [2014] show that CDS spreads are higher for firms with more uncertain asset values. A comprehensive review on CDS-related research in accounting is provided by Griffin [2014]. Information quality is arguably better for public than for private firms. However, Kovner and Wei [2014] find that, among firms with traded CDS contracts, there is no significant difference in the level of CDS spreads between firms with and without publicly listed equity.

3.3 Reduced-form model

An alternative approach to structural pricing frameworks for CDS is given by reduced-form models. While these have proven to be more successful practically, one drawback is that they typically assume a latent default process, and are thus silent as to the economic determinants of spreads. Reduced-form models assume that the default time for a firm is unpredictable, and that it follows a Poisson process, which occurs randomly based on an underlying probability distribution. This approach has proven versatile and useful in practical applications. The most widely used reduced-form approach is based on Jarrow and Turnbull [1995]. The probability of default within time $[t, t+dt)$ conditional on no earlier default is characterized by

$$Pr[\tau < t + dt \mid \tau \geq t] = \lambda(t)dt, \tag{3.1}$$

where $\lambda(t)$ is the default intensity or hazard rate. It can be shown that the survival probability to time T, conditional on survival to the valuation time t_V, $Q(t_V, T)$, is given by

$$Q(t_V, T) = exp\left[-\int_{t_V}^{T} \lambda(s)ds\right]. \tag{3.2}$$

For CDS pricing, the reduced-form model is used to value both the premium leg and the protection leg of a CDS contract. The premium leg is defined as a series of CDS spread payments made until the earlier of the contract maturity or a contingent credit event. The protection leg is the contingent payment made upon occurrence of the credit event. To estimate the CDS spread, the present values of both legs must be equal at inception in order for the fair CDS spread to be derived. A number of papers price CDS with reduced-form models.[10] One such example is Longstaff et al. [2005], who use the reduced-form pricing framework developed in Duffie [1999], Lando [1998], Duffie and Singleton [1997], and Duffie and Singleton [1999]. Following Duffie and Singleton [1997], the riskless rate (r_t) and default intensity (λ) are assumed to follow stochastic processes that evolve independently of each other.[11] The independence assumption implies that the term structure can be specified exogenously, without an explicit modeling of its risk-neutral dynamics. They further assume that a bond holder recovers a fraction $1-w$ of the par value in the event of default. Assuming continuous payments of the premium s, the premium leg ($P(s,T)$) can be expressed as

$$P(s,T) = E\left[s\int_0^T exp\left(-\int_0^t r_s + \lambda_s ds\right) dt\right]. \tag{3.3}$$

[10]The structural and reduced-form models can be linked in the case of incomplete accounting information. See Duffie and Lando [2001] for a theoretical framework and Yu [2005] for an empirical test of the theory.

[11]Longstaff et al. [2005] assume that illiquidity affects bond prices, but not CDS spreads.

Similarly, the protection leg of a CDS contract can be expressed as

$$PR(w,T) = E\left[w\int_0^T \lambda_t exp\left(-\int_0^t r_s + \lambda_s ds\right)dt\right]. \tag{3.4}$$

Setting the premium leg equal to the protection leg yields the CDS premium

$$s = \frac{E\left[w\int_0^T \lambda_t exp\left(-\int_0^t r_s + \lambda_s ds\right)dt\right]}{E\left[\int_0^T exp\left(-\int_0^t r_s + \lambda_s ds\right)dt\right]}. \tag{3.5}$$

Given the assumptions of the default intensity process, the authors derive closed-form solutions for the CDS premium and fit the model using 5-year CDS spreads for 68 firms over the period March 2001 to October 2002.

It is worth emphasizing that the default intensity λ is specified under the risk-neutral pricing measure, which is the relevant measure for CDS pricing. The risk-neutral default intensity differs substantially from the so-called physical or real-world default intensity. This discrepancy is also reflected in the observed CDS spreads, which represent a compensation that is higher than what is required based on the default probabilities. The difference represents a risk premium, which investors demand as a compensation for unpredictable variation in future default rates. In other words, CDS spreads represent a risk-adjusted expected loss, which is approximately equal to the sum of the expected loss given default, and a risk premium compensating for undiversifiable systematic risk and the idiosyncratic jump-at-default risk Amato [2005].[12] Berndt et al. [2008] study default risk premia and their variation over time by examining ratios of risk-neutral default intensities, implied from CDS spreads, to Moody's KMV expected default frequencies (EDFs) to measure physical default rates at a higher frequency. Using a sample of 93 firms in three industries, broadcasting and entertainment, healthcare, and oil and gas, the authors document substantial variation of risk premia over time. The average ratio of risk-neutral to

[12]Berndt [2014] decomposes CDS spreads into an expected loss component, a credit risk premium component and a residual component. She finds that expected losses and credit risk premia combined account for less than 45% of the level of credit spreads.

the physical default intensity is about 2, with spikes that go up as high as 10.

In contrast to Longstaff et al. [2005], Chen et al. [2008] allow for a correlation between interest and credit risk by jointly specifying the dynamics of interest rates and credit default intensities. Moreover, their model yields explicit solutions for CDS spreads, which significantly improves the computational efficiency. They test the model fit with CDS transaction data for 60 firms from February 15, 2000 to April 8, 2003. An average pricing error of 3% indicates that the model can be further improved. Moreover, in their model, the authors assume the recovery rate to be constant and fix it at the industry average rate of 40%, an estimate widely used in practice. More realistic assumptions regarding the recovery rate, including random recovery, could further improve the fit of the model.

In contrast to structural credit risk models, reduced-form models, while easier to implement in practice, lack economic intuition about the determinants of default risk. Doshi et al. [2013] address this weakness by developing a reduced-form, discrete-time, quadratic no-arbitrage model for CDS pricing, where the default intensity is driven by observable covariates. In contrast to a linear specification with Gaussian state variables, this quadratic specification restricts the default intensity to be strictly positive, without any restrictions on the parameter values. The authors use a parsimonious model specification with four observable covariates, including two term structure factors, firm leverage, and historical volatility. The model is estimated using daily data for 95 constituent firms of the DJ.CDX.NA.IG.1 index from 2001 to 2010, for which balance sheet data are available. The estimation includes CDS spreads for 1-, 5-, and 10-year maturities, while the 3- and 7-year maturities are used for out-of-sample tests. The estimation is conducted in two steps. First, the latent stochastic term structure variables are estimated using an unscented Kalman filter with a quasi-maximum likelihood procedure. Second, the model is estimated firm-by-firm with both the term structure variables and the other observable covariates.

The results indicate that the quadratic no-arbitrage model provides a good statistical fit. Although the model fit worsens during the financial crisis period, the quadratic no-arbitrage model outperforms the linear regression model with an average root mean square error of 42.6 basis points. As suggested by structural models, and consistent with Ericsson et al. [2009], both volatility and leverage have positive effects on CDS spreads.[13]

3.4 Counterparty risk and liquidity

CDS spreads may be affected by other factors such as counterparty risk and liquidity. Concerns regarding counterparty risk became more widespread following the default of Lehman Brothers, as the company was a substantial player in the OTC credit derivative market.[14] The default risk of CDS counterparties may affect the CDS valuation as it reduces the value of the insurance promised by the protection seller. More specifically, if a CDS seller defaults, the CDS buyer may not receive the CDS payment if the default of the counterparty coincides with or precedes the credit event. The potential inability of CDS sellers with higher default risk to respect their insurance commitments may therefore force them to sell CDS contracts at lower prices compared to similar contracts offered by financially healthier counterparties. The economic impact of counterparty risk on CDS spreads may, however, be offset through the practice of posting collateral in the CDS market.

Indeed, Arora et al. [2012] find counterparty credit risk to be priced, although the magnitude is estimated to be economically small. A counterparty's credit risk would have to increase by roughly six percentage points to reduce the spread by one basis point. The analysis, conducted using a proprietary dataset, is based on CDS transaction prices and actionable quotations provided by 14 large CDS dealers on 125 distinct firms in the CDS index during the sample period March 31, 2008 to January 20, 2009. For each reference entity on each date, multiple CDS protection sellers may provide their five-year CDS prices simultaneously.

[13]Other related works on this topic include Carr and Wu [2010], for example.

[14]We discussed counterparty risk in relation to CCPs in Section 2. In this section, we focus only on the *pricing* effect of counterparty risk. This issue is closely related to the pricing of CDS contracts on large financial intermediaries, which are usually the major CDS sellers. Hasan et al. [2014] show that bank CDS spreads are generally consistent with structural model predictions, but also reflect risk-taking by banks because of potential government bailouts.

A panel regression of the CDS price (or quote) provided by the CDS protection seller on the credit risk measure of the CDS seller is used to detect whether counterparty risk is priced. The CDS protection seller's credit risk is measured by its own CDS spread. Counterparty risk is priced if there is evidence of a statistically significant negative relationship between the quoted CDS spread and the seller's credit risk. To be specific, a 645 basis points increase in the CDS seller's credit spread results in only a one basis point decrease in the CDS spread that the seller charges. The authors justify the small economic magnitude of the results based on the common practice of collateralization in the CDS market. The analysis of subsamples reveals that counterparty risk was priced prior to the Lehman Bankruptcy, while there is no evidence that counterparty risk was priced for the CDS spreads of financial firms. Generally speaking, these findings have important policy implications. For example, the finding of a small economic impact of counterparty risk on CDS pricing indicates that market participants believe the current market mechanism to be effective in managing counterparty risk. Further, this casts doubt on the usefulness of creating a central CDS clearing house structure with the purpose of mitigating counterparty risk. Giglio [2011] estimates bounds on systemic financial risk, i.e., the risk that many banks fail simultaneously, using the CDS spreads of financial firms. This identification is possible since CDS spreads contain information about the joint default probability of the bond issuer and the protection seller, while bond spreads contain information only about the former.

Another friction that may affect CDS spreads is the illiquidity and liquidity risk in CDS spreads. Early work by Longstaff et al. [2005] argued that CDS spreads are less affected by liquidity due to their contractual nature as, compared with corporate bonds, it is relatively easier to trade large notional amounts of CDS contracts. Thus, this study, as well as a number of others, uses CDS spreads as a pure measure of credit risk. More recently, however, empirical evidence has suggested that CDS spreads are not a pure measure of default risk, after all, since they also reflect a liquidity premium.[15]

[15] Jarrow [2012] discusses problems with using CDS to imply default probabilities.

Liquidity is generally defined as the degree to which assets can be traded quickly in the market without affecting the assets' current market price. Traders in the CDS market face obstacles due to information asymmetries, search costs, transaction and funding costs. Both CDS buyers and CDS sellers are affected by these frictions relating to expected illiquidity, although the effects may be asymmetric.[16] Besides the level of illiquidity, CDS market makers potentially face liquidity risk, which should be priced if the variation in expected liquidity will affect future trading.

Various liquidity measures can be constructed to reflect different aspects of liquidity. The most common measure of liquidity is the bid-ask spread, which is widely used in the context of CDS markets as well. A rise in the bid-ask spread represents the evaporation of liquidity from the CDS market. An alternative measure of liquidity is the sensitivity of the price to the size of the trade, or the price impact, as proposed by Amihud [2002]. If the market is liquid, we expect that a large volume of an asset could be traded without very much of an effect on the asset's price. In a variation of this approach, Tang and Yan [2007] capture this price impact through the ratio of spread volatility to the total number of quotes. In addition, dealers with funding constraints may face inventory risk, which may be proxied using the number of contracts outstanding. Furthermore, matching intensity reflects another liquidity characteristic that can be measured by the ratio of trades over quotes.[17] Using their measure of liquidity, Tang and Yan [2007] investigate the effect of liquidity characteristics and liquidity risk on CDS prices. They find that liquidity is indeed priced, and that higher illiquidity is associated with higher CDS prices. More specifically, their estimates yield a liquidity premium earned by the protection seller of approximately 11% of the mid quote.

[16] Kamga and Wilde [2013] call these frictions liquidity risk.

[17] Mayordomo et al. [2014b] document liquidity commonalities in the CDS market, i.e., the co-movement between firm-specific liquidity with market- and industry-wide liquidity measures. This co-movement is stronger during crisis periods and regionally more pronounced in the Euro Zone, but it doesn't depend on firm-specific characteristics.

Bongaerts et al. [2011] develop a formal equilibrium asset pricing model to investigate liquidity risk in the CDS market, incorporating both liquidity risk and short-selling costs, arising from the hedging of non-traded risk. An empirical test of the model over the sample period 2004–2008 suggests that CDS liquidity, measured by the bid-ask spread, significantly affects CDS prices. The study also confirms the results of Tang and Yan [2007], namely that the compensation for bearing liquidity risk is borne by the CDS protection sellers. Qiu and Yu [2012] examine the effect of CDS liquidity on CDS spreads using depth, defined as the number of dealers providing a daily quote for a given reference entity. These authors try to tease out the "competition" effect, whereby a liquid CDS market indicates increased competition among CDS sellers, and therefore lower CDS spreads, and an "asymmetric information" effect, whereby the increased number of CDS dealers may indicate more information asymmetry, which would result in higher CDS premia. The empirical test, based on a sample of 732 firms from 2001 to 2008, finds that the effect of liquidity on CDS spreads is generally negative. While an increase in liquidity decreases CDS prices on average, the increase in liquidity may increase CDS spreads when the existing number of dealers is large. The number of dealers providing a quote is a proxy for the degree of asymmetric information.

In contrast to the previous papers on CDS liquidity, Buhler and Trapp [2009] directly incorporate a measure of CDS liquidity intensity into a reduced-form model for CDS pricing. The model, which allows for a correlation between liquidity and default risk, is estimated using bid and ask quotes for a sample of Euro-denominated CDS contracts. The liquidity premium, which is also found to be earned by the protection seller, represents about 5% of the mid quotes. Chen et al. [2010], in contrast, also investigate the CDS liquidity dynamics in a reduced-form model, but assume that the liquidity premium is obtained by the protection *buyer*. Their findings reflect those of Kamga and Wilde [2013], who explicitly show that more of the liquidity premium is captured by the protection buyer based on a structural state-space estimation. The estimation, based on ask and bid prices of 118 European CDS names from the iTraxx Europe index, over the sample period 2004 to 2010, supports a significant correlation between default and liquidity risk. This result underscores the need to explicitly allow the default and liquidity premia to be correlated in CDS pricing models. The authors further investigate the asymmetry in the liquidity premium by separating the total CDS bid-ask spread into a liquidity premium on both the bid and ask prices. The proportion of the liquidity premium attributed to the ask spread is measured as $\frac{(CDSaskprice - CDSdefaultpremium)}{CDSaskprice - CDSbidprice}$, which is the ratio of the ask liquidity premium to the bid-ask spread. The results indicate that the bid liquidity premium is, on average, larger than the ask liquidity premium. Therefore, mid-quotes are not a pure measure of default risk. Compared to the protection seller, the CDS protection buyer receives a larger liquidity premium. Moreover, the results suggest that the liquidity premium is state dependent: more liquid markets are associated with higher liquidity premia. Compared with the CDS buyer, the CDS seller acts as a liquidity regulator by decreasing his liquidity premium in periods of low default risk. Furthermore, the effects are heterogeneous across firms, with lower liquidity premia for financial than for non-financial firms.

Junge and Trolle [2013] also focus on liquidity risk in CDS markets and they define it as the covariation between CDS returns and market-wide liquidity. To investigate whether liquidity risk is priced in the cross-section of single-name CDS, they develop a factor pricing model using returns and expected returns rather than CDS spreads. Using detailed DTCC transactions data for a sample of 35 financial firms, Shachar [2012] finds evidence that the order imbalances of end-users may have a CDS pricing impact, which depend on the sign of the dealers' inventory. Gündüz et al. [2013] find similar price effects from order flows as a function of inventory risk using a proprietary transactions data set from DTCC. Tang and Yan [2013] use transactions data from the GFI Group and focus on the changes in CDS spreads. They document non-trivial effects of excess demand and liquidity changes on movements of CDS spreads. Siriwardane [2014] uses dealer-level transactions data from DTCC to measure CDS sellers' capacity to supply CDS and reaches the similar conclusion that dealers' risk-bearing capacity determines pricing and aggregate risk premia in CDS markets.

Duffie et al. [2005, 2007] show that search frictions affect asset prices in OTC markets. Moreover, Zhu [2012] develops a dynamic model of opaque OTC markets and finds that the supplier's search efforts affect asset prices. Bao and Pan [2013] find that illiquidity in the CDS market generates excess volatility relative to firm fundamental volatility in CDS returns.[18]

So far, we have discussed illiquidity, illiquidity risk and counterparty risk as potentially priced sources of risk in the CDS market. In addition, unpredictable time variation in the recovery rates of the underlying assets may also affect the CDS premium. While several papers have discussed methods of estimating the recovery rate from the CDS spreads, most studies assume constant recovery rates and simply neglect the recovery risk. This is partially due to the difficulty of jointly identifying the dynamics of default and recovery risk.[19] The knowledge of the term structure of CDS spreads facilitates identification of default and recovery risk [Pan and Singleton, 2008]. Elkamhi et al. [2014] estimate recovery rates using CDS spreads for multiple maturities of 152 firms during 2004–2007. Based on a quadratic pricing model, they find that the average recovery rate in their sample is 53.79% with substantial cross-sectional variation, which is much higher than the standard assumption in existing studies and industry practice.[20] They further find that the estimated 5-year default probabilities are on average 67% higher that what is obtained using the standard 40% recovery assumption. Therefore, relying on long-run historical averages of recovery rates might lead to a substantial valuation bias.[21]

[18] Other papers that focus on counterparty risk and/or liquidity/liquidity risk include Hull and White [2001], Lei and Ap Gwilym [2007], Kraft and Steffensen [2007], Dunbar [2008], Pu et al. [2011], Morkoetter et al. [2012], Chen et al. [2013], and Kolokolova et al. [2014]. See also Biswas et al. [2014], who study the trading costs of CDS and show that CDS are cheaper to trade than bonds for small size trades, but more expensive for large trades.

[19] A recent paper by Jankowitsch et al. [2014] documents the variation in recovery rates across different types of default events, industries, and debt seniorities, among other characteristics.

[20] Schneider et al. [2011] estimate an affine intensity-based jump diffusion model, and find an average recovery rate of 79%.

[21] Other papers analyzing this issue include Das and Hanouna [2006], Christensen [2007], Schlaefer and Uhrig-Homburg [2014], Conrad et al. [2013], and Doshi [2011].

Finally, the delivery option implicit in CDS contracts may also affect the pricing of CDS, as is suggested by Jankowitsch et al. [2008] for corporate CDS, and by Ammer and Cai [2011] for sovereign CDS. Berndt et al. [2007] explicitly account for restructuring risk in a reduced-form pricing model for default swaps and show that CDS contracts with the CR clause contain a 6% to 8% premium relative to the contract without restructuring.

3.5 The term structure of CDS spreads

What does the shape of the term structure of credit spreads look like? According to the classical Merton [1974] framework, the term structure of spreads should be upward sloping for high-quality credits, hump-shaped for medium-quality credits, and downward sloping for low creditworthiness. Lando and Mortensen [2005] use corporate CDS spreads to confirm these theoretical predictions, and their findings are replicated and corroborated for the sovereign market by Augustin [2014]. Chen et al. [2013] model the dynamics of the interest rate and credit risk jointly to determine the term structure of CDS spreads. Han and Zhou [2012] show that the term structure of CDS spreads has predictive power for stock returns, while Veronesi and Zingales [2010] use the term structure of default probabilities implied from bank CDS spreads as a proxy for the probability of a bank run.

One difficulty with the study of the CDS term structure is uneven liquidity across contract maturities. CDS contracts are usually most liquid in the middle of the maturity spectrum, i.e., five-year contracts are much more liquid than one-year and ten-year contracts. This is, in particular, true for corporate reference names, while liquidity in the sovereign market is comparatively much more balanced across maturities (Pan and Singleton [2008]). This may, albeit only partially, explain why the term structure of CDS spreads has mostly been studied in the context of sovereign CDS. Augustin [2013] shows that the shape of the term structure of sovereign CDS spreads contains relevant information for signalling the relative importance of global and local risk factors for the dynamics of spreads. Dockner et al. [2013] extract information from the sovereign CDS term structure to improve the predictability of government bond returns, and Badaoui et al. [2014] study implied liquidity risk in the term structure of sovereign CDS spreads. We discuss these papers relating to the sovereign CDS literature in detail in Section 7.

Pan and Singleton [2008] also suggest that the term structure of CDS spreads contains valuable information to separately identify the default probabilities from recovery rates. They illustrate their analysis in the sovereign context using the term structure of spreads for Mexico, Korea, and Turkey. For additional analysis in the context of corporate CDS, see Elkamhi et al. [2014] and Doshi [2011]. We should add a word of caution, though, by noting that the empirical separation of recovery rates and default probabilities is econometrically challenging.

3.6 The loan-only credit default swap (LCDS)

While the above papers mainly focus on the pricing of single-name CDS, several other references discuss pricing models for other types of CDS contracts, such as *Loan-Only CDS* (LCDS), sovereign CDS and synthetic CDOs. In this section, we focus on LCDS pricing.[22]

LCDS were launched in both Europe and North America in 2006. The LCDX index was launched in April 2007, which sped up the standardization of the LCDS market. LCDS allow investors to trade credit risk embedded in the underlying syndicated secured loan, rather than any other underlying assets of traditional CDS contracts, such as bonds or unsecured loans.[23] Differences in the characteristics of the underlying assets are an important ingredient to be considered in the pricing of LCDS. For example, the recovery rate for LCDS is much higher than for CDS on bonds, because the underlying assets for LCDS are syndicated secured loans. Moreover, according to ISDA [2010], credit events

[22] We discuss sovereign CDS pricing in Section 7, and synthetic CDO pricing in Section 8.

[23] Benzschawel et al. [2008] find that, while investment-grade names are more likely to have CDS traded on their debt, LCDS are dominated by non-investment grade names.

for LCDS generally include the bankruptcy of a reference entity and failure to pay.

An important distinguishing feature for LCDS pricing is the cancelability feature embedded in such contracts, as loans can be prepaid through refinancing. LCDS contracts can terminate as a result of either default or cancelation. However, only default triggers an insurance payment. Furthermore, while LCDS contain two swap legs, similar to standard CDS contracts, each leg has a different trigger probability. Thus, it becomes important to consider the default process, the cancelation process, and the correlation between the two when we think about LCDS pricing.[24] The cancelation feature may be valued either based on historical data or using a ratings-based approach.[25] Intuitively, we should observe a negative correlation between cancelation and the default probability. Bandreddi et al. [2007] develop a double-barrier model with a Gaussian distribution instead of a Poisson process for modeling the default and cancelation process. Wu and Liang [2012] have introduced correlated stochastic processes for default, prepayment and recovery, which are technically more challenging.

CDS and LCDS typically share the same underlying reference entity, although the reference assets are different. Ignoring the cancelability feature, one simplifying assumption is that CDS and LCDS should share the same probability of default. In this case, the following relationship should hold [Ong et al., 2012]:

$$\frac{spread_{LCDS}}{1 - recovery_{LCDS}} = \frac{spread_{CDS}}{1 - recovery_{CDS}}.$$

Kryzanowski et al. [2014] discuss the pricing-parity deviation between CDS and the loan CDS market. They use the daily CDS and LCDS data for 120 single names from Markit during the period of April 2008 to March 2012. To eliminate the pricing difference due to the cancelation feature, they focus purely on non-cancelable LCDS. To investigate the research question, they first identify a parity relation between CDS and

[24] See Ong et al. [2012] for a survey of the LCDS pricing models.
[25] For the valuation of cancelable LCDS, see Wei [2007] and Shek et al. [2007].

LCDS under no-arbitrage assumptions, and then they construct a simulated portfolio that exploits the pricing-parity deviations. They conclude that there is market segmentation between the CDS and LCDS markets, with the possibility of making significantly positive payoffs by exploiting the pricing-parity deviations, which can be explained with firm-level variables. While such price discrepancies arise in the LCDS market, it may be difficult to arbitrage this basis away, due to insufficient market liquidity when one needs to trade simultaneously in both the CDS and LCDS markets.

4

CDS and Related Markets: Corporate Bonds and Stocks

The creation of CDS has equipped market participants with alternative tools to invest, hedge and speculate. Thus, the initiation of CDS trading may plausibly have altered characteristics of related markets, such as informational efficiency, price discovery, liquidity or pricing. In this section, we subsequently examine the relationship between CDS and corporate bonds, equity and options.

4.1 CDS and corporate bonds

The most immediate asset related to a CDS is the reference bond underlying the insurance product. In this subsection, we first examine the pricing relationship between the CDS and the underlying bond market. We then discuss the evidence on how the initiation of CDS has affected various characteristics of the underlying bond market. Last, we discuss how the purchase of CDS relates to other methods of shorting credit risk.

4.1.1 CDS-bond basis

In frictionless and complete markets, credit risk should be priced similarly across the cash and synthetic credit derivative markets. In other words, as discussed in Section 3, the CDS spread on a given risky company should be exactly equal to the risky bond yield spread of a par floating-rate note in excess of the appropriate risk-free rate. [see Duffie, 1999].[1] The difference between these two spreads, the so-called *CDS-bond basis*, should essentially be zero and should not present any arbitrage opportunities. Empirically, however, we do observe pricing differences in the cash and the bond market, in different periods for different bonds. The CDS-bond basis has been used as a measure of the non-default component of the bond yield, i.e., the premium for other factors such as liquidity, taxes, and other frictions. CDS facilitate the study of the non-default component of corporate bond yields, as CDS spreads provide a direct measure of the market price of a firm's credit risk. A number of academic papers, as well as practitioners, use the CDS spread as a pure proxy for the bond yield's default component and investigate the determinants of the CDS-bond basis.

There are, in fact, multiple ways to calculate the CDS-bond basis. The simplest method is to use the difference between the CDS spread of a company and a maturity-matched bond yield. However, Duffie and Liu [2001] show that this simple, model-independent approach can often be biased. Therefore, a second approach is to directly use a credit risk model to simultaneously price the bond yield and CDS spreads. This approach largely depends, however, on the choice of credit risk model used, which itself may not generate quantitatively realistic credit spreads. To make the bond spread more comparable with the CDS spread, a third approach calculates the CDS-bond basis by deriving a par-equivalent CDS spread [Elisade et al., 2009], which is essentially a bond-implied CDS spread that takes into account the term structure of CDS default probabilities and recovery rates.

In theory, a non-zero CDS-bond basis implies an arbitrage relation between CDS and the underlying bond. When the basis is negative,

[1] See also Choudhry [2006] for a useful book on the CDS-bond basis.

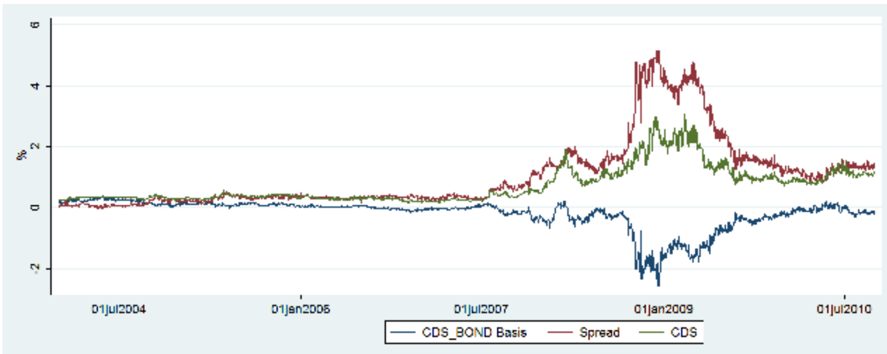

Figure 4.1: CDS-BOND basis.

This figure provides an illustration of the CDS-bond basis, i.e., the difference between a CDS spread and the credit spread on the same underlying bond, for a selected sample of 177 bonds. The red line relates to the credit spread, the green line to the CDS spread, and the blue line to the CDS-bond basis.
Source: Authors' computation.

a strategy of taking a long position in the cash bond and purchasing CDS protection should generate a positive excess return that is free of any default risk. On the other hand, when the basis is positive, the appropriate strategy involves selling CDS protection and shorting the underlying bond.[2] By exploring the arbitrage relationship, arbitrageurs may help close the basis gap and push it toward zero. However, the empirical evidence to date suggests that the CDS-bond basis is slightly positive during normal times, and that it was significantly and persistently negative during the global financial crisis period, as is illustrated in Figure 4.1 for a selected sample of 177 bonds. A number of papers investigate the drivers of the CDS-bond basis, and further try to identify factors that prevent arbitrageurs from closing the basis gap. We discuss this literature in detail below.

Longstaff et al. [2005] were the first to provide new evidence relating to the corporate yield spread and the CDS-bond basis, using CDS data for 68 firms from March 2001 to October 2002. Assuming that the

[2] Duffie [1999] and Nashikkar et al. [2011] discuss why this arbitrage relation might not exactly hold.

CDS spread reflects a pure measure of default risk, the authors use the difference between the bond yield and the CDS spread as a proxy for the non-default component, and show that it is strongly related to various bond liquidity measures, both in the time series and in the cross-section. Blanco et al. [2005] test the relationship between CDS spreads and bond yield spreads in a sample of 33 U.S. and European investment-grade firms from January 2001 to June 2002. Their results suggest that CDS and bond markets price credit risk more or less similarly. In cases where there is a deviation between the CDS and bond yield spreads, they show that the CDS spread leads the bond yield spread in the price discovery process.[3]

Nashikkar et al. [2011] study the CDS-bond basis over a much longer time period than previous studies, covering the period from July 2002 to June 2006 for over 1,167 firms. To investigate the non-default component of bond spreads, they conduct regressions of the CDS-bond basis on measures of bond liquidity and other factors. The CDS-bond basis is calculated as the difference between the CDS spread and the par-equivalent spread of a bond. Bond liquidity is measured as latent liquidity, which is calculated based on institutional bond holdings, rather than the actual bond transactions. Specifically, the latent liquidity measure is the weighted average turnover of fund bond holdings, where the weights are the fractions of bonds held by particular funds. In addition to bond latent liquidity, the authors also control for other bond-specific transaction-based liquidity measures, CDS liquidity, firm-specific credit risk variables, and bond characteristics. The study finds that latent liquidity has significant explanatory power for the CDS-bond basis, even after controlling for the bond transaction-based liquidity measures. They also show that the CDS bid-ask spread has strong explanatory power for the basis and conclude that the basis is driven by both bond market and CDS market liquidity. The results further show that the CDS-bond basis is also related to firm credit risk characteristics, such as leverage and tangible assets, as well as covenants or tax status. This indicates that the CDS spread does not

[3] Zhu [2006] also documents that the CDS market leads the bond market in terms of price discovery.

fully capture the credit risk of the bond, because of frictions that affect the arbitrage relationship between the CDS and bond markets. The authors also find that the cost of shorting bonds significantly increases the basis.

While the above-mentioned early studies of the basis find the basis to be slightly positive prior to the financial crisis, the CDS-bond basis turned persistently negative during the crisis period [see Fontana, 2012]. This has led many recent papers to investigate the drivers of the negative basis during the 2007–2009 crisis. Anecdotal evidence shows that the deleveraging activity of financial institutions may drive the basis into negative territory. During the crisis period, a rise in funding costs allegedly forced investors to free up their balance sheets and led many financial institutions to sell off their corporate bond holdings. This selling pressure may have decreased bond prices, and further pushed the basis into negative territory. Garleanu and Pedersen [2011] develop a margin-based asset pricing model, where the funding constraints can give rise to price differences between two financial instruments with identical cash flows but different margin requirements. Their model generates interesting predictions for the basis, which are empirically tested using the CDS-bond basis over the period 2005–2009. The authors show that the time-series variation in the CDS-bond basis is closely related to the shadow cost of capital, which can be captured through the difference between collateralized and uncollateralized interest rates. Cross-sectional differences in the basis between investment-grade and high-yield bonds are captured by their different margin requirements.

Mitchell and Pulvino [2012] explicitly focus on the debt financing risk and investigate its impact on the arbitrage activities of hedge funds. They argue that the CDS-bond basis trade is one of the most common arbitrage strategies employed by hedge funds. Such arbitrageurs obtain their debt financing from rehypothecation, which effectively means collateralized loans obtained from prime brokers, who themselves post this collateral against borrowed funds. Specifically, according to the standard prime brokerage agreement, hedge funds receive financing from their prime brokers, and grant the prime brokers the right to rehypothecate the hedge funds' securities. By rehypothecating, the prime brokers obtain a loan from a third party, i.e., rehypothecation lenders, who are the ultimate financers in the transaction. During the global financial crisis period, however, rehypothecation lenders terminated their financing lines, and forced the sale of securities provided as collateral, including corporate bonds, causing their prices to decline sharply and their yields to spike up. As a consequence, arbitrageurs experienced a sudden withdrawal of their prime source of debt capital. Prime brokers and hedge funds were also forced to deleverage, which further widened the negative CDS-bond basis, due to the spike in the cash bond yield spread.

After identifying factors that drive the CDS-bond basis, a relevant question that remains is why these factors have a persistent impact on the basis. If arbitrageurs implement the arbitrage trade fairly expeditiously, we should not observe a persistent non-zero basis in the market. Therefore, there must be some other frictions that prevent arbitrageurs from closing the basis gap. However, given the difference in arbitrage strategies for long and short positions in the bond and CDS protection, it may be that the factors driving the limits to arbitrage might be different for the cases of positive and respectively negative bases. When the basis is positive, arbitrageurs can profit from selling the CDS protection and shorting corporate bonds. However, bonds can be difficult to short [as argued by Nashikkar et al., 2011]. The optionality arising out of the ability of the short position to deliver the cheapest bond would also serve to make the basis seem larger than otherwise [as pointed out by Blanco et al., 2005, Nashikkar et al., 2011], since it may be traded "special," i.e., command a larger repo rate.[4]

When the basis becomes negative, the appropriate arbitrage strategy involves taking a long position in the cash bond and purchasing CDS protection. The main risks associated with this negative basis trade include funding risk, sizing the long CDS position, liquidity risk, and counterparty risk for the protection seller. These risk factors may prevent arbitrageurs from implementing a negative basis trade, which is consistent with frictions and limits to arbitrage theories. Arbitrageurs

[4]For details about CTD options, see Jankowitsch et al. [2008] for corporate bonds, and Ammer and Cai [2011] for sovereign bonds.

will choose basis trades with the most negative basis after controlling for such risks. For example, to implement the arbitrage strategy, arbitrageurs need to have access to financing. As discussed in Mitchell and Pulvino [2012], debt financing risk can not only drive the basis into negative territory, but also prevent arbitrageurs from profiting from such arbitrage opportunities.

Bai and Collin-Dufresne [2013] investigate the negative and persistent CDS-bond basis during the crisis and post-crisis periods. Based on several limits to arbitrage theories, they expect the risk characteristics of basis trades to be related to the cross-sectional variation in the size and sign of the basis. They test their hypothesis using a sample of 487 firms with single-name CDS from the Markit database over the period January 2006 to December 2011. To explain the violation of the arbitrage condition between CDS contracts and bonds (i.e., the non-zero basis), they first construct a set of proxies for trading frictions, including trading liquidity, funding cost, and counterparty risk. Consistent with the limits to arbitrage theories, they find that their proxies for trading frictions can explain the basis during the crisis period. However, most of the factors lose their explanatory power during the post-crisis period.[5]

Choi and Shachar [2014] challenge the common wisdom that deleveraging by dealers was responsible for the negative CDS-bond basis, using data from the Federal Reserve Bank of New York on dealers' aggregate bond inventories. The authors argue that, after the Lehman crash, dealers were actively "providing liquidity" by purchasing corporate bonds from hedge funds, which were running for the exit and unwinding basis arbitrage trades. Thus, while dealers were "leaning against the basis," their activity was insufficient to close the gap. Feldhutter et al. [2014] find the pricing difference between bonds and CDS may also be explained by a credit control premium in bond prices, which is especially important as a firm's credit quality declines. This

[5]Fontana [2012] also studies the CDS-bond basis during the 2007–2009 crisis period. Levin et al. [2005] use the basis as an aggregate proxy for frictions in the fixed income market. Other relevant papers on the CDS-bond basis include Adler and Song [2010], Wit [2004], Zhu [2006], Li and Huang [2011], Bhanot and Guo [2011], and Augustin [2012]. A survey of the literature on the CDS-bond basis for sovereign bonds follows in Section 7.

may explain the violation of arbitrage for CDS and bond spreads.[6] In addition to the determinants of the basis, Li et al. [2011] investigate the effect of CDS-bond basis arbitrage for bond pricing. They find that basis arbitrageurs introduce new risks to the corporate bond market, including counterparty risk and funding liquidity risk.

4.1.2 The effect of CDS on the bond market

The introduction of CDS contracts has created an alternative avenue through which investors in the fixed income market can trade credit risk. However, this raises the question of whether and how the initiation of CDS contracts affected the underlying cash bond market, in terms of pricing, liquidity and market efficiency among other economic characteristics. Alternatively, the introduction of CDS may have altered the way in which new information gets incorporated into prices.[7] Blanco et al. [2005] find strong evidence that the CDS market leads the bond market in determining the new price of credit risk, albeit in a very limited sample, in the early days of CDS trading, and well before the crisis. The authors argue that price discovery occurs in the CDS market because of its synthetic nature, which makes the CDS market a more convenient venue in which to trade credit risk. Moreover, they argue that the clienteles that participate in the CDS and bond markets are likely to be different. In particular, institutional investors, who are typically well informed, are likely to trade in both the cash and CDS markets, while retail investors trade mostly in the cash market. Hence, the introduction of an alternative venue for trading credit risk improves price discovery and, in turn, the efficiency of the cash bond market.[8]

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[6] See Section 5.3 for a further discussion.

[7] In this section, we leave aside the issue of whether the introduction of CDS trading alters the borrowing cost of the underlying entity, an important question that we take up in Section 5. We discuss the evidence on price discovery, liquidity and bond market quality in this section.

[8] Mayordomo et al. [2011] examine the relative price discovery of asset swap packages, bonds, and CDS, during the subprime crisis. While they find the existence of a clear leadership of derivatives in terms of price discovery, they also argue that the relative role of price discovery, across derivatives, is state-dependent as a function of liquidity.

Recent studies investigate these issues using larger samples. Nashikkar et al. [2011] find evidence of a liquidity spillover effect from the CDS market to the bond market, whereby CDS liquidity affects both bond liquidity and bond prices. In a similar vein, Das et al. [2014] investigate the effect of CDS trading on the secondary corporate bond market, using a sample of 350 firms from 2002 to 2008, both in the time series and in the cross-section. In order to investigate the effect of CDS trading on bond market efficiency, contemporaneous bond returns are regressed on contemporaneous and lagged values of stock returns and the corresponding changes in CDS spreads. If lagged values are jointly significant in determining bond returns, this indicates that the bond market is relatively inefficient in incorporating relevant information compared to other markets. To address the endogeneity issue, the authors further implement a two-stage Heckman [1979] approach and difference-in-difference tests. When testing the bond market quality, the authors construct and compare the market quality measures of Hasbrouck [1995], which is based on the discrepancy between efficient prices and transaction prices, for bonds both before and after the inception of CDS. To study the impact of CDS contracts on bond market liquidity, several liquidity proxies are used, such as trading volume or turnover. In a nutshell, the results suggest that CDS trading hurts bond market efficiency. After the inception of CDS trading, there is no reduction in pricing errors, and no improvement in liquidity in the bond market. These findings may be explained by the shift in the clienteles of investors who are trading in bonds. Since the more liquid CDS market is an attractive place for informed trading, institutional investors, who typically have better information, migrate to the CDS market, resulting in a decline in the cash bond market's efficiency, quality and liquidity. Massa and Zhang [2012] provide evidence that CDS contracts improve bond liquidity because of reduced fire sale risk in the face of lower liquidation needs around credit rating downgrades.

4.1.3 Instruments for shorting credit risk: Shorting bonds, loan sales, and CDS

When investors have a negative view about a firm's credit risk, they can implement that view by either shorting bonds or purchasing CDS protection. This choice is especially relevant for informed traders who wish to profit from their private information. For example, Acharya and Johnson [2007] find evidence of informed trading in the CDS market. However, Asquith et al. [2013] find no evidence that bond sellers have private information. They investigate the market for borrowing corporate bonds, mainly for the purpose of shorting, and the effect of CDS trading on such bond shorting. Their analysis is conducted with a large proprietary database on bond inventory and bond loans provided by a major custodian of corporate bonds from 2004 to 2007. They find that the cost of borrowing bonds is comparable to the cost of borrowing stocks, which has decreased steadily over time. The borrowing costs change with factors such as loan size, percentage of inventory lent, credit rating, and borrower identity. The recent credit crisis seems to have increased the variance of borrowing costs across bonds. Moreover, the authors fail to find evidence of informed trading by bond short sellers, since bond sellers do not earn excess returns in their analysis. They further find that bonds with traded CDS tend to be more actively lent. Borrowing costs for such bonds are slightly higher for those with traded CDS. Overall, they conclude that CDS contracts are statistically related to bond shorting, but do not substantially substitute for it.

Besides shorting bonds and buying CDS protection, investors may profit from insider information through loan sales. Alternatively, these instruments might be used for hedging purposes. The choice between loan sales and purchasing CDS protection has been discussed in the previous literature, from which a number of papers theoretically investigate the choice. Duffee and Zhou [2001] provide an early discussion of the benefits of CDS contracts as risk transfer tools, but also express caution on the potential downside of CDS trading for firms. They model the impact of the introduction of CDS contracts from the perspective of creditors, particularly banks. The banks' information advantage regarding borrower credit quality can cause both adverse selection and moral hazard concerns. In particular, CDS trading may reduce other types of risk sharing, such as secondary loan sales, with ambiguous welfare consequences. Parlour and Winton [2013] present the efficiency implications of CDS contracts in terms of risk transfer and monitoring and suggest that, overall, CDS contracts as a risk transfer mechanism are more likely to undermine monitoring. Allen and Carletti [2006] show that the credit risk transfers can be beneficial when banks face a systemic demand for liquidity. However, when they face idiosyncratic liquidity risk and hedge this risk in the inter-bank market, credit risk transfer can be detrimental to welfare. Further, such hedging via CDS contracts may lead to contagion between the banking and the real sectors and increase the risk of financial crises.

Empirically, Beyhaghi and Massoud [2012] find that banks' choices between loan sales and CDS relate to the characteristics of both borrowers and lenders. They document that banks use loan sales to hedge the risk of low-quality borrowers, and CDS contracts to hedge the risk of high-quality borrowers defaulting, especially if monitoring costs are high. Moreover, reputable lenders are less likely to hedge the credit risk of high-quality borrowers with either loan sales or CDS.

4.2 CDS and the equity market

The traditional Merton [1974] structural framework characterizes the corporate capital structure as a series of contingent claims on a firm's assets. Both debt and equity values are determined by the risk-free borrowing rate, the value of firms' assets as well as firms' asset volatility. In other words, debt and equity prices, and hence returns, are determined by the same company-specific information. In the absence of any frictions, both asset markets should be perfectly integrated. Moreover, there exists a no-arbitrage pricing relationship between equity and credit spreads, which should theoretically carry forward to the relationship between equity and CDS spreads. In this section, we will review the literature that has, explicitly or implicitly, verified or challenged these theoretical predictions of the classical Merton model and its extensions. For this purpose, we classify the existing literature into two main categories: those papers that study the information flow between equity and credit markets, and those papers that study capital structure arbitrage across the two markets. In a third subsection, we review the research that examines whether the introduction or existence of CDS contracts created any externalities for the equity market. Under the assumption of complete markets, CDS spreads are redundant assets. Yet, their fairly recent creation relative to stocks, and their tremendous growth over the past two decades, suggests that the addition of corporate credit derivatives to the investor opportunity set may provide complementary information.

4.2.1 Information flow between the equity and CDS markets

The equity prices and CDS spreads of a firm are exposed to the same fundamental shocks relating to information about its future cash flows. However, informed investors may choose to trade in only one of the two asset classes, which would lead to earlier price discovery in the market that is the chosen venue for informed trading.[9] A number of papers investigate such a hypothesis by studying the lead-lag linkage between the CDS and equity markets. Acharya and Johnson [2007] find that changes in CDS spreads negatively predict stock returns for a sample of 79 U.S. firms during the period from January 2001 to October 2004. The information flow from the CDS market to the bond market is restricted to firms that experience adverse credit news and to days with negative information. Further, they show that the intensity of the information flow is stronger if the company has a greater number of bank relationships. The authors interpret this evidence in favor of insider trading in the CDS market by banks that exploit their private information obtained from bank-lending relationships. However, they find no evidence that the degree of asymmetric information adversely affects the prices or liquidity in the equity market. The reason may be that the negative effects of informed trading are balanced against the gains in liquidity provision coming from the informed traders.[10] In a follow-up paper, Acharya and Johnson [2010] find evidence of localized information flows within markets. They show that, for leveraged

[9]Informed investors may choose to trade in one market rather than the other because of various considerations, such as capital constraints, disagreement, asymmetric information, leverage, price impact, and transaction costs.

[10]Berndt and Ostrovnaya [2014] find significant information flows from the CDS market to the equity and option markets for high-yield firms.

buyouts, the presence of more insiders leads to greater levels of insider activity, in the sense that a larger number of equity participants in the lending syndicate is associated with greater levels of suspicious stock and option activity.

Ni and Pan [2011] also find that changes in CDS spreads can predict stock returns over the following few days. However, the pattern of predictability is asymmetric and driven mostly by those stocks that experience negative information in the CDS market. In their view, this empirical evidence is economically explained by short-sale restrictions in the stock market. In the presence of equity short-sale constraints, pessimistic investors can express their views only in the credit market. Thus, stock returns become predictable by CDS spread changes because the negative information in CDS markets slowly gets incorporated into equity prices. Marsh and Wagner [2012] focus on daily lead-lag patterns in equity and CDS markets and find that the equity market leads the CDS market.

In addition to the level of CDS spreads, Han and Zhou [2012] document that the slope of the term structure of CDS spreads, measured as the difference between the five-year and one-year CDS spreads, negatively predicts stock returns. Moreover, the predictability is more persistent than that of changes in the levels of spreads. In a sample of 695 U.S. firms, they show, with CDS data from August 2002 to December 2009, that stocks with flatter CDS slopes outperform those with steeper CDS slopes by more than 1% per month over the following six-month period. In contrast to previous studies, they do not find that the predictability pattern is asymmetric. They further find that CDS slopes positively predict changes in the level of CDS spreads. The predictive power stems from the information diffusion from the CDS market to the stock market. Hence, the slope of the term structure of CDS spreads contains valuable information about the future credit quality of the firm, but this information is not contemporaneously reflected in the stock price.

In contrast to Acharya and Johnson [2007], several studies find that informed traders primarily trade in the equity market rather than the CDS market. Hilscher et al. [2014], for instance, document that the equity market leads the CDS market at daily and weekly frequencies.[11] They hypothesize that informed traders self-select into a market venue based on considerations of price impact, leverage, and transaction costs. According to this choice-of-market theory, they predict a separating equilibrium in which, because of the high bid-ask spreads in the CDS market, informed traders primarily trade in the equity market.[12] Liquidity traders, on the other hand, do participate in the CDS market. The authors test their hypothesis using a sample of 800 firms from 2001 to 2007 by using equity returns to predict spread returns, proxied by the percentage changes in quoted CDS spreads, and vice versa. The analysis is conducted within rating categories, i.e., AAA-A, BBB and non-investment grade. In line with their hypothesis, the authors find that equity returns predict credit returns at daily and weekly frequencies, up to a time lag of four weeks. However, they find that credit returns cannot predict equity returns. Such findings have implications for regulatory proposals to ban naked corporate CDS trading, for example. Moreover, they find a significant delay in the adjustment of CDS spreads to the information released in the equity market. This delay in adjustment is explained by transaction costs and mispricing, created by investor inattention. On the one hand, transaction costs may make it difficult to profit from the predictability of CDS returns, which explains the slow adjustment of CDS spreads.[13] On the other hand, the delayed

[11]Forte and Pena [2009] explore the price discovery process for the stock, CDS and bond markets simultaneously, in a sample of 17 North American and European non-financial firms, during the period September 2001 to June 2003. They find that stock returns lead CDS spreads and bond yields more frequently, than the other way around. Norden and Weber [2009] document similar findings in a sample of 58 firms during 2000-2002.

[12]This is different from the evidence of a pooling equilibrium in the option and the equity market as in Ni et al. [2008], for example.

[13]The authors measure transaction costs using CDS market depth. The market depth of a CDS contract measures the number of CDS quotes traded in a given period. In this paper, low depth is an indicator for firms in the lowest quartile of CDS quotes. Then the authors regress the fraction of credit protection return response on various transaction cost measures. They find firms with low depth (high transaction costs) have lower response rates. Consistent with the prediction from the transaction costs, they further find that CDS spreads adjust more quickly if the equity return is large in absolute value.

adjustment may be related to mispricing created by investor inattention, as liquidity traders in the CDS market may not watch events as closely as those in the equity market. This interpretation is backed by the fact that the CDS market responds much faster to the equity market when CDS traders are more likely to pay attention to corporate events such as earning announcements.

The findings in Hilscher et al. [2014] strongly contradict the evidence of insider trading in the CDS market supported in Acharya and Johnson [2007]. The former authors therefore provide additional arguments to justify the differential results. They argue that the results in Acharya and Johnson [2007] are restricted to a small sample of distressed firms. In addition, they emphasize that a firm's distress is measured with ex-post information, which violates the assumptions for predictability tests. CDS returns fail to predict equity market returns if distress is measured using only ex-ante information, or if the standard errors are adjusted for heteroskedasticity. While the equity market plays a significant role in price discovery, the authors find that the CDS market volatility may lead the volatility in the equity market. Fung et al. [2008] investigate the relationship between the CDS market and the equity market using CDX indices. Their results indicate that the direction of information flow across the two markets depends on the credit quality of the reference entity. For sub-investment-grade firms, they find evidence of mutual information feedback. For investment-grade firms, in contrast, the equity market leads the CDS market in terms of price discovery. This suggests that market participants should seek information from both the equity and the CDS markets in making their investment decisions.

Lee et al. [2014] document evidence of momentum in CDS returns, which is relatively stronger for firms with low credit ratings and high depth, and cannot be explained by common stock- and bond-based risk factors. Momentum returns (approximately 52 bps return per month for a three-month formation period and a one-month holding period) arise through anticipation of future rating changes, in the sense that past winners are associated with future rating upgrades and past losers with future rating downgrades. The results also suggest that the CDS market contains incremental information relative to the stock market with spillover effect from CDS to stock return momentum. An investment strategy that exploits this additional information by double sorting on both CDS and stock momentum measures can improve investment performance by avoiding the momentum "crashes" documented in stock momentum strategies.

Other studies have investigated the informational efficiency of the CDS and the equity markets by comparing the price responses in both markets to corporate events such as bankruptcy filings or rating changes. One such study is undertaken by Jorion and Zhang [2007], who investigate intra-industry contagion using a sample of 5-year CDS spreads for 820 obligors from 2001 to 2004. The authors conjecture that the deterioration of a firm's credit quality may affect the equity and CDS markets of industry peers. The purpose of the study is to disentangle contagion from competition effects through the sign of cross-asset correlations, a negative (positive) correlation among CDS spreads being indicative of competition (contagion) effects. The empirical design focuses on Chapter 11 and Chapter 7 bankruptcies, as well as large jumps in CDS spreads. The results suggest that Chapter 11 bankruptcies and jumps are followed by contagion, while Chapter 7 bankruptcies are more likely to exhibit competition effects. Intra-industry contagion effects also appear to be better captured in the CDS than in the stock market. In a related study, Jorion and Zhang [2009] argue that counterparty risk may be another channel of credit contagion that could add to the explanation of default clustering. The authors use a sample of 251 bankruptcy filings from 1999 to 2005 to examine the reaction of the creditors' CDS and equity prices following the distress events.[14] The results indicate that bankruptcy announcements of counterparty firms lead to lower stock prices and wider CDS spreads for creditors. More specifically, the average cumulative abnormal stock return (CDS spread change) is -1.90% (5.17 bps) for the 11-day window, which is greater than the intra-industry contagion effect of -0.41% found in Jorion and Zhang [2007]. In addition, these effects are cross-sectionally

[14] Since there are fewer CDS quotes than stock quotes, the final CDS sample is smaller than the stock sample with 128 bankruptcy filings from 2001 to 2005.

related to the size of the exposure, previous stock return correlations or recovery rates, and they are stronger, if the distressed company is a customer of the creditor, or if is liquidated rather than restructured.

Norden and Weber [2004] focus on the response of the CDS and the stock markets to credit rating announcements and find evidence that the CDS market reacts earlier to reviews regarding downgrades.[15] In addition, Schweikhard and Tsesmelidakis [2012] find evidence that the CDS and equity markets for financial institutions decoupled during the recent financial crisis in the face of massive government intervention. In a structural framework, they show that the implicit government guarantees, offered to European financial institutions during the global financial crisis, caused their CDS spreads to be lower than they would have been otherwise. Hence, the "disconnect" between the CDS and equity markets can be explained by government intervention, which benefited debt holders, but not equity holders.

4.2.2 Arbitrage between the equity and credit markets

Structural models following Merton [1974] directly imply perfect integration between the equity and credit markets. As discussed in Friewald et al. [2014], the Merton model predicts that the "market price of risk (the Sharpe ratio) must be the same for all contingent claims written on a firm's assets. Hence, risk premia in equity and credit markets must be related."[16] The authors directly estimate risk premia from CDS data and investigate the link between the equity and credit markets. Specifically, in a sample of 491 U.S. firms from 2001 to 2010, they identify risk premia for individual firms from the CDS forward curve and relate the estimated risk premia to the excess equity returns. They find a significant positive relation between credit

[15] Castellano and Giacometti [2012] find misalignments between CDS-implied rating changes and actual credit rating events. These differences are more pronounced during the crisis period.

[16] Also Huang and Huang [2012] note and use the theoretical result that Sharpe ratios should be the same across different asset classes.

risk premia and equity excess returns in portfolios sorted monthly based on the estimated risk premia.[17]

Although Merton [1974] implies that equity and credit should be similarly priced on a risk-adjusted basis, several studies provide empirical evidence of significant short-term pricing discrepancies that could be exploited for capital structure arbitrage.[18] Capital structure arbitrage refers to a trading strategy that explores the mispricing between a firm's CDS and its equity. Such a trading strategy could be implemented by selling (buying) credit protection and selling (buying) the stock when the theoretical model-predicted CDS spread is substantially lower (higher) than the market-observed CDS spread. The arbitrageur profits when the observed CDS spread converges to the model-predicted CDS spread. A delta-hedged equity position can be used to offset the changes in the value of the CDS spread. While such a strategy is, in theory, market-neutral, the arbitrageur may suffer from mark-to-market losses if both CDS spreads and equity prices increase simultaneously and the arbitrageur has a short position in both assets.

The existing literature attempts to explain the pricing discrepancies from different perspectives such as, among others, wealth transfers across shareholders and bond holders, and differential risk factors, or limits to arbitrage across markets.[19] Alternatively, the returns in each market may be spanned by different pricing factors, which would explain persistent pricing discrepancies. For example, a number of studies find that CDS spreads are not a pure measure of credit risk, but contain a liquidity component.[20]

Duarte et al. [2007] focus on the limits-to-arbitrage explanation of the relationship between the equity and credit markets. They study the risk and return characteristics of a capital structure arbitrage strategy

[17] In the context of market integration, it is worthwhile citing Titman [2002], who relates the structural credit risk models' failure to explain observed credit spreads to an imperfect integration of corporate bond and equity markets.

[18] Theoretically, if there is price discrepancy between two related markets, arbitrageurs should engage in arbitrage activities and eliminate the mispricing.

[19] For example, Bakshi et al. [2000] explain the pricing discrepancies between call option and equity prices using changes in equity volatility.

[20] The several references include Tang and Yan [2007], Bongaerts et al. [2011], Qiu and Yu [2012], and Junge and Trolle [2013].

implemented using 5-year CDS of a sample of 261 firms from 2001 to 2004. The authors simulate a trading strategy where, for each CDS firm during the sample period, an arbitrageur will sell insurance protection and short the stock when the observed CDS spread in the market is above a threshold percentage of the model-implied CDS spread. The position is closed either after 180 days or when the theoretical and observed spreads converge. The transaction cost is assumed to be 5%, reflected in the bid-ask spread. Besides the transaction costs, initial capital is required to finance the equity position. The excess returns earned from the individual capital structure arbitrage strategies are regressed on a set of equity and bond market factors, as well as a proxy for default risk to examine whether capital structure arbitrage profits are abnormal. The authors find that the initial capital required for a capital structure arbitrage strategy to generate a return with 10% annualized standard deviation is several times higher than for other fixed-income arbitrage strategies. Besides the initially required capital, the arbitrage trade also requires a high level of "intellectual capital" to identify the arbitrage opportunity and to hedge out the risks using complex models. Moreover, the capital structure arbitrage is only profitable when the deviation between the observed and model-implied CDS spread is substantial, i.e., the threshold percentage above which the arbitrage trade is initiated must be large. However, the authors document that, in their sample, convergence between market and model-implied spreads only occurs for a small fraction of the individual arbitrage strategies. The regression analysis nevertheless suggests that the capital structure arbitrage generates risk-adjusted excess returns.

Kapadia and Pu [2012] also explain the lack of integration between the CDS and equity markets through a "limits-to-arbitrage" argument. They argue that, in principle, capital structure arbitrage strategies implemented by market participants should improve the integration of the equity and credit markets. However, as the arbitrage is not costless because of frictions related to illiquidity and/or idiosyncratic risk, investors cannot perfectly exploit the arbitrage opportunities and pricing discrepancies remain. Therefore, limits to arbitrage may explain the low correlation between the equity and credit markets. The authors investigate their hypothesis using a sample of 214 firms during the period from 2001 to 2009. To identify short-term pricing discrepancies, they use the concordance of price changes in the equity and CDS markets. Pricing discrepancies are then related to empirical measures that are reflective of limits to arbitrage, such as idiosyncratic volatility and funding liquidity. The authors use various econometric specifications and control for other risk factors suggested by prior literature to rule out alternative explanations to the pricing discrepancies between the CDS and equity markets.[21] Overall, the results indicate that illiquidity, idiosyncratic risk and equity volatility jointly explain about 29% of the discrepancy between stock and CDS spread returns, which ought to capture the integration between these two markets. At the same time, the modest explanatory power of the regressions suggests that equity volatility and the level of debt, the two most important determinants of CDS spreads [Ericsson et al., 2009], cannot fully explain the pricing discrepancies.

The shortage of arbitrage capital available to investors during the financial crisis is proposed as an explanation for the no-arbitrage pricing violations across markets, possibly applicable to the equity and CDS markets setting as well. Duffie [2010c], for example, suggests that the depletion of dealer capital may explain the distortions in the CDS-bond basis. Similarly, Mitchell and Pulvino [2012] use the argument of limited arbitrage capital to explain the wide negative CDS-bond basis during the crisis period.

4.2.3 The effect of CDS trading on the equity market

In complete markets without any frictions, CDS contracts are redundant assets. However, in the presence of frictions and incomplete markets, the addition of CDS contracts to the investor opportunity set may enhance price efficiency and market liquidity. The significant growth of the corporate CDS market since its inception in the early 1990s thus warrants asking the question of how the introduction or the existence

[21] The relationship between equity price and CDS spreads is affected by multiple factors in addition to limits to arbitrage. For example, previous papers have shown that mergers and takeovers, or systematic factors can affect the integration between the CDS and equity markets.

of the credit derivative market has altered various characteristics of the equity market.

Boehmer et al. [2014] focus on the effect of CDS trading on equity market characteristics such as market liquidity and price efficiency. From an ex-ante perspective, CDS contracts may improve equity market liquidity because they represent efficient tools for risk sharing. CDS protection sellers can dynamically hedge their positions in equity markets through a delta hedging strategy. Thus, trading in the CDS market increases trading in the equity market. In addition, the ability to hedge may endogenously attract more investors into both markets. Alternatively, investors may choose the CDS market instead of the equity market to express negative views, thereby decreasing liquidity in the equity market. Moreover, Acharya and Johnson [2007] suggest that the CDS market provides a venue for insider trading. Informed trading in the CDS market may improve the informational efficiency in the equity market due to the positive effect of information spillovers. Alternatively, CDS trading may reduce the equity price efficiency because of negative trader-driven spillovers. More precisely, if informed traders trade in multiple markets, it may become more difficult for market makers to learn from these trades. Such informational externalities may induce additional second-order effects. On the one hand, the improved equity price efficiency may attract investors to trade these securities and, therefore, improve equity market liquidity. On the other hand, the expanded opportunity set may make informed traders more aggressive, which could cause uninformed traders to exit the market altogether and, therefore, decrease the market liquidity. Whether the net impact on the equity market from the existence of CDS markets is negative or positive remains, ultimately, an empirical question.

Boehmer et al. [2014] investigate these hypotheses using a sample of corporate CDS contracts during 2003–2007. The authors find that CDS contracts have significant negative effects on equity market liquidity and price efficiency. Overall, however, these effects are state-dependent. In bad states, negative information spillovers dominate, while in good states, CDS seem to complement the market with net positive effects. Several tools are used to avoid concerns that the results are driven by unobserved characteristics that determine both equity market characteristics and selection into CDS trading. Namely, to address such endogeneity and sample selection issues, propensity score matching techniques, difference-in-difference analysis and an instrumental variable approach are used. More specifically, the trading activity in the bonds of the underlying reference firms' competitors should capture investors' credit trading demand and not directly influence the quality of the equity market. Another possibility may be that the results are biased because of the existence of an active equity option and bond market. Comparing the impact from the CDS market with that of other related markets, the authors further show that the equity option market has positive effects on the equity market quality.[22] In contrast the effect from the bond market on the equity market is negative. Goldstein et al. [2014] provide a framework for examining the informational effects of derivative markets on the underlying market. Different derivative markets might have systematic differences in the model parameters. This model can help explain why different derivative markets have different effects on the underlying market.

4.3 CDS and equity options

Equity derivatives such as exchange-traded options were hedging tools before the advent of the CDS market. Carr and Wu [2010] discuss the similarities between put options and CDS, and point out a simple link between deep out-of-the-money put options and CDS contracts. Following such a logic, they show that CDS and options can be jointly priced. Carr and Wu [2007] study the comovement of sovereign CDS spreads and currency option implied volatilities using data from Brazil and Mexico. They find that the default intensity is more persistent than the currency return variance. In practice, some arbitrage trades are based on CDS and options. Fonseca and Gottschalk [2013] discuss cross-hedging strategies between CDS spreads and option volatility during crises.

[22] Raman et al. [1998] also find that option trading improves the stock market quality.

There are several notable differences between those two types of derivatives. First, options typically have a shorter maturity. The most frequently traded options have a 3-month maturity while 5-year CDS contracts are the most liquid. Second, options are exchange-traded but CDS are traded OTC. Third, the CDS market consists purely of institutional investors while both institutional and individual investors trade options. The introduction of CDS may also impact the option price, liquidity, and market efficiency. However, there is currently no research focusing on this dimension.

5

CDS and Corporate Finance

The discussion in the section on the pricing of CDS contracts, Section 3, was based on the assumption that the cash flows of the underlying entity are unaffected by the existence of credit derivatives contracts referencing a future default event, i.e., the credit derivatives are merely redundant assets. However, the validity of this assumption is an empirical issue. In this section we discuss how the existence of CDS contracts affects the financing and investment decisions of the *reference entities* underlying the derivative contracts. There are plausible reasons to believe that the introduction of hedging instruments on the underlying entity's credit may affect the real side by altering the strategic behavior of the entity. Any such externality, whether positive or negative, should ultimately be reflected in firms' operating and financial performance, their access to capital and the cost of finance. Since many of the papers on this topic relate to corporate credit, in the first subsection we will focus our attention on how CDS affect the credit supply and borrowing costs of firms. In the next subsection, we will then discuss how CDS affect bankruptcy risk, in particular by influencing creditors' incentives in the restructuring process. Although there are many other aspects of the impact of CDS contracts on the real side of a firm, our understanding is that the intersection of CDS and corporate finance, thus far, has likely progressed the most around these two research topics. We will then discussion the intersection of CDS and corporate governance in the third subsection.

While this section focuses on how companies with traded CDS on their outstanding debt are affected by the existence of such hedging products, a fair question to ask is how the existence of CDS also affects their end-users. To this end, a detailed discussion on such implications is provided in Section 6.[1] The papers discussed in Section 6 are closely related to the issues in this section, as banks are often the driving forces behind some of the effects we analyze here. Therefore, these two sections should be understood in an integrated way.

5.1 Credit supply and cost of debt

At the broadest level, corporations raise capital by issuing either equity or debt. Debt financing typically takes the form of either bank loans or publicly traded bonds. Prior to the creation of the credit derivatives market, risk mitigation and sharing for bank lenders and bond holders through the credit risk transfer channel was quite limited. Loan sales were rare and corporate bonds are often illiquid. The cost of limited risk sharing must ultimately be borne by corporate borrowers. CDS fundamentally alter the risk-sharing mechanism and thereby affect the behavior of lenders and hence corporate borrowing costs. We start by reviewing the theoretical predictions of this literature and the related empirical evidence.

5.1.1 Theory

Morrison [2005] was among the first to model the effect of CDS on corporate financing decisions. The key message of this paper is that credit derivatives may lead to financial disintermediation and reduced bank

[1] For example, derivative contracts enjoy privileged treatment in bankruptcy and derivative counterparties are essentially senior to all other residual claimants. Bolton and Oehmke [2014] study theoretically how this privileged treatment of derivatives in bankruptcy affects derivative users' borrowing costs and incentives for efficient hedging.

monitoring. He develops a static two-period investment model where managers are able to extract private rents from an investment project. Managers choose to finance the project either by borrowing from a bank, or by issuing a publicly traded corporate bond. Without credit derivatives, companies would partially fund the investment through a bank loan with the associated benefit of bank monitoring. This signals the quality of the project and reduces the overall borrowing costs of the mixed financing strategy. However, in the presence of credit derivatives, banks may divest part of the credit risk in order to reduce the concentration of risk in their portfolio. This, in turn, reduces the monitoring incentives of banks. In this case, the bank's role in certifying the firm's financial condition which permits the firm to obtain cheaper bond market financing is no longer as important. As a consequence, entrepreneurs may instead issue speculative-grade bonds and engage in second-best behavior. Thus, in this framework, bond investors lose the benefits associated with bank monitoring after the introduction of credit derivatives.

One feature of CDS contracts is that they permit the separation of creditors' cash flow rights from their control rights. As a consequence, lenders may potentially become tougher with borrowers during the debt renegotiation process. The source of this motivation is the ability of lenders to retain control rights in a firm, even as they eliminate economic exposure by hedging the credit risk with CDS contracts. In other words, these lenders become "empty creditors," a term coined by Hu and Black [2008] to refer to, among other situations, creditors whose exposures are hedged by CDS.[2] Thus, creditors who hold CDS protection may have different incentives than unhedged creditors.

[2]The concept of an "empty creditor" is rooted in the concept of an "empty voter," which was coined by Hu and Black [2006], and pertains to the separation of cash flow rights from voting rights on the equity side. See also Kahan and Rock [2007] and Hu and Black [2007]. The concept of empty creditors is also closely connected to the notion that credit insurance alters lenders' incentives during periods of financial distress, which was discussed even earlier by Pollack [2003], p. 46. Pollack [2003] is concerned with "the moral hazard problem that may arise if a credit default swap contract does not include the *Restructuring* clause as a credit event and the protection buyer forces the Reference Entity into bankruptcy in order to trigger a default under the swap." See also Kiff et al. [2009] on this topic.

They may use their control rights strategically to force companies into bankruptcy in order to receive a more handsome insurance payment. This would be more favorable for the creditor than accepting a haircut in a debt renegotiation process, even though it may be socially inefficient because of job losses and welfare destruction. In equilibrium, the existence of a CDS contract may, therefore, lead to ex-ante commitment benefits, whereby the borrowing companies default less often. Bolton and Oehmke [2011] illustrate this mechanism in a three-period investment model with periodic payments to the creditors. Interim cash-flows are unobservable, which may lead borrowers to decide to strategically default. In response to missed interest payments, creditors can decide whether to pursue the project or liquidate the firm. The results suggest that creditors are more inclined to liquidate, which reduces the strategic default incentives. The flip side of the coin is that creditors sometimes overinsure, and enforce too many defaults as a consequence. Such excessive defaults are socially inefficient and welfare decreasing, given that certain positive net present value projects are liquidated rather than restructured. It is worth emphasizing that the benefits of CDSs do not only come from a reduction in strategic default. They come more generally from an increase in the bargaining power of creditors. To see this, note that, even after a non-strategic default, creditors can extract more from other claim holders, if they also enjoy CDS protection. In other words, the mechanism would also work in the absence of any concern about strategic default.

We use a simple framework to demonstrate the basic intuition of Bolton and Oehmke [2011]. Consider first the case where creditors lend X to the firm. When there are no CDS traded on a firm, if the firm is in financial distress and consequently declares bankruptcy, creditors will recover $r \times X$, where r is the recovery rate in bankruptcy. Consider, on the other hand, that the creditors allow the firm to restructure the debt, since the recovery value of the assets in bankruptcy is less than its value as a going concern. Suppose the firm offers the creditors part of the difference between the "going concern" value and the recovery value of the assets in bankruptcy, and agrees to pay them, say, $R \times X$, with $R > r$. Clearly, the creditors would consider such a restructuring favorably, and try to avoid bankruptcy.[3] In general, restructuring would dominate bankruptcy.

Suppose now that the creditors can also buy CDS protection against the firm's credit events. Clearly, bankruptcy will always be defined as a credit event. However, restructuring may or may not be defined as a credit event, as per the clauses of the CDS contract. Subrahmanyam et al. [2014a] provide a discussion of contract clauses. In the case of CR CDS, assume that the CDS premium (price) is F, in present value terms, at the time of default and that the creditors buy CDS against Y of the notional value of the CDS. If the firm defaults, the creditors' total payoff with CDS protection is $[r \times X + (1 - r - F) \times Y]$ in the event of bankruptcy, and $[R \times X + (1 - R - F) \times Y]$ if the debt is restructured. Therefore, the creditors are better off with bankruptcy than with restructuring if

$$[r \times X + (1 - r - F) \times Y] > [R \times X + (1 - R - F) \times Y], \qquad (5.1)$$

i.e., when $Y > X$, since $R > r$. Hence, bankruptcy dominates restructuring as a choice for creditors for whom the amount of CDS purchased exceeds the bonds held ("empty creditors"), even when restructuring is covered by the CDS. In the equilibrium model of Bolton and Oehmke [2011], CDS sellers fully anticipate this incentive of CDS buyers, and price it into the CDS premium. Although CDS sellers may have an incentive to bail out the reference firms (by injecting more capital as long as it is less than the CDS payout) in order not to trigger CDS payments, they cannot do so unilaterally; the empty creditors who are the CDS buyers, and other creditors, will mostly decide the fate of the company, as any new financing would require the existing creditors' approval, and CDS sellers are not part of this negotiation process.[4]

[3]The precise size of R would be determined in a bargaining process between the creditors and the shareholders of the firm.

[4]Bolton and Oehmke [2011] assume that protection sellers do not participate in renegotiation. This assumption is generally reasonable, since in practice, protection sellers rarely participate in debt renegotiations. There exist counterexamples, nevertheless, such as in the case of Amherst Holdings in 2009, when the protection seller, assisted by other parties, paid off the loan for the borrower in order to prevent default.

Now consider the case of XR CDS. Assume that the CDS premium, in this case, is f in present value terms, where $f < F$. Suppose again that the creditors buy CDS against Y of the notional value of the CDS. Therefore, if the firm defaults, the creditors' total payoff with CDS protection is $[r \times X + (1 - r - f) \times Y]$ in the event of bankruptcy, and $[R \times X - f \times Y]$ if the debt is restructured. Bankruptcy is a preferred outcome for the creditors if

$$[r \times X + (1 - r - f) \times Y] > [R \times X - f \times Y], \tag{5.2}$$

or if

$$Y > \frac{R - r}{1 - r} X, \tag{5.3}$$

which can be true even when $Y < X$, since $R < 1$. Thus, for XR CDS, bankruptcy is preferred when even a relatively small amount of CDS are purchased; hence, bankruptcy is the preferred outcome for a larger range of holdings of XR CDS by the creditors. It is also evident that buying CDS protection with XR CDS contracts is more profitable in the event of bankruptcy than restructuring without CDS protection, so long as

$$[r \times X + (1 - r - f) \times Y] > R \times X, \tag{5.4}$$

which is equivalent to saying that[5]

$$Y > \frac{R - r}{1 - r - f} X. \tag{5.5}$$

The above condition is met when $Y > X$, as long as $R < 1 - f$, which is almost always true as the cost of CDS protection is usually lower than the loss in the event of restructuring. Even if $Y < X$, the condition is likely to hold, for reasonable values of R and f. Further, the greater the difference between Y and X, the greater will be the incentive for creditors to push the firm into bankruptcy.

To recap, we demonstrate that (a) creditors have an incentive to overinsure and push the firm into bankruptcy, (b) this incentive increases with the difference between Y and X, i.e., the amount of CDS

[5]The calculation for the CR CDS is the same, except that the fee is F instead of f. The precise range of values for Y relative to X will be smaller than for the XR CDS, as argued above.

contracts outstanding relative to the firm's debt, and (c) the probability of bankruptcy occurring is greater for XR CDS contracts.

Che and Sethi [2014] theoretically show that the CDS market benefits borrowers by increasing their debt capacity and lowering interest rates in the case where CDS can only be purchased against an insurable interest. However, since the CDS market provides lenders with an alternative venue in which to trade credit risk [Oehmke and Zawadowski, 2014b], lenders may also be less willing to extend credit to the firm if investors are allowed to hold naked CDS positions, i.e., they are CDS buyers who have no exposure to the underlying borrower so that they have no insurable interest. Che and Sethi [2014] argue that CDS "induce investors who are most optimistic about borrower revenues to sell credit protection instead of buying bonds, which diverts capital away from potential borrowers and channels it into collateral to support speculative positions."[6] From this perspective, naked CDS positions reduce firms' debt capacity as investors shift their money away from financing real investments to collateralizing speculative positions. This further reduces debtors' power to negotiate the terms of a loan. Moreover, the model suggests the emergence of multiple equilibria, whereby firms may find it more difficult to roll over maturing debt, i.e., they face "rollover risk." Hence, borrowers may be adversely affected by CDS trading, especially if it is naked, i.e., without ownership of the underlying bonds.[7]

Oehmke and Zawadowski [2014a] theoretically model the effect of the introduction of CDS trading on the bonds issued by the underlying entity. In their framework, CDS are non-redundant assets and can affect the underlying bonds due to the liquidity differences between the two markets. Their formulation assumes that the CDS market is relatively more liquid than the underlying bond market. They identify a tradeoff

[6]Portes [2010], Goderis and Wagner [2011], and Sambalaibat [2011], among others, discuss the externalities arising from naked sovereign CDS trading in the context of sovereign bonds. We describe their findings in Section 7, which covers the literature on sovereign CDS.

[7]Note that borrowers can benefit nevertheless from the availability of naked CDS positions if beliefs about the worst case outcome for borrower revenues are sufficiently optimistic.

between a “crowding-out” effect and an improvement in the allocation of risk in the bond market. Thus, the effect of CDS trading on the underlying bond price depends specifically on this tradeoff. On the one hand, the availability of CDS protection may induce some investors to switch from the bond market to the CDS market.[8] On the other hand, the presence of leveraged basis traders after the CDS introduction may allow long-term investors to hold more of the illiquid bonds due to the ready availability of hedgers. For example, negative basis trades take a long position in the bond and simultaneously purchase CDS protection, which tend to push up bond prices. When the liquidity differential is substantial, and when basis traders are able to leverage their positions, the introduction of CDS trading is more likely to raise bond prices.[9]

The previously highlighted predictions are primarily unconditional, although both the causes and consequences of CDS trading may vary over time. Campello and Matta [2013] predict that the empty creditor problem is indeed procyclical, based on a static three-period investment model. Managers borrow from a financial intermediary to finance a project. They have discretion over their effort level, which is unobservable, but can be inferred from the outcome of the investment project. The precision of the inference depends on market conditions. The manager may also strategically default by missing interim payments, as cash flows are unobservable, as in Bolton and Oehmke [2011]. Lenders, on the other hand, decide whether to hedge their credit risk exposure by buying CDS protection or not, after the manager has made his effort. If the borrower fails to make an interim payment, lenders can either negotiate a haircut on the loan and continue the project, or liquidate the firm. The model predicts that CDS contracts could increase the debt capacity of the firm during economic booms and for more successful firms, as their managers are

[8]For example, optimistic bond holders may choose to sell CDS protection rather than taking a long position in bonds, which would lower bond prices. Pessimistic investors would switch from shorting bonds to buying CDS contracts, which would increase bond prices, because of the diminished short selling.

[9]It is worthwhile to note that while most of the papers in this literature assume that the number of traders is fixed, Sambalaibat [2013] develops a search-based model for sovereign CDS where the number of traders is not fixed, and new investors may enter the market because of the availability of hedges.

more likely to exert higher efforts. Campello and Matta [2012] also argue that, in the presence of CDS trading, managers can invest in riskier projects. Such "risk-shifting" behavior increases the borrowers' probability of default. Finally, Fostel and Geanakoplos [2013] show that the introduction of naked CDS may generate underinvestment, and that financial innovations such as CDS can change the collateral capacity of durable assets, which may further alter investment decisions, ex ante. This prediction contrasts with Bolton and Oehmke [2011], in which investments may increase due to a better credit supply.[10]

The above-cited theoretical models have several implications for corporate financing decisions. For example, in the generalization of the classic Modigliani-Miller formulation, firm leverage is determined by the tradeoff between bankruptcy costs and the tax shield, information asymmetry between insiders and outsiders, as well as the overall market conditions. If the presence of CDS contracts changes the debt capacity of the firm for other reasons and also alters the risk of bankruptcy, the optimal capital structure of the firm will also be affected. We discuss the empirical evidence on CDS, debt capacity and credit risk in the following subsection.

5.1.2 Empirical Evidence

Saretto and Tookes [2013] show that firm leverage and debt maturity increase after CDS trading. In other words, they argue that the credit supply to firms is greater when lenders can hedge their credit exposures with CDS. The study focuses on non-financial S&P 500 firms. More precisely, the authors study a sample of 3,168 firm-year observations from 2002 to 2010, among which 1,578 firm-year observations are associated with active CDS trading.[11] A comparison of company characteristics between firms with and without traded CDS suggests that CDS firms

[10] In Bolton and Oehmke [2011], CDS enhance creditors' bargaining power in ex-post renegotiations. This raises the debtor's pledgeable income and helps reduce the incidence of strategic default. Through these commitment benefits, CDS may relax firms' borrowing constraints and increase investment.

[11] The sample selection is based on available CDS information from Bloomberg, and hence, it excludes firms with zero debt.

have, on average, similar credit ratings to non-CDS firms, but higher leverage and longer debt maturities.[12] Both separate and joint analysis yields that leverage and debt maturity increase after the onset of CDS trading. To mitigate concerns that the results are driven by unobserved firm characteristics that are correlated with CDS trading, the authors incorporate the amount of banks' foreign exchange derivatives usage as an instrumental variable in their regression design. The effect of CDS trading on leverage and maturity remains significantly positive even after controlling for the selection into CDS trading using this instrument. In addition, the authors verify their results using two exogenous shocks to credit supply: within-state defaults and write-downs during the 2007–2008 financial crisis. The conclusion from this study is that the presence of CDS trading increases firms' financing capacity. Hirtle [2009], on the other hand, finds limited evidence that CDS increase the bank credit supply. More precisely, she shows that, while the use of CDS by bank lenders increases their credit supply to large corporate borrowers, this benefit is offset by increased credit spreads. The analysis in this study is based on aggregate bank lending and derivative usage data.[13]

The Saretto and Tookes [2013] study suggests that CDS induce an overall increase in credit supply. Whether this supply shift benefits all borrowers equally is debatable. Ashcraft and Santos [2009] find that, following the initiation of CDS trading, borrowing costs increase for high-risk borrowers, while they decrease for low-risk borrowers. This suggests that CDS trading reduces asymmetric information such that creditworthy borrowers are easier to identify, thereby mitigating, if not eliminating, the proverbial "lemons problem." The sample in this study stretches from the second quarter of 2001 to the second quarter of 2005. It contains 51 firms that initiated CDS trading and 152 matching firms

[12]Debt maturity is computed based on the detailed debt structure information available in Capital IQ, and weighted by the principal value of each debt issue.

[13]The sample is a combined dataset from the Federal Reserve Survey of the terms of business lending, the Federal Reserve Senior Loan Officers' Opinion Survey, and the quarterly Consolidated Reports of Condition and Income, generally referred to as the Call Reports.

without any CDS trading.[14] The data used by Ashcraft and Santos [2009] may be noisy, as their classification into CDS and non-CDS firms is based on the Markit database only.[15] Markit started its data coverage in 2001. Thus, some firms may have already had traded CDS prior to 2001, but they would not be classified as CDS firms until they were quoted for the first time in the Markit database.

Kim [2013] uses Markit data from 2001 to 2008 and a sample of 227 firms with CDS quotes to find evidence that firms with high strategic default incentives experience a relatively larger reduction in their corporate bond spreads following the introduction of CDS. This suggests that firms are more likely to face a limited commitment problem prior to the introduction of CDS. Massa and Zhang [2012] show that CDS can reduce fire sale risk. Regulations often impose significantly greater capital requirements for insurance companies on their holdings of speculative-grade bonds. Thus, the necessity to sell issues downgraded below investment-grade status may induce temporary price pressure [Ellul et al., 2011]. The opportunity to hedge the capital requirements through CDS reduces the need to divest fallen angels (bonds that were initially investment grade, but were subsequently downgraded to speculative-grade ratings). This mechanism decreases bond yield spreads and increases bond liquidity. The sample in this study covers U.S. corporate bonds using CDS information obtained from Markit data during the time period between 2001 and 2009. Shim and Zhu [2014] analyze how the existence of CDS trading affects corporate bonds in Asian economies over the period January 2003 to June

[14]The identification of the CDS initiation dates is based on Markit. Firms with CDS trading prior to January 2001 (the beginning of the sample period) are removed as the starting date cannot be precisely determined in those cases. The raw sample in the study contains 537 companies with existing CDS contracts, among which 76 already existed before the start of the sample period in 2001. Firms with credit ratings above A+ and below B in the quarter before CDS trading are also excluded. The need for available information on bond and loan issuance further reduces the sample.

[15]This critique more generally applies to studies using Markit as the *single* source of information to identify the CDS initiation dates. It is far better for studies to combine multiple sources of CDS information to identify the CDS initiation dates, in particular information prior to 2001. For a more detailed discussion, see Subrahmanyam et al. [2014a].

2009. They find that bond yield spreads at issuance are 18 basis points lower when the issuer has CDS contracts based on it with quoted prices 30 days before the bond is issued. Their sample covers 1,091 corporate bond issues from 236 firms, among which 643 issues from 116 firms have traded CDS.

Since 2008, some issuers have started to issue corporate bonds and loans with coupon payments linked to their CDS spreads. Ivanov et al. [2014] analyze such market-based pricing schemes. They identify 117 loans, issued by 51 firms and 18 banks, with an interest rate tied to the CDS spreads of the issuer.[16] They find that such loans have lower spreads at origination and fewer covenants than otherwise similar standard loans. The saving on the loan spreads is estimated to be 32 basis points, after controlling for borrower and lender characteristics. Most of these loans are revolver-type debt contracts from investment-grade borrowers.

Surveying the previous references highlights the conclusion that the overall empirical evidence about the effects of CDS trading on a firm's cost of debt is rather mixed, with results pointing toward both benefits and costs from the existence of CDS contracts on a firm, and some studies reporting no effects whatsoever. A possible explanation for these contradictory findings is that we still lack large-sample evidence, over a sufficiently long time. Also, the onset of the global financial crisis, and the consequent structural shifts in financial markets in general, and CDS markets in particular, may have caused a regime change that confounded the effects, to some degree. The reduced transparency due to the fact that CDS are not traded on an exchange and were not even cleared until very recently, and the previously highlighted difficulty of identifying the dates of CDS initiation, further complicate these studies.

While borrowers certainly care about the price, quantity, and maturity of their debt, they also care about other borrowing terms such as debt covenants. While Morrison [2005] suggests that the existence of CDS may reduce banks' monitoring incentives, this could be reflected in

[16] Their sample also includes 28 loans from 11 firms and 8 banks with interest rates linked to the CDX index. The sample period starts in the second quarter of 2008 and ends in the fourth quarter of 2012.

more stringent covenants tied to bond issues. Alternatively, CDS may serve as an ex-ante commitment device, as suggested by Bolton and Oehmke [2011], thereby allowing creditors to loosen these covenants. On the other hand, borrowers may demand looser covenants if they are concerned about tougher creditors in debt renegotiation or loan rollovers. Shan et al. [2014a] provide evidence in favor of the latter arguments by finding that loan covenants are loosened after CDS trading. The covenant loosening effect associated with CDS trading is most pronounced for firms with less serious information problems and for firms with better credit quality.

Finally, if CDS can serve as efficient monitoring tools, they may also replace credit ratings as a proxy for access to capital markets.[17] Such an argument is sustained by the evidence in Chava et al. [2013]. If credit ratings affect firm capital structure, then CDS will substitute for the role of ratings. The authors use a sample from 1998 to 2007, covering 1,293 firms, of which 390 have traded CDS. They find that a firm's stock price reacts significantly less to a credit rating downgrade after a CDS contract starts trading on its debt.

5.2 Restructuring and bankruptcy

In traditional banking relationships, lenders are concerned about the borrowers' ability to repay their debt. In case of financial distress before the loan has been repaid, lenders are typically willing to renegotiate with the borrowers in order to keep them as a going concern.[18] However, when lenders can buy CDS protection and receive insurance payments from protection sellers rather than accepting a haircut in debt renegotiations, their incentives for helping the borrowers to overcome financial distress may be undermined. In particular, lenders may hold "negative economic ownership," using the terminology of Hu and Black [2008], and become empty creditors who have superior negotiating power, even though they are not necessarily negatively exposed to the borrower's

[17]Han and Wang [2014] use dealers' CDS spreads to proxy for their financial strength.

[18]See, among others, Hart and Moore [1988], Bolton and Scharfstein [1990], Hart and Moore [1998], and Mella-Barral and Perraudin [1997].

default (Bolton and Oehmke [2011]). Such creditors clearly decrease a firm's likelihood of survival.

Subrahmanyam et al. [2014a] empirically test this hypothesis. Bankruptcies are rare events and naturally require a long time series in order for meaningful conclusions to be drawn. The authors, therefore, construct a comprehensive bankruptcy record from 1997 to 2009, including 940 bankruptcies from both large and small firms. They also compile CDS trading records using actual transaction data over the same time period. Their CDS sample covers 901 CDS initiations for North American firms. They find that firms are more likely to be downgraded or to go bankrupt after CDS trading. Their findings are robust to the inclusion of two instrumental variables for CDS trading, lenders' amount of foreign exchange hedging and lenders' Tier 1 capital ratio. Moreover, CDS trading arguably affects already distressed firms the most. The decisive influence of empty creditors does not materialize until creditors and borrowers arrive at the negotiation table, in the event of distress, to discuss potential restructuring of the debt. Subrahmanyam et al. [2014a] indeed show that CDS firms are more likely to go bankrupt once they are in financial distress, and this effect is most pronounced when the traded CDS contracts do not include the restructuring clause as a credit event. Without the restructuring clause in the CDS contract, CDS buyers have a preference for bankruptcy over restructuring. The authors also find that the number of creditors increases after CDS trading. Creditor coordination is more difficult for larger numbers of creditors, leading to a higher likelihood of bankruptcy. Peristiani and Savino [2011] study the implications for bankruptcy using a comparatively smaller sample. They find consistent evidence to Subrahmanyam et al. [2014a] (albeit weaker), in that firms are more likely to go bankrupt after the inception of CDS trading.

Most distressed firms attempt to restructure their debt to stay out of bankruptcy. Several studies examine the success of restructuring in the presence of CDS trading. The evidence on whether CDS trading improves or worsens the restructuring prospects is mixed. Bedendo et al. [2012] analyze 163 defaults over the period from January 2007 to June 2011, covering 65 out-of-court distressed exchanges and 98

Chapter 11 bankruptcy filings. They do not find evidence that CDS influence restructuring outcomes. Debt issuers may allegedly cooperate strategically with select creditors to minimize the impact of pressure from empty creditors. Narayanan and Uzmanoglu [2012] use data on 84 distressed exchanges (25 CDS and 59 non-CDS) from 2004 to 2011 to conclude that CDS trading does not play a significant role in restructuring outcomes. Therefore, they argue that, even though the influence of CDS for restructuring is taken into account by borrowers and lenders, in equilibrium CDS may not have observable effects on distress resolution because borrowers "work around" empty creditors.

Besides the voting outcome for restructuring proposals, another interesting aspect is how creditors with vested interests behave in the voting process. If creditors are protected by CDS, they may not care about the outcome and may not bother with voting at all. Danis [2012] analyzes participation rates in the restructuring voting records from 2006 to 2011. His sample covers 210 corporate bonds involved in 80 exchange offers. He finds that 29% fewer creditors vote for restructuring when there is a CDS contract referencing the bonds compared to a situation without a CDS. He uses the changes following the CDS Big Bang in 2009 as an exogenous shock to mitigate various endogeneity concerns.

Trading CDS in the secondary market could potentially also affect primary market securities issuance. For example, Arentsen et al. [2014] argue that "since issuers and investors in mortgage-backed securities (MBS) could hedge the credit risk of the subprime loans underlying MBS with CDS contracts, this helped fuel the demand for subprime loans, which were supplied by loan originators who reduced lending standards to meet demand." They examine data on the privately securitized subprime mortgages originated during the period from 2003 to 2007. The findings suggest that CDS coverage significantly increased the probability of loan delinquency by more than 10% during the financial crisis. CDS also facilitated the issuance of lower-quality securities, thereby increasing the overall default rate for all securities offered.

Despite all this mixed evidence, it is probably fair to conclude that CDS influence the restructuring versus bankruptcy decision in some way. In any case, these results should be considered in light of the selection issue in the restructuring analysis. Some distressed firms may self-select into pre-packaged Chapter 11 bankruptcy instead of restructuring their debt outright. Probably, a more useful debate to have is whether any noted effects are economically meaningful. Also, one issue to keep in mind in addressing this question, data problems aside, is concerned with the various dimensions in which the existence of CDS and CDS trading can affect corporate finance decisions. This raises various policy questions. For example, some argue that bankruptcy law should be changed to cater to the existence of CDS. Lubben and Narayanan [2012] specifically discuss the implications of CDS trading on reorganization methods. They suggest that creditors' CDS positions must be disclosed during the debt renegotiation process of financially distressed firms in order to be consistent with the spirit of the bankruptcy law. Pollack [2003] suggests that CDS protection sellers should be involved in the distress resolution process. Overall, we believe that further research, based on larger and more complete samples, is needed before conclusions can be made in favor of a specific policy recommendation.

5.3 Corporate governance

If CDS trading affects the incentives and strategic behavior of firms with regard to their debt obligations, it stands to reason that it ought also to affect their corporate governance. In particular, if external governance is weakened after CDS trading, especially since lenders have lower monitoring incentives, then internal governance may need to be more vigilant to offset such effects. Colonnello [2014] provides empirical evidence that board independence increases after CDS trading over the period from 2001 to 2011, using a sample of 347 CDS and 1,127 non-CDS firms. With a similar insight, Bolton et al. [2011] propose linking executive compensation to firm's CDS spreads in order to address excessive managerial risk taking, in particular risk shifting. Feldhutter et al. [2014] use CDS as a benchmark for bond spreads to measure the value of control rights. They find that CDS prices reflect the cash flows of the underlying bonds, but not the control rights. As firms' credit quality declines, the value of creditor control increases since creditor control can affect managerial decisions. Then they measure the creditor control premium in bond spreads as the difference between the bond price and that of an equivalent non-voting synthetic bond that is constructed using CDS. In a sample of 2,020 publicly traded bonds of 963 U.S. companies, they find that control rights affect bond prices and liquidity. The creditor control premium monotonically increases as default approaches, to over 6% by the time of default.

While the empirical evidence seems to support the view that firms can raise more external funding after CDS start trading on their debt, it is unclear how those funds are deployed. Moreover, firms may find their financial flexibility increased after CDS trading and, therefore, may hold less cash. On the other hand, firms may also be concerned about the previously discussed empty creditor problem and debt rollover risk. This would incentivize them to hold more cash. Subrahmanyam et al. [2014b] support the latter hypothesis by finding that firms hold more cash after CDS trading. Their finding suggests that the concerns over losing creditor support in times when it is most needed may dominate the increased financial flexibility or perceived credit supply. This conservative cash policy may serve as a buffer against heightened risk taking and aggressive accounting practices. How exactly these actions balance out is still unclear and an interesting avenue for future research. Presumably, all corporate policies will be reflected in the performance of firms over the long run, and a firm's liquidity policy is certainly an important aspect of its strategy.

The empirical literature on the relationship between CDS and corporate finance has grown tremendously over recent years, and there are other interesting implications of CDS trading in terms of corporate policy and external corporate governance. For example, Martin and Roychowdhury [2014] find that the borrowing firms' accounting conservatism reduces after the onset of CDS trading as lenders are less vigilant in monitoring the borrowers. This is, in particular, evidenced by asymmetric timeliness of loss recognition. In other words, firms become more aggressive in their accounting practices after CDS start trading on their debt. The effect is more pronounced when lenders have lower reputation costs due to reducing monitoring, when outstanding contracts have more financial covenants, and when lenders are more active in their monitoring before the introduction of CDS. Moreover, the empty creditor problem and weakened monitoring incentives of lenders can increase firms' business and audit risk, which may burden CDS firms with higher audit fees than non-CDS firms Du et al. [2013]. Colonnello [2014] finds evidence suggesting that creditors tighten corporate controls when CDS-referenced firms violate loan covenants. Karolyi [2013] studies the effects of CDS trading on borrowers' behavior and finds evidence consistent with increased risk taking. In a sample of 49 homebuilders from 2001 to 2010, among which 22 have CDS trading, he finds that borrowers increase both operational and financial risk taking after CDS initiation. On the brighter side, Kim et al. [2014] find that managers are more likely to issue earnings forecasts when firms have actively traded CDS.

While many studies identify the effect of CDS trading on the underlying reference firms, it turns out that only a small fraction of firms, typically larger in size, actually have CDS referencing their debt. However, there exist rich economic linkages between CDS and non-CDS firms, which could possibly introduce spillover effects between the two groups. One such relevant and important economic link is the customer-supplier relationship. Li and Tang [2013] construct the economic linkages between industrial firms to study this issue. The authors focus on the specific situation when the customer's debt has CDS traded on it, but the debt of the supplier does not. If customers become riskier after CDS trading, then suppliers may want to reduce their leverage to maintain their credit profile. The findings suggest that the supplier's leverage is lower following the onset of CDS trading on the customer's debt. Customers may also be concerned with their supplier's CDS trading. Hortacsu et al. [2013] find that products sell at lower prices when a company's CDS spread is higher. This evidence suggests that consumers use information implied by CDS spreads. Moreover, such use of CDS may create a feedback loop and potentially induce a downward spiral: distressed firms have higher CDS spreads, and their product market competitiveness is reduced, which further deteriorates their credit quality.

To summarize, the existing empirical evidence paints a consistent picture that CDS trading allows firms to borrow more, most likely at lower interest rates, potentially at longer maturities, and with looser covenants. However, firms may not always access this additional source of financing in the best possible way, for example holding inefficient cash balances. Borrowers could very well be negatively affected by such availability of additional financing and face increased bankruptcy risk. Finally, the existence of CDS contracts seems to affect both external and internal corporate governance in various dimensions. A clear conclusion on these topics is premature, but given their broad relevance, further empirical research in order to validate or invalidate the existing theoretical predictions is warranted.

6

CDS and Financial Intermediaries

The CDS market is dominated by institutional investors, as evidenced by the fact that approximately 85% of all transactions are classified as dealer-to-dealer trades, according to the DTCC. This is confirmed by Chen et al. [2011], who report that the largest 14 dealers account for about 90% of all CDS transactions, with more than half of these being executed *within* these 14 dealers.[1] As is to be expected, banks are the major players in the credit derivative market. In fact, they were the main group among the proponents of CDS who lobbied for the contracts to be recognized in bank regulations as hedging instruments when calculating capital requirements. In August 1996, the Federal Reserve Board published a Supervision and Regulation Report to discuss the hedging role of CDS for bank credit risk.[2] In June 1999, it was formally proposed that CDS be included in the Basel II capital accord, which was officially approved in 2004, and effectively implemented in 2006. The inclusion of CDS as hedging tools in regulatory capital directives makes it reasonable to hypothesize that these changes

[1]The major CDS dealers and Markit are facing anti-trust lawsuits for alleged collusion.

[2]The OCC, which governs national banks, did the same around the same time.

have affected the incentives and behavior of CDS end-users. In this section, we discuss the use of CDS contracts by financial intermediaries, in general, and how they have impacted on the performance of lenders and the debtor-creditor relationship, in particular.

6.1 Performance of banks

Several papers have examined the effect of CDS trading on the incentives and the behavior of lenders to firms, in particular banks. Acharya and Johnson [2007] suggest that financial intermediaries potentially purchase credit insurance based on superior information they obtain from their lending relationships with clients. This results in informed trading, effectively insider trading, that is revealed in CDS prices before it gets incorporated in the borrower's stock prices. They further show that this evidence becomes stronger if the borrower has a higher number of bank relationships. Acharya and Johnson [2010] also provide similar evidence in the context of leveraged buyouts, by showing that such insider trading becomes stronger as the number of parties involved in the transaction increases.

Although the evidence provided by Acharya and Johnson suggests that banks exploit insider trading opportunities in the CDS market, Minton et al. [2009] find that banks' use of CDS is limited, possibly due to a lack of liquidity in trading CDS contracts. According to the discussion in Minton et al. [2009], only 23 out of the 395 large banks in their sample used credit derivatives in 2005. For U.S. bank holding companies with assets above $1 billion, during the period from 1999 to 2005, a substantial proportion of the CDS positions are for dealer activities and the hedging positions are rather small compared to their loan portfolios. Their findings imply that banks did not become effectively less risky after their use of CDS for hedging. Their conjecture of the ineffectiveness of CDS positions to substantially mitigate credit risk is, to some extent, supported by the well-known "London Whale" trading fiasco in early 2012, when J.P. Morgan lost $6.2 billion in CDS index trading at its chief investment office in London. Since that well-publicized episode, regulators have been justifiably skeptical about the claims of bankers regarding the risk reduction potential of CDS trading.

Hakenes and Schnabel [2010] present a banking model showing that, if banks have private information about the quality of loans, they have an incentive to make unprofitable loans whose risks can be transferred to other parties via CDS, using an "originate-to- distribute" model. Such bank behavior leads to an increase in aggregate risk and a decrease in welfare. A similarly negative view is shared by Biais et al. [2014], who show that, although CDS are designed for hedging, they can promote excessive risk taking. Their logic is as follows. Protection sellers facing potentially large CDS payouts may engage in risk shifting by selling more CDS and reducing their efforts in honouring the contracts they sold, which may have implications for other unrelated firms. Therefore, financially weak firms, in particular, should not act as protection sellers.

In the current regulatory dispensation in most countries, CDS are generally permitted to be used to lower capital requirements, which may potentially induce regulatory arbitrage, if the regulatory rules are not in line with market realities. In this spirit, Yorulmazer [2013] analyzes the use of CDS for regulatory capital relief and its consequences for systemic risk. In his model, the bank and the CDS seller (insurer) prefer high correlation in their returns and jointly shift the risk to the regulator. He shows that CDS can help banks expand balance sheets and fuel asset price bubbles. Another prediction of his model is that CDS can be traded at a price higher than their fair value, the "mispricing" reflecting the value of capital relief. Empirical support for the model by Yorulmazer [2013] can be found in Shan et al. [2014b], who examine the effects of CDS on bank capital adequacy and lending behavior. They find that banks use CDS to improve the appearance of their capital adequacy as stipulated by regulations, while consequently engaging in more risky lending. While banks that use CDS appear resilient to internal shocks on loan portfolios, they are more vulnerable to external shocks in the CDS market. Banks that were active CDS users at the onset of the 2007–2009 credit crisis raised capital and reduced lending to a greater extent than banks that did not use CDS. CDS-using banks enjoyed better stock returns than their non-CDS-using peers during the pre-crisis period, but they suffered sharper stock price declines during the crisis. The findings suggest that regulatory capital regulation on the use of CDS enabled banks to mask their real capital inadequacy: they became more aggressive in their lending practices and more vulnerable to external shocks.

Hirtle [2009] uses a proprietary bank micro dataset of individual corporate loans to explore whether the use of credit derivatives is associated with an increase in bank credit supply. She finds only limited evidence that greater use of credit derivatives is associated with a greater supply of bank credit. In fact, the strongest effect in her sample is found for large term loans — newly negotiated loans extended to large corporate borrowers — with a largely negative impact on (previously negotiated) lending commitments. Even for large term borrowers, increases in the volume of credit are offset by higher credit spreads. The use of credit derivatives appears to be complementary to other forms of hedging by banks, although those banks most active in hedging appear to charge relatively more for additional amounts of credit. These findings suggest that the benefits of the growth of credit derivatives may be limited, accruing mainly to large firms that are likely to be "named credits" in these transactions. The conclusion in Hirtle [2009] seems contradictory to other studies, such as Saretto and Tookes [2013], but is to some extent consistent with Shan et al. [2014b]. It is important to point out, though, that Saretto and Tookes [2013] look at the entire capital structure of firms (i.e., not just bank loans) and find that most of the impact of CDS on firms' capital structures arises through corporate bonds, rather than through bank loans.

While there are justifiable concerns that financial intermediaries may exploit the private information obtained from their access to firms in the context of their corporate loan book to trade in the CDS market, CDS are still considered to be effective tools for transferring credit risk. By buying default protection, lenders can use CDS to mitigate their credit risk exposure. On the other hand, CDS may affect lenders' monitoring incentives and make them more lax in containing such risks. Duffee and Zhou [2001] provide an early discussion of the benefits of CDS contracts as risk transfer tools, but also express caution on the potential downside of CDS trading for firms. They model the impact of the introduction of CDS contracts from the perspective of creditors, focusing on banks. The banks' informational advantage regarding the borrower's credit quality may lead to adverse selection and moral hazard concerns. More specifically, CDS trading may reduce other types of risk sharing, such as secondary loan sales, with ambiguous welfare consequences. This view is supported by Morrison [2005], who argues that CDS can lead to disintermediation as banks may lose their incentives to monitor borrowers closely once their exposures are hedged with CDS.

Also, Arping [2014] shows that credit risk transfer alters the incentives of both lenders and borrowers. He argues, however, that by making investors tougher in restructuring, CDS protection can discipline the borrower, but may discourage the use of debt financing. Thompson [2010] extends the work of Duffee and Zhou [2001] by allowing for informational asymmetry in the CDS market, and by relaxing the "maturity mismatch" assumption. In this augmented model, it is no longer clear whether the use of CDS as credit risk transfer tools would be beneficial. The outcome depends on the interplay between the nature of the moral hazard problem, the relationship between the bank and the borrower, the cost of loan sales and the cost of capital. Allen and Carletti [2006] show that credit risk transfer can be beneficial when banks face systematic demand for liquidity. However, when they face idiosyncratic liquidity risk and hedge this risk in the inter-bank market, credit risk transfer can be detrimental to welfare. Further, such hedging via CDS may lead to contagion between the banking and real sectors and could potentially increase the risk of financial crises.

The effect of CDS mimics the impact of loan sales on the creditor's monitoring incentive. Loan sales provide an alternative tool for credit risk transfer. Gorton and Pennacchi [1995], for example, focus on the moral hazard problem after loan sales. They conclude that banks can overcome the moral hazard problem by continuing to hold on to a fraction of the loan, and hence having "skin in the game." Parlour and Plantin [2008] emphasize the impact of a liquid loan sale market on a bank's ex-ante incentive to monitor the debtor firm. They provide conditions under which a liquid credit risk transfer market can be socially inefficient. Parlour and Winton [2013] focus on a bank's decision to lay off credit risk through loan sales versus CDS protection.

They explicitly present efficiency implications in terms of risk transfer and monitoring, and suggest that CDS, as a risk transfer mechanism, are overall more likely to undermine the monitoring of banks. Beyhaghi and Massoud [2012] find that banks are more likely to hedge with CDS when monitoring costs are high.

In contrast to the largely negative effects documented above, Norden et al. [2014] argue that banks benefit from improved risk management enabled through CDS, and that these benefits are passed on to borrowers. They investigate whether, and through which channel, the active use of credit derivatives changes bank behavior in the credit market. Their principal finding is that banks with larger gross positions in credit derivatives charge significantly lower corporate loan spreads, while banks' net positions are not consistently related to loan pricing. They also find that the magnitude of the risk management effect remained unchanged during the crisis period of 2007–2009, when banks with larger gross positions in credit derivatives cut their lending by less than other banks during the crisis, and had consistently lower loan charge-offs.

In Section 5, we discussed how CDS may create empty creditors. Furthermore, CDS can also affect banks' lending behavior, including the amount, cost and contract terms of their credit supply. Although CDS provide creditors with an avenue for protecting their loan exposures, the unintended consequence is that creditors may become excessively tough and borrowers may be concerned about this. Such forces may have an ex-ante perverse effect on debt contracting, such as through covenants which enhance future creditor control. Shan et al. [2014a] find that debt covenants are less strict if there are CDS contracts referencing the borrower's debt at the time of loan initiation. This finding remains robust after taking into account the selection of CDS trading. The loosening of covenants is more pronounced when the lenders are active CDS users, and for borrowers with higher credit quality. Their findings are consistent with the view that CDS substitute covenants for creditor protection. Hence, credit derivatives represent outside options that affect financial contracting, which could have positive welfare consequences.

6.2 Other financial institutions

In addition to financial intermediaries such as commercial and investment banks, and insurance companies, shadow banks such as hedge funds, and mutual funds, are also active users of CDS and influential players in the CDS market. In fact, the current market trends suggest that hedge funds are becoming increasingly important players in the CDS market. Siriwardane [2014] document that hedge funds and asset managers have become the dominant CDS protection sellers since the fourth quarter of 2013. An example of their increasing influence is that they are even represented on ISDA Credit Derivatives DCs.

Since CDS are insurance-like contracts, it is natural for insurance companies to be market facilitators and participants in this market. It should be pointed out that financial intermediaries have been sellers of CDS protection from the early days of this product. Indeed, in the early years of the CDS market, insurance companies tended to sell naked credit protection, and were severely affected during the global financial crisis. However, since the crisis, insurance companies appear to have been net buyers of protection, as they have used CDS to hedge their bond portfolio holdings. It could be argued that banks have become even more "too big to fail" and are net sellers, rather than buyers, of CDS protection. Hedge funds are on both sides of the market, depending on their portfolios and their market views.[3]

Besides regulatory capital relief and hedging opportunities, relaxing collateral constraints can be another motivation for institutional investors to participate in the CDS market (as argued by Shen et al. [2014]). This motive is particularly strong for shadow banks such as hedge funds. The model in the Shen et al. [2014] paper analyzes the banks' choice between buying bonds, making loans, and selling CDS. Similarly, Oehmke and Zawadowski [2014a] argue that CDS contracts provide a more liquid alternative to trading the underlying bonds for institutional investors.

The evidence in Yu [2006] and Duarte et al. [2007] suggests that hedge funds can use CDS to conduct capital structure arbitrage and

[3]See BBA [2006] and IMF [2013], among others.

earn abnormal risk-adjusted returns. One vivid anecdotal example of this evidence is the activity of the Paulson Hedge Fund during the subprime mortgage crisis, as is illustrated by Lewis [2011] and Zuckerman [2010]. They dubb the Paulson CDS trades as, respectively, the "big short" and the "biggest trade ever". Despite this evidence, the growing literature on the CDS-bond basis, especially during the crisis period, also suggests that hedge funds engaging in capital structure arbitrage activities are vulnerable to large losses. (See for example the discussion on "arbitrage crash" related to CDS-bond basis trades in Mitchell and Pulvino [2012].) Some anecdotes include the in-house hedge funds at Deutsche Bank and Merrill Lynch, and the once famous Boaz Weinstein, which lost $2 billion in 2008. After the credit crisis, hedge funds partially retreated from the CDS market, despite an initial active participation and the popularity of capital structure arbitrage since 2002. One reason, although speculative, may be that CDS have become less attractive to hedge funds, especially bond mutual funds, as CDS are often fully collateralized, which removes the leverage embedded in CDS contracts. CDS, as a synthetic way of trading cash bonds, also face potentially higher volatility and clearing requirements. In addition, there are legal uncertainties as to whether a particular event or risk will be deemed to be a credit event, and thus covered by the CDS contract.

Hilscher et al. [2014] provide evidence that equity returns lead CDS returns at daily and weekly frequencies. Kapadia and Pu [2012] also show that CDS trading can be innocuous, as CDS spreads and stock prices often move independently (possibly due to limits to arbitrage). The above evidence casts doubt on the pervasiveness of insider trading in the CDS market and the effectiveness of CDS in offering trading opportunities for hedge funds.

Insurance companies, in particular AIG, were major players in the CDS market, and were arguably the driving force behind its explosive growth, in the pre-crisis years. AIG provided insurance to the famous J.P. Morgan synthetic CDO "Bistro" deal by selling insurance on the "super senior" tranche of the deal in early 1998 ("Bistro" was marketed at the very end of 1997). Joe Cassano, then an executive at AIG

Financial Products, called this transaction a "watershed" event that had changed the insurance business and the credit derivatives market forever. Since then, AIG FP and other insurance companies have sold many more CDS contracts. In 2007, AIG had outstanding short CDS positions valued at $546 billion.

One reason for the success of bank-insurance companies involved in CDS transaction is their ability to conduct regulatory arbitrage. Banks can buy CDS from insurance companies for regulatory capital relief. However, insurance companies are not subject to banking regulations. Moreover, although the insurance industry has its own regulatory capital requirements, insurance regulatory authorities have regulated CDS significantly less stringently than traditional insurance products. For example, in 2004 the state of New York amended its insurance laws and specifically excluded CDS from their coverage. The alleged logic is that insurance is meant to protect consumers, while the CDS market is comprised entirely of institutional investors. Thus, there is no consumer interest in need of protection. Many other states followed New York and argued that insurance companies did not need to hold much capital when they sold CDS protection.

The Office of Thrift Supervision (OTS), a relatively weak bank regulator, nominally had responsibility for AIG's non-insurance financial operations, because AIG owned a small thrift, but the OTS had no way of regulating a sophisticated operation like AIG. Moreover, AIG was able to choose which regulator it worked with, to its own advantage. Irrespective of the regulatory oversight, CDS are still subject to ISDA Master Agreements and the insurance companies need to honor their contractual obligations to their counterparties. Some allege that Goldman Sachs required AIG to post a large amount of collateral for the CDS that AIG sold to Goldman Sachs. AIG was not able to provide the collateral within the time specified. Eventually, AIG had to be bailed out by the U.S. Government in September 2008. In June 2012, AIG remained the largest investment of the Troubled Asset Relief Program (TARP).[4] Sjostrom [2009], Boyd [2011] and Greenberg [2013] discuss

[4]Special Inspector General for the Troubled Asset Relief Program (SIGTARP), July 25, 2012, "AIG remains in TARP as TARP's Largest Investment." Available

the AIG bailout. They highlight that AIG's collapse was largely caused by its $526 billion in short CDS positions sold through AIG Financial Products. Around $379 billion of its 2007 short CDS positions were used by banks for regulatory capital relief, "a perfectly legal ploy that allowed banks to free up money to make more loans," as Cassano mentioned to the Federal Depository Insurance Corporation (FDIC) when he explained AIG's procedure in selling CDS.

The lawsuit SEC vs. Goldman Sachs on the Abacus 2007-AC1 CDO involving the Paulson Fund and Royal Bank of Scotland [Fraser, 2014, explains the RBS downfall] also illustrates the interactions between banks and insurance companies (in this case ACA). Goldman paid $550 million to settle the case. Another interesting case is the Amherst hedge fund's canny trade against J.P. Morgan, Bank of America, etc., reported in 2009. Amherst sold sufficient CDS to be able to use some of the premiums to pay off the failing loans, effectively preventing the credit events from being triggered.

Overall, there are many disputes between insurance companies, banks, and hedge funds involving CDS transactions, even though at the time of signing the contracts, both sides in these deals believed that they were taking advantage of the other side. For example, the hedge fund Paramax sold $1.31 billion of CDS protection to UBS in May 2007, after it was approached in February 2007, even though Paramax only had $200 million of capital. Paramax started receiving margin calls from UBS in July 2007, and by November Paramax had depleted its capital, although it had not yet satisified all of UBS's claims. UBS filed a lawsuit against Paramax in December 2007 for breaching contractual agreements. In May 2009, MBIA alleged that Merrill Lynch had attempted to offload $5.7 billion in deteriorating U.S. subprime mortgages and other collateral from its books by packaging them as CDOs or hedging their exposure through swap agreements with insurers. The swap contracts between MBIA and Merrill were written between September 2006 and March 2007. In a countersuit, Merrill Lynch alleged that Financial Guaranty SCA subsidiary XL

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at http://www.sigtarp.gov/Audit%20Reports/AIG_Remains_in_TARP_Mini_Book.pdf

Capital Assurance Inc (XLCA) was attempting to avoid obligations of up to $3.1 billion in CDS positions.

Fung et al. [2012] examine the effects of CDS usage on the risk profile and performance of Life and Property/Casualty insurance companies. Using a transactions dataset of insurers for the period 2001–2009, they find consistent evidence that the utilization of CDS for income generation purposes is associated with greater market risk, deterioration of financial performance, and lower firm value, for both Life and Property/Casualty insurers.

Unlike that of insurance companies and commercial banks, mutual funds' penetration into the CDS market has been gradual. However, they are increasingly using CDS to either hedge their credit risk exposures or synthetically take on credit risk exposures. In particular, bond funds recently became active in the CDS market.[5] Adam and Guettler [2014] examine bond funds and find no performance differences between CDS users and CDS non-users in general. However, funds that were net short CDS during the crisis suffered from severe underperformance. Team-managed funds exhibited poor market-timing abilities using CDS. They were, on average, net long before the crisis and net short during the crisis. As a result, team-managed funds underperformed funds managed by a single manager.

Overall, the evidence shows that financial institutions use CDS strategically, consistent with the discussions in Bolton and Oehmke [2013]. Moreover, underperforming institutions have stronger incentives to use CDS. CDS usage is more of a risk-taking than a risk management strategy. We note that there is a need for more research in this area as, so far, we know little about how exactly hedge funds use CDS.

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[5]See "No Bonds, No Problem as Pimco Increases Bets Using Swaps," Bloomberg, July 29, 2014. (Available at http://www.bloomberg.com/news/2014-07-28/no-bonds-no-problem-as-pimco-increases-bets-using-swaps.html) Also, "Pimco Said to Wager $10 Billion in Default Swaps," Bloomberg, November 9, 2013.

7

Sovereign CDS

Sovereign CDS moved into the spotlight of financial markets during the European sovereign debt crisis when speculators were blamed for artificially increasing sovereign borrowing costs by buying *naked* credit insurance against a contingent government default. This led to a temporary ban on naked sovereign CDS positions by the German financial regulator Bundesanstalt fuer Finanzdienstleistungsaufsicht (BaFin) in May 2010, and to a permanent ban by the E.U. in November 2012. While the major development of the credit insurance market for government debt occurred only at the beginning of the twenty-first century, Tett [2009] provides anecdotal evidence of early sovereign CDS trading in 1994 when J.P. Morgan's and Citibank's asset management entered into contracts written on government bonds of Belgium, Italy and Sweden. Part of this section on sovereign CDS builds on the survey of the empirical literature on sovereign CDS in Augustin [2014], which provides more detail and discussion on recent research in this area.

7.1 Major differences from corporate CDS

One of the fundamental differences between corporate and sovereign CDS contracts relates to the nature of the credit events that trigger a contingent default insurance payment. Whereas standard corporate credit events are bankruptcy, failure to pay and, if covered, restructuring, bankruptcy is typically replaced with repudiation/moratorium for sovereign reference entities.[1] Broadly, this occurs if the reference entity repudiates one or more relevant obligation(s) or declares a moratorium in respect of one or more relevant obligation(s) in excess of an agreed default requirement. Moreover, while European corporate CDS have typically traded under the MMR clause, and North American under the XR clause since the Big Bang Protocol, sovereign reference entities typically trade with CR. This means that there is no maturity limitation on deliverable obligations beyond the usual 30 years in the event of a restructuring credit event.

A second difference relative to corporate CDS is that, for sovereign reference entities, there is less concentrated trading in the 5-year contract. The total volume of gross notional amount outstanding for maturities above one and up to five years was $18.25 trillion in 2012, representing a 67.76% market share. Pan and Singleton [2008] and Packer and Suthiphongchai [2003], in contrast, reproduced Bank for International Settlements (BIS) statistics to document that contracts with 3- and 10-year maturities accounted each for approximately 20% of the sovereign volumes, and that also the 1-year contract made up 10% of the trading.

Another detail of CDS contracts that is relatively more important for sovereign reference entities is the currency denomination of the contract. The reason is that there is a high risk of currency depreciation, or even re-denomination, by the sovereign in the event of default. For example, were the U.S. to default, an insurance payout in U.S. dollars would likely be much less attractive than a payout denominated in euros. This risk also seems to be priced into credit insurance

[1]As previously mentioned, other corporate credit events include obligation default and obligation acceleration.

agreements, as price quotes on the same underlying sovereign government differ across currency denominations.[2] Market participants can even trade these differences directly in so-called quanto swaps, which provide protection against a credit event and currency depreciation at the same time. We believe that the information embedded in sovereign quanto swaps is a suitable topic for more detailed future research.

Lastly, sovereign CDS are special as they can be used as a proxy hedge to offset a portfolio's country exposure. The use of such proxy hedges is particularly critical in the context of the permanent ban on naked CDS positions implemented by the E.U. in November 2012. However, the regulation specifically permits the purchase of uncovered CDS contracts if such a purchase is meant to hedge a portfolio of assets whose value had a historical correlation of at least 70% with the government bond price over the 12 months (or more) prior to the CDS purchase.

7.2 Default events: Ecuador, Greece and Argentina

There have been multiple sovereign defaults over the last two decades, ranging from Russia in 1998 to Argentina in 2014.[3] However, we are aware of only three default events that effectively triggered a sovereign CDS credit event and that were subsequently auction-settled: Ecuador in 2008, Greece in 2012 and Argentina in 2014.[4] Whether CDS payouts were bilaterally settled in other default events is *publicly* unknown. However, several industry reports, such as MorganStanley [2011], provide opinion pieces about whether such defaults should have triggered

[2]While this currency risk also affects the corporate CDS contracts on firms domiciled in the country in question, in this case the U.S., it is likely to be more severe in the case of sovereign CDS.

[3]The exact default dates and number of countries in default seem to vary depending on the source. According to Standard&Poor's 2013 sovereign default study, there have been a total of 18 sovereign defaults since 1998, and many more bailouts, the defaults being Russia (1999), Pakistan (1999), Indonesia (1999, 2000, 2002), Argentina (2001, 2014), Paraguay (2003), Uruguay (2003), Grenada (2004, 2012), Venezuela (2005), Dominican Republic (2005), Belize (2005), Seychelles (2008), Ecuador (2008), Jamaica (2010), and Greece (2012).

[4]The details of all CDS auction settlements, both corporate and sovereign, since 2005 are available at http://www.creditfixings.com/CreditEventAuctions/fixings.jsp.

a CDS payout or not. We are personally aware of at least one legal settlement in relation to the 1998 Russian default, which involved a dispute, between Lehman Brothers International Europe and Morgan Guaranty Trust Company, contesting the payout on a CDS transaction negotiated in 1997.

As usual, the devil can be found in the details, and legal contract clauses matter in the definition of the credit event, and consequently the pricing of the CDS contract. Issues to be considered include whether the default references foreign- or local-currency-denominated debt, and whether the default occurred on publicly traded debt or inter-government liabilities. In general, sovereign CDS are written on foreign-currency-denominated debt, and as such, a missed payment on local outstanding debt would not necessarily represent a valid credit event. One interesting case is that of the aforementioned Russian default of 1998, in which part of the dispute related to the type of debt on which the default occurred, domestic versus foreign, and publicly traded versus inter-government debt. Another interesting case in this context is that of Kazakhstan. According to anecdotal evidence, a hedge fund manager was allegedly asked to sell one-year CDS protection on Kazakhstan at a time when the country had no foreign currency debt outstanding. Even though issuance-to-default within one year is extremely unlikely, the trader did not sell the CDS because he was worried that the country could potentially inherit foreign-denominated debt through bank nationalization, which would significantly increase its default risk. This actually occurred. On the other hand, the country could have repudiated the bank debt, instead imposing risk on the CDS of the banks, as in the case of the Dutch bank SNS Reaal.[5]

Another important aspect is that a restructuring credit event should in principle be binding on *all* bond holders. Thus, it matters whether sovereign debt restructuring is voluntary or forced upon the creditors. Such issues introduce uncertainty into the contingent CDS payout, which has become particularly relevant since the introduction of collective action clauses (CACs) into the contracts of sovereign bond issues.

[5] See also http://www.ft.com/intl/cms/s/0/61533508-722f-11de-ba94-00144feabdc0.html#axzz2wRqJoCIX.

This subject was heavily publicized during the Greek default in 2012, when the existence of a CAC was ultimately responsible for triggering a credit event, as more than the required 66.7% of all bond holders agreed to a voluntary debt restructuring. This activated the CAC and coerced the remaining private holders of Greek bonds to exchange their securities for new bonds with a lower face value and longer maturities. In any case, the final judgment about whether or not it was a CDS credit event was to be made by the ISDA Credit Derivatives DC, which played a key role in this arbitration process. Verdier [2004] describes the legal aspects of how credit derivatives can impact sovereign debt restructuring. Also, Wright [2011] discusses potential problems with the role of CDS in discouraging creditor participation in voluntary exchange offers.

Payments on Ecuador's CDS were triggered when President Rafael Correa refused to meet an interest payment due on December 15, 2008 on the country's 2012 global bond. At the same time, Correa also declared a default on all of Ecuador's $3.8 billion global bond debt, citing a government ruling that the bonds had been contracted illegally. Ecuador's government did not make a $30.6 million interest payment within the 30-day grace period that started after the country failed to make its payment by the original due date, which was November 15, 2008. Ecuador, which also defaulted in 1999, owed approximately $10 billion to bond holders, multilateral lenders and other countries. Ecuador's CDS auction, which was the first publicly known sovereign CDS auction, was completed on January 14, 2009, and CDS sellers were required to pay buyers 68.625 cents per dollar of debt, based on the recovery price set at the auction.

The second publicly known sovereign CDS auction was the one triggered by the default of the Hellenic Republic (Greece). The auction was held on March 19, 2012 and the final recovery price for the CDS settlement determined by the auction was 21.5 cents on the dollar. The gross and net notional CDS amounts outstanding for contracts written on the Hellenic Republic during Greece's default episode were of the order of magnitude of $72 billion and $3 billion, respectively.[6] The Greek default

[6]See the statistics from DTCC reported in Augustin [2014].

event is noteworthy as it highlighted the legal uncertainty surrounding the triggering of sovereign credit events. As is discussed in Salomao [2013], the Europe-Middle East-Africa (EMEA) DC met twice in 2012 to vote on whether or not the Greek debt restructuring process and the subordination of existing debt by new debt issued to the European Central Bank (ECB) constituted a credit event. In their first meeting on March 1, the committee ruled against calling it a credit event, arguing that both the subordination of private Greek bond holders to the ECB and the restructuring reflected a voluntary renegotiation. In their second meeting on March 9, however, the committee ruled that the exchange offer for the existing Greek debt constituted a credit event as the activation of the CAC coerced the 14.2% of private holders who did not accept the exchange offer to accept the debt restructuring. Salomao [2013] formally includes this legal uncertainty about CDS payouts in a model of endogenous sovereign default.

A key precedent for future sovereign distress episodes was recently set by the ruling of a U.S. federal judge that Argentina was legally required to pay all outstanding creditors from the 2001 default before it could repay any other creditors. While, in 2001, most investors agreed to a substantial haircut and accepted restructured bonds, a minority of creditors did not agree to the newly proposed terms. A part of this debt has been purchased over the years by a consortium of hedge funds, which, under the lead of Elliott Management Corporation, has persistently been trying to sue Argentina in the U.S. courts. The ruling marks a milestone in the longstanding disputes between the Argentine government and the plaintiffs, commonly referred to as "vulture funds." The failure by Argentina to respect the ruling has led to missed interest payments and a de facto default. The formal auction, which was held on September 3, 2014, yielded a recovery rate of 39.5%.

While we are not aware of any other sovereign defaults that have triggered a sovereign CDS payout, it may be useful to allude to potential future CDS payouts that could be triggered in the case of technical default. For example, the spikes in the volumes of CDS traded on U.S. Treasury debt during the U.S. government lock-out periods in summer 2011, and again in late 2013, suggest that a credit event could have been triggered if the U.S. had failed to meet its debt obligations on time, despite its creditworthiness. Significant legal uncertainty also arises about the evolution of CDS spreads in the case of sovereign split ups, as was recently demonstrated by the discussions around the UK CDS contract in light of the Scottish independence vote.[7]

7.3 The market for sovereign CDS

In this subsection, we first review the size and structure of the sovereign CDS market. We next discuss the type of participants, followed by an overview of trading patterns in the market.

7.3.1 Market size

As mentioned earlier, the overall market for credit derivatives exploded from roughly \$6 trillion in 2004 and reached a peak of a bit more than \$58 trillion in the second term of 2007, and subsequently dropped to \$24 trillion, in gross notional amount outstanding, in June 2013.[8] Of these, the notional amounts outstanding for sovereign credit derivatives, which are reproduced in Panel A of Table 7.1, represent, at \$3.43 trillion in 2013, approximately 13% of the overall market for OTC credit derivatives. While a large fraction of corporate CDS trading is in multi-name instruments (roughly 42% of the market in 2012), sovereign CDS trading is largely concentrated in single-name products, which, at \$3.24 trillion in gross notional amount outstanding, accounted for a substantial fraction (96%) of the total CDS market in June 2013. Notional amounts outstanding proxy for market size and provide the basis for contractual payments in derivatives markets. Gross market values, in contrast, represent the sum of all market values that are currently in

[7]See Osborne, Tom, "Scotland secession: would UK CDSs be affected?" *Risk* magazine, July 25, 2014.

[8]The BIS publishes semi-annual reports on the notional amounts outstanding and gross market values of OTC derivatives and statistics, and these are available for CDS since 2004. The notional amounts probably underestimate the total market value slightly as only 11 countries, including those with major markets, reported OTC derivative statistics to the BIS before 2012: Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the UK and the U.S. From December 2011, Australia and Spain have also contributed to the semiannual survey, increasing the number of reporting countries to 13. Source: www.bis.org.

Table 7.1: Sovereign CDS: Notional amounts outstanding ('000,000,000).

Panel A: Sovereign Credit Derivatives — Notional Amount outstanding ('000,000,000)

Period	**All OTC**	**Credit Derivatives** (%)	**Sov. All** (%)	**Sov. Single Name** (%)	**Sov. Multi-Name** (%)
2011-H1	706 884	32 409 (4.58)	2 908 (8.97)	2 749 (8.48)	159 (0.49)
2011-H2	647 777	28 626 (4.42)	3 039 (10.62)	2 928 (10.23)	111 (0.39)
2012-H1	638 928	26 931 (4.21)	2 986 (11.09)	2 848 (10.58)	138 (0.51)
2012-H2	632,579	25,069 (3.96)	2,941 (11.73)	2,799 (11.16)	143 (0.57)
2013-H1	692,908	24,349 (3.51)	3,243 (13.32)	3,098 (12.72)	145 (0.60)

Panel B: Counterparties of Single-Name Sovereign Credit Default Swaps — ('000,000,000)

	2010-H1	**2011-H1**	**2012-H1**	**2013-H1**
All Counterparties	2 394	2 749	2 848	3,098
Reporting Dealers	1 320	1 837	2 026	2,325
(Fraction)	(55.17)	(66.81)	(71.13)	(75.03)
Other Financial Institutions	828	891	802	752
(Fraction)	(42.51)	(32.43)	(28.14)	(24.28)
Central Counterparties	—	2	116	128
Banks and Security Firms	828	592	378	374
Insurance & Fin. Guaranty Firms	9	15	14	15
SPVs	8	18	11	10
Hedge Funds	89	145	154	116
Other Financial Customers	84	119	127	109
Non-Financial Institutions	55	21	21	21
(Fraction)	(2.32)	(0.76)	(0.72)	(0.68)

Panel A of this table reports the total gross notional amount outstanding, in billion $, of all OTC credit derivatives, all credit derivatives (and their market share in % of all OTC derivatives) and sovereign credit derivatives (single-name and multi-name) with their respective market shares in % of all credit derivatives). Panel B shows the counterparties of sovereign single-name credit default swaps. Source: www.bis.org.

either a gain or loss position. This latter figure therefore more accurately measures the scale of financial risk transfer. If we assume that the ratio of gross credit exposure to the total notional amount is identical for sovereigns as for the entire market, then, as a rule of thumb, we may estimate that the gross market value of the outstanding contracts was about $97 billion in June 2013, as opposed to the total net exposure of approximately $20.2 billion.[9]

7.3.2 Market participants

OTC markets lack transparency, which makes it challenging to infer the ultimate risk holder in the large network of bilateral risk exposures. Hedge funds, in particular, are often blamed during sovereign crises for artificially increasing public borrowing costs by taking one-sided speculative bets on governments' default. Doubts regarding such claims are justified by looking at a snapshot of all counterparties that are reported to be involved in the trading of sovereign CDS in Panel B of Table 7.1. First, these statistics suggest that reporting dealers make up the bulk of the market, with a gross notional amount outstanding of approximately $2.33 trillion in June 2013, which corresponds to a market share of 75.03%. Second in line are banks and security firms, with a gross notional amount outstanding of $374 billion or a market share of 12.07%. The fact that hedge funds, with a gross notional amount outstanding of $116 billion, represent a much smaller fraction (3.74%) of the market, suggests that sovereign CDS are used predominantly for hedging motives.[10] Nevertheless, we emphasize that dealer positions increased by more than 76% from 2010 to 2012. This could reflect arbitrage opportunities that arose during the European sovereign debt crisis. During the same time window, banks and security firms, on the other hand, decreased their exposure from $828 billion to $378 billion.

[9]BIS defines gross market value as the sum of the absolute values of all open contracts that have either positive or negative replacement values, evaluated at market prices prevailing on the reporting date. Gross market values are not reported in the BIS document, but are available on the BIS web site.

[10]Bongaerts et al. [2011] report similar evidence that banks (insurance companies and funds) are foremost net buyers (sellers) of corporate CDS.

7.3.3 Trading in the sovereign CDS market

Another useful information for CDS trading patterns is the DTCC, which, through its Trade Information Warehouse, started publishing weekly reports on stocks and flows for CDS trading in October 2008. In addition to aggregate positions, the DTCC reports current and historical positions for the 1,000 most-traded reference contracts. The average gross and net notional amounts outstanding in (million) dollar equivalents for all sovereign contracts among the 1,000 most liquid CDS are reported in Table 7.2. Note that these statistics exclude sovereign U.S. states and refer to the time period October 31, 2008 through April 12, 2013. In addition, the table reports the average number of contracts, the ratio of gross to net notional amount outstanding, and the ratio of net notional amount outstanding to the number of contracts. The countries are grouped according to the five geographical regions defined by Markit: Americas, Asia excluding Japan, Australia and New Zealand, EMEA, and Japan. The sum of the cross-sectional averages in gross notional amounts for sovereigns in the data repository is about \$2.3 trillion. The net economic exposure, which takes into account \$213.5 billion of offsetting exposures between sellers and buyers, represents about 9.23% of that amount. This represents approximately 81% of the outstanding single-name sovereign CDS as reported by BIS in the first semester of 2012, or 75% of the amount reported in 2013 (see Table 7.1).[11]

During the first five years for which the DTCC has been reporting this information, the countries with the highest average net notional amounts outstanding include Italy (\$22.5 billion), Germany (\$15.1 billion), France (\$15.0 billion), Brazil (\$14.8 billion), and Spain (\$14.5 billion). The total number of traded contracts, measured using all country averages, is 165,089 and the average ratio across countries of gross to net notional amount outstanding is 11.70.[12] Column (7) further shows that the net credit exposure per contract is \$1.8 million, on average, but

[11] We note that this number does not reflect the values for U.S. states and other non-government supranational bodies.

[12] The ratio of gross to net exposure has remained stable and in the ballpark of 11 over time.

Table 7.2: Trade information warehouse data.

(1) Country	(2) DC Region	(3) Gross Notional	(4) Net Notional	(5) # Contracts	(6) Gross/Net	(7) Net/Contract	(8) Debt	(9) Debt/GDP
Italy	EMEA	270 981	22 519	7 785	12.17	3.41	2 502	1.26
Germany	EMEA	91 108	15 141	3 026	5.88	6.34	2 796	0.83
France	EMEA	93 262	15 043	4 114	5.99	4.92	2 322	0.90
Brazil	Americas	152 475	14 793	10 759	10.56	1.38	1 554	0.64
Spain	EMEA	135 864	14 449	5 854	9.49	3.13	1 216	0.91
UK	EMEA	50 369	8 535	3 250	6.06	3.00	2 158	0.89
Mexico	Americas	109 732	7 411	8 792	14.97	0.84	501	0.43
Greece	EMEA	66 710	6 537	3 375	11.63	2.68	435	1.71
Austria	EMEA	45 893	6 510	1 992	7.49	3.65	291	0.74
Japan	Japan	44 079	6 434	4 216	6.49	2.12	14 157	2.37
Portugal	EMEA	59 996	6 331	3 081	10.14	2.68	251	1.19
Turkey	EMEA	149 734	5 938	9 921	25.72	0.61	295	0.38
China	Asia Ex-Jp.	44 703	5 497	4 715	9.12	1.13	1 828	0.22
Belgium	EMEA	42 209	5 352	2 126	8.16	3.61	472	0.99
Russia	EMEA	106 661	4 816	7 950	22.90	0.62	215	0.11
Korea	Asia Ex-Jp.	63 559	4 711	6 860	13.95	0.69	385	0.33
Ireland	EMEA	38 218	4 178	2 222	9.87	2.59	241	1.18
United States	Americas	17 580	3 272	756	5.24	5.42	16 777	1.07
Hungary	EMEA	59 220	3 190	5 200	21.21	0.68	95	0.74
Australia	Australia NZ	19 089	3 020	1 898	6.27	1.77	417	0.27

(*Continued*)

Table 7.2: (*Continued*)

(1) Country	(2) DC Region	(3) Gross Notional	(4) Net Notional	(5) # Contracts	(6) Gross/Net	(7) Net/Contract	(8) Debt	(9) Debt/GDP
Netherlands	EMEA	20 193	2 977	1 018	6.60	3.87	525	0.68
Sweden	EMEA	17 089	2 738	939	6.57	3.39	193	0.37
Philippines	Asia Ex-Jp.	59 082	2 588	6 853	23.04	0.39	100	0.42
Indonesia	Asia Ex-Jp.	36 350	2 560	4 630	14.82	0.55	214	0.24
Denmark	EMEA	13 274	2 357	984	5.57	3.47	146	0.47
South Africa	EMEA	41 718	2 327	4 586	17.99	0.51	161	0.41
Finland	EMEA	13 490	2 147	551	6.10	4.94	130	0.53
Argentina	Americas	49 243	2 037	5 107	24.81	0.40	215	0.45
Poland	EMEA	33 785	2 002	3 108	17.53	0.71	259	0.55
Venezuela	Americas	50 418	1 999	4 812	25.48	0.42	173	0.51
Colombia	Americas	29 865	1 977	3 045	15.44	0.65	118	0.32
Peru	Americas	22 619	1 795	2 333	12.63	0.78	39	0.20
Ukraine	EMEA	43 161	1 429	3 638	33.36	0.38	64	0.35
Malaysia	Asia Ex-Jp.	18 882	1 248	2 392	15.54	0.52	163	0.53
Romania	EMEA	16 496	1 177	1 753	14.48	0.70	59	0.35
Thailand	Asia Ex-Jp.	17 378	1 116	2 401	15.80	0.47	167	0.44
Israel	EMEA	9 205	1 065	1 045	9.27	0.99	181	0.73

(*Continued*)

Table 7.2: (*Continued*)

(1) Country	(2) DC Region	(3) Gross Notional	(4) Net Notional	(5) # Contracts	(6) Gross/Net	(7) Net/Contract	(8) Debt	(9) Debt/GDP
Bulgaria	EMEA	18 003	1 037	1 857	19.58	0.58	9	0.18
Kazakhstan	EMEA	20 696	1 013	1 875	21.80	0.54	25	0.12
Norway	EMEA	6 542	956	311	6.59	4.40	248	0.50
Czech Rep.	EMEA	10 527	943	888	11.84	1.19	83	0.43
Slovak Rep.	EMEA	9 773	905	770	11.06	1.25	42	0.46
Iceland	EMEA	7 521	828	1 063	9.21	0.78	13	0.94
Slovenia	EMEA	5 011	784	430	6.46	2.03	24	0.53
Latvia	EMEA	8 862	667	1 084	13.97	0.63	10	0.37
Lithuania	EMEA	5 850	656	690	9.49	1.03	17	0.40
Panama	Americas	7 085	649	1 005	11.30	0.65	13	0.36
Egypt	EMEA	3 691	648	865	6.04	0.86	203	0.80
Qatar	EMEA	6 927	631	918	11.83	0.70	65	0.35
Vietnam	Asia Ex-Jp.	8 184	611	1 201	13.69	0.51	69	0.50
Croatia	EMEA	8 059	610	1 039	14.07	0.63	31	0.54
Ecuador	Americas	4 804	605	551	8.07	1.09	16	0.23
Dubai (UAE)	EMEA	6 511	597	830	12.27	1.02	157	0.42
Hong Kong	Asia Ex-Jp.	1 705	586	125	2.91	4.69	66	0.27
Chile	Americas	4 601	582	485	7.96	1.24	31	0.11
New Zealand	Australia NZ	3 107	538	348	5.76	1.64	65	0.39
Switzerland	EMEA	1 440	506	96	2.85	5.27	219	0.37

(*Continued*)

Table 7.2: (*Continued*)

(1) Country	(2) DC Region	(3) Gross Notional	(4) Net Notional	(5) # Contracts	(6) Gross/Net	(7) Net/Contract	(8) Debt	(9) Debt/GDP
Lebanon	EMEA	2 031	475	340	4.29	1.40	57	1.35
Saudia Arabia	EMEA	2 474	472	281	5.30	1.70	36	0.05
Estonia	EMEA	2 997	420	398	7.39	1.07	2	0.08
Cyprus	EMEA	1 866	315	236	5.94	1.43	20	0.88
Tunisia	EMEA	1 999	274	316	7.40	0.87	21	0.46
Total/Average(∗)		2 313 956	213 524	165 089	11.70∗	1.80∗	861	0.58

This table is a replication of the statistics illustrated in Augustin [2014]. The table reports the average gross (Column 3) and net (Column 4) notional amount (in million $) on CDS contracts outstanding in dollar equivalents of the sovereign reference entities among the 1,000 most-traded contracts over the time period October 31, 2008 through April 12, 2013. All numbers are reported in millions of dollars. Column 5 indicates the average number of contracts live in the Depository Trust & Clearing Corporation's (DTCC) Trade Information Warehouse (Warehouse) over the same time period. Column 6 reports the ratio of gross to net notional amount outstanding and Column 7 the average ratio of net notional amount outstanding to number of contracts outstanding. The notional values are represented as U.S. dollar equivalents using the prevailing foreign exchange rates. Columns 8 and 9 report the gross amount of public debt in billions of dollars and the debt-to- GDP ratio as of 2012, taken from the World Economic Outlook database in Datastream Thomson Reuters. The final row, labeled *Total/Average* reports the sum over all rows for Columns 3, 4 and 5, and the average for Columns 6 and 7. The values are reported in descending order according to the net notional amount outstanding. The countries are grouped into five regions: Americas, Asia ex-Japan, Australia and New Zealand, Europe/Middle East and Africa (EMEA), and Japan.
Source: www.dtcc.com and Datastream/Thomson Reuters.

that there is an important amount of dispersion in the cross-section. Interestingly, there is a tendency for emerging market countries to be traded with smaller net exposures per contract, while developed economies have a lower number of contracts outstanding, with a greater net exposure per contract. The U.S. and Germany, the world's largest reference bond markets, lead the list with, respectively, \$5.42 and \$6.34 million per contract. The Philippines and Ukraine appear at the bottom of the list, with an average of \$390,000 and \$380,000 per traded contract, respectively.

The gross amount of public debt (in billions of U.S. dollars) and the debt-to-GDP ratios for each country in 2012 are reported in columns (8) and (9) of Table 7.2. Unreported calculations highlight that, for many countries, the net economic exposure compared to public debt is below 2%, with an average and median value of, 2.2% and 1.3%, respectively.[13] The statistics are heavily skewed, in particular, by Estonia and Bulgaria, which have values of 23.3% and 11.4%, repectively. While Duffie [2010a,b] provides empirical evidence based on the DTCC statistics that the amount of CDS outstanding is not related to the level of spreads, Augustin [2014] highlights a statistically significant relationship between the net notional amount of CDS outstanding and the gross amount of government debt and the level of GDP.[14] However, the relationship appears weaker if we compare the levels of debt against gross amounts and the number of contracts outstanding. So far, three empirical studies have explicitly analyzed this database for corporate and sovereign reference entities respectively. Berg and Streitz [2012] analyze the sovereign CDS data in DTCC for 57 countries from October 2008 to July 2010. They report that countries that are smaller and that are rated just above investment-grade have larger ratios of net notional amounts outstanding to the total size of debt. In contrast, countries that are larger and that have speculative ratings are associated with higher ratios of of turnover to net notional amounts

[13]The debt-to-GDP ratios are obtained from the World Economic Outlook Database.

[14]Duffie [2010a] illustrates this evidence in his testimony to the United House of Representatives.

outstanding. Furthermore, they show that increases in turnover are related to negative rating changes and watches, but not to size.[15]

In order to complete the picture about trading patterns in the sovereign CDS market, it may be useful to report the results from earlier studies and reports that summarize information from various dealer and broker sources. In a Federal Reserve Bank of New York staff report, Chen et al. [2011] document a three-month sample from May 1, to July 31, 2010 including 29,146 single-name sovereign CDS transactions for 74 reference names. This snapshot, which reflects a period of low trading activity compared to historical averages, suggests that the most liquid names traded, on average, 30 times per day. Less liquid CDS traded on average 15 times per day and there were only two trades per day, on average, for the infrequently traded reference firms. The dollar-denominated contracts traded primarily in $5 million ticket sizes, the median (mean) trade was $10 million ($16.74 million), while the most frequent euro-denominated trade (only 574 transactions) was $10 million, with a median (mean) size of $5 million ($12.53 million).[16] One of the surprising conclusions from this staff report is that the market concentration is low, as the authors report a Herfindahl-Hirshman concentration index, based on the regulatory definitions of the Department of Justice, ranging between 885 and 965. In contrast, anecdotal evidence suggests that the market is rather concentrated, which is also emphasized by Giglio [2011], who, based on industry reports, states that the largest 10 counterparties (all broker/dealers) accounted for approximately 89% of the total protection sold in 2006. In connection with the transition to SEFs, it may be interesting to note that the market seems already heavily standardized, as 92% of all single-name CDS contracts

[15]As discussed in Section 2, Oehmke and Zawadowski [2014b] study the determinants of corporate trading, while Peltonen et al. [2014] use the data to analyze the network structure between financial and sovereign entities. Oehmke and Zawadowski [2014b] find that higher amounts of (corporate) CDS outstanding are associated with firms that have more assets and bonds outstanding, and that have a higher dispersion of analysts' forecasts. They highlight the role of frictions in the bond market (as proxied by the fragmentation of the underlying bonds into separate issues) as a main determinant of trading in the CDS market.

[16]Trades for single-name sovereign CDS were on average double the size of the corporate single-name CDS.

in the sample had a fixed coupon and 97% had fixed quarterly payment dates. Finally, market participation seems to have been active during this three-month period. The report indicates that 50 investors traded at least once a day, on average, 200 market participants traded at least once a week, and 340 at least once a month. Among these investors, dealers were more likely to sell protection and the four most active dealers participated in 45% of all CDS transactions, which made up 50% of the total notional amount.

Earlier evidence, based on both quotes and transactions data from CreditTrade for 77 sovereign reference countries from January 1997 to June 2003, is provided by Packer and Suthiphongchai [2003]. The authors emphasize that there was a low trading volume in this early period of sovereign CDS trading by showing that a mere 6% of all quotes led to transactions in 2002. These trades were heavily concentrated among a few reference names. More than 40% of all quotes were accounted for by five countries: Brazil, Japan, Mexico, the Philippines and South Africa. This evidence is complemented in a study by Lei and Ap Gwilym [2007], who provided descriptive statistics on the attributes and evolution of CDS trading for a sample of American (North American and Latin American) quotes and trades, of which roughly 12% correspond to sovereign reference entities (of which the majority, (85.2%) is related to Brazil, Colombia, Mexico and Venezuela). Overall, their statistics suggest that the market has become more liquid over time, with decreasing quote-to-trade ratios and a change in the most commonly traded/quoted notional amounts from $10 to $5 million (possibly due to the development of the CDS index market).[17]

[17]The data are provided by CreditTrade and the sample period goes from June 10, 1997 to March 3, 2005. The dominating currency denomination is U.S. dollars for 99% of the contracts. 98.32% of all contracts are written on senior unsecured debt and 90.36% of the sample references the MR clause. (Note that this was before the implementation of the Big Bang protocol in 2009.) Five-year contracts are the most frequently quoted (83%). Moreover, the average number of reference names traded/quoted has increased throughout time, with an average of 56 reference names per day in 2005. In each year, the lowest number of reference CDS traded/quoted was one (apart from 2005, when it was four). The ratio of quotes to trades is considerable,

7.4 Sovereign CDS spread determinants

The search for the empirical determinants of corporate credit risk has occupied industry professionals and academics ever since Merton [1974] published a structural model for the pricing of risky debt in a contingent-claims framework. For sovereigns, however, this issue is further complicated since a government can strategically default at its own discretion. Therefore, even if we could clearly identify asset volatility and leverage for a sovereign government, it is not clear whether these theoretically predicted determinants of corporate credit risk would be binding government constraints. The emergence of actively traded sovereign CDS contracts has allowed researchers to obtain high-frequency data that are less plagued (than publicly traded sovereign bonds) by legal and contractual differences in order to address this question.[18]

Another feature that complicates the modeling of sovereign credit risk is the strong factor structure observed in sovereign CDS spreads, and their changes, in particular, at higher trading frequencies. While one would intuitively expect the variations in sovereign spreads to be impacted by country-specific fundamentals, there is considerable evidence that an extensive fraction of the fluctuations in sovereign CDS spreads is determined by global factors that are unrelated to a country's economy. Such global risk factors are most commonly associated with the U.S. Nevertheless, the European sovereign debt crisis has revived the attention paid to domestic risk factors by highlighting a strong link between the financial health of governments and that of their financial institutions.[19] Correctly identifying the risk factors rooted in the variation in sovereign yield spreads is important as it provides insights into the usefulness of political intervention to bring down public borrowing costs and the diversification benefits implied by dynamic asset

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but diminishing over time. Lastly, the total number of quotes and trades peaks on Wednesdays and features an inverted U-shaped pattern during the week.

[18] Ericsson et al. [2009] use corporate CDS data to validate the role of theoretical variables suggested by structural credit risk models.

[19] The most telling case was Ireland, which guaranteed the debt of its banks. The feedback loop between the credit risk of banks and sovereigns is analyzed by Acharya et al. [2014a].

allocation. It also provides inputs for risk management models and influences financial hedging decisions.

7.4.1 Global risk factors

There are two reasons why researchers have treasure-hunted for sources of global risk: Sovereign CDS spreads co-move notably over time and they “jump” together when global events occur that ought to affect risk premia. The co-movement suggests that a strong factor structure is present, which is confirmed in, among others, Pan and Singleton [2008] and Augustin and Tédongap [2014] at the daily frequency, and in Longstaff et al. [2011] and Augustin [2013] at the monthly frequency. The first common component is typically able to explain between 78% and 96% of the variation in spread changes at the daily level, and between 57% and 64% at the monthly frequency. This factor structure is much stronger compared with what we know from international equity markets.

Striking evidence on the role of global financial risk factors is given by Longstaff et al. [2011]. Using 5-year CDS of 26 countries from October 2000 to January 2010, the authors show that not only spread changes but also the expected loss component in spreads are relatively better explained by U.S. equity, volatility, and bond market risk premia than by variables related to the local economy. This work builds on a theoretical CDS pricing model developed in Pan and Singleton [2008], who demonstrate that the risk premia of Korea, Mexico, and Turkey co-move greatly over time and that they are cyclically related to the CBOE VIX option volatility index, the spread between the 10-year return on U.S. BB-rated industrial corporate bonds and the 6-month U.S. Treasury bill rate, and as well as the volatility implied by currency options.[20]

[20] In fact, one of the main contributions of Pan and Singleton [2008] is to show that the term structure of CDS spreads contains identifying information for disentangling the default and loss processes if recovery rates are defined as a function of face value. Their findings lend support to the standard practice of defining a constant recovery rate of 25% for sovereign CDS. Bilal and Singh [2012], on the other hand, emphasize the importance of accounting for stochastic recovery rates in the pricing of CDS spreads, in particular for sovereign contracts. Another related study is Zhang [2008], who designs a CDS pricing framework to separately identify expectations about

Ang and Longstaff [2013] compare sovereign CDS spreads on U.S. states to those of E.U. countries and decompose spreads into a common systemic and country-specific non-systemic component. The authors conclude that systemic risk originates in financial markets rather than in macroeconomic fundamentals. This conclusion rests on the argument that the U.S. is economically more integrated than the E.U., but that the systemic risk component is larger for the E.U. countries. Moreover, systemic risk appears to be correlated with financial market variables.

In contrast to Ang and Longstaff [2013], the empirical evidence on U.S. financial risk, Augustin and Tédongap [2014] show that expected consumption growth and macroeconomic uncertainty in the U.S. are strongly associated with the first two principal components extracted from the entire term structure of CDS spreads of 38 countries. These results are robust to the impact of global financial risk factors such as the CBOE volatility index, the variance risk premium, the U.S. excess equity return, the price-earnings ratio and the high-yield and investment-grade bond spreads.[21]

Additional evidence regarding the influence of the economic factors in the U.S. on global sovereign CDS premia is presented by Dooley and Hutchison [2009], who show negative and positive news from the U.S., both real and financial, were channeled to 14 geographically dispersed countries during the 2007–2009 subprime crisis. In particular, the Lehman bankruptcy and the enlargement of Federal Reserve swap lines with the central banks of industrial and emerging countries impacted all country spreads in the same direction.[22] Since

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recovery rates and default probabilities, with an application to Argentina. In this case study, risk-adjusted and historical default probabilities are linked to business cycle changes, the U.S. and Argentine credit conditions, and the local economy.

[21]Augustin and Tédongap [2014] rationalize these findings in a recursive preference-based model with long-run risk that embeds a reduced-form default process. The default intensity is animated by long-run expectations of future U.S. consumption growth and macroeconomic uncertainty, and matches higher-order moments of spreads in the term structure, and in the cross-section, across rating categories.

[22]On October 13, 2008, the Fed eliminated its U.S. dollar swap limits to industrial countries, and on October 29, 2008, the Federal Open Market Committee FOMC granted swap lines to the central banks of Brazil, Korea, Mexico, and Singapore for up to $30 billion.

the Lehman event, developed economies also seem to have become more integrated with the U.S. according to Wang and Moore [2012], who review the dynamic correlations across the sovereign CDS spreads of 38 emerging and developed countries with the U.S. from January 2007 to December 2009. A stronger link with the U.S. appears to be rooted in the U.S. interest rate channel. Fender et al. [2012] attribute a dominant role to global and regional risk factors in explaining daily CDS spread changes of 12 emerging economies from April 2002 to December 2011.

A different explanation for the co-movement in sovereign spreads is given by Benzoni et al. [2012], who suggest that, after negative country-specific shocks, agents revise their beliefs about the default probabilities of all countries, which, in turn, causes greater credit spread correlations than if spreads were depended only on macroeconomic fundamentals.[23] Another plausible channel for the strong co-movement is suggested by Anton et al. [2013], who show that commonality in dealer quotes for sovereign CDS spreads is a powerful predictor of cross-sectional CDS return correlations. Given the strong concentration of CDS trading among U.S. dealers, this commonality would also explain the tight relationship with U.S. risk factors.

7.4.2 Local financial risk factors — the sovereign-bank nexus

The European sovereign debt crisis that followed multiple bank bailouts during the global financial crisis has motivated new research on the relationship between sovereign and country-specific financial risk. Acharya et al. [2014a], for example, illustrate how the financial strain of excessive debt burden from public bank bailouts may feed back into the financial

[23] Benzoni et al. [2012] use the fragile beliefs framework of Hansen and Sargent [2010] to illustrate their mechanism. In addition to the *hidden* contagion factor that characterizes the state of the underlying economy, spreads are modeled to depend also on global financial uncertainty (VIX and the U.S. high-yield bond spread defined as the difference between the BB and BBB indices of corporate bond effective yields provided by Bank of America Merrill Lynch) and a country-specific macroeconomic conditions index. The model is applied to daily 5-year sovereign CDS spreads of 11 eurozone countries over the sample period of February 12, 2004 to September 30, 2010.

sector by diluting the value of bank bailout guarantees and by causing collateral damage to their sovereign bond holdings. While the authors emphasize how the two-way feedback effect between sovereign and financial risk leads to a co-movement in the CDS spreads of sovereign countries and their financial companies, Dieckmann and Plank [2011] accentuate the unilateral private-to-public risk transfer through which investors incorporate their forecasts of financial industry bailouts. Their results suggest that the health of both a country's and the world's financial system explain sovereign CDS spreads, but the magnitude of the relationship depends on the importance of a country's financial system pre-crisis and is stronger for member countries of the Economic and Monetary Union. Support for a private-to-public risk transfer is also presented by Ejsing and Lemke [2011], who show that bank bailouts led to a contraction of banks' CDS spreads at the expense of increasing sovereign spreads during January 2008 and June 2009.

Kallestrup et al. [2011] confirm that contingent liabilities arising from implicit or explicit guarantees to the bank sector impact sovereign CDS premia by showing that cross-country financial linkages can explain the variation in sovereign CDS spreads beyond what can be explained by global and country-specific risk factors. Measures of cross-country linkages, which are based on consolidated BIS banking statistics, reflect banks' exposures to both the domestic and foreign public, bank and private (non-bank) sectors. In a related study, Kallestrup [2011] documents an association between sovereign credit risk and macrofinancial risk indicators computed using bank balance sheet information. Altman and Rijken [2011] do not focus on financial companies per se, but apply the credit scoring methodology to evaluate sovereign default probabilities based on public companies' balance sheet information in a "bottom-up" approach. This advocates that the financial health and profitability of a country's economy significantly affects default risk.

Sgherri and Zoli [2009] corroborate the power of a common time-varying factor for sovereign CDS spreads of ten European economies from January 1999 to April 2009, but argue that the solvency of the national banking systems has gained increasing influence over time. Alter and Schuler [2012] find that default risk was passed on predominantly from the bank to the sovereign sector before a financial rescue package from the ECB, the International Monetary Fund (IMF) and the E.U., while risk spread also in the other direction from sovereigns to banks after the bailouts.[24]

7.4.3 Global and local risk factors

Remolona et al. [2008] plausibly argue for the co-existence of both global and local risk factors.[25] Decomposing monthly 5-year emerging markets sovereign CDS spreads into a market-based proxy for expected loss and a risk premium, the authors find empirical evidence that global risk aversion is the commanding factor for the sovereign risk premium component, while country fundamentals and market liquidity are more material for default probabilities.[26] Examining total spreads rather than the decomposition, Caceres et al. [2010] argue that risk aversion was responsible for growing sovereign spreads during the beginning of the crisis. As the storm unfolded, however, country-specific factors such as public debt levels and budget deficits played the most important role. Similarly, Arghyrou and Kontonikas [2012] document a regime shift in sovereign debt pricing toward country-specific macro-fundamentals, since differential macro-fundamentals can justify cross-sectional differences in spreads only during the crisis. Aizenman et al. [2013] focus on the fiscal health of sovereigns and find that a rise of 1 percentage point in the debt-to-tax ratio increases 5-year CDS spreads by

[24]Further support for the liaison between sovereign and bank CDS is provided by Aktug et al. [2013]. Chan et al. [2009] document negative correlations between the sovereign CDS and domestic stock market returns in seven Asian economies. Avino and Cotter [2014] document a cointegrating relationship between the bank and sovereign CDS spreads of six European countries from January 2004 to March 2013.

[25]Zhang et al. [2013], who replicate the analysis of Longstaff et al. [2011] for (mostly) Asian economies, also find that both global and local risk factors have explanatory power for sovereign CDS spread changes.

[26]Proxies for global risk aversion are the Tarashev et al. [2003] effective risk appetite indicator, the VIX index and a Risk Tolerance Index by J.P. Morgan Chase. Fundamental variables in the analysis encompass inflation, industrial production, GDP growth consensus forecasts, and foreign exchange reserves.

15 to 81 basis points, while a rise of 1 percentage point in the fiscal-balance-to-tax ratio predicts a drop in spreads by 194 to 829 basis points.[27] Finally, Lopez-Espinosa et al. [2014] study the determinants of country-specific exposures to global sovereign tail risk, measured as the average CDS spread conditional on the real-GDP weighted average of country-specific 5-year CDS spreads being above a given predetermined threshold level. The results, based on a sample of 53 countries, suggest that the exposure to global tail risk is more pronounced for countries that have lower GDP growth, higher debt-to GDP ratios and higher interest rates.

A rather different country-specific channel is suggested by Cosset and Jeanneret [2013], who propose that governments that are more efficient at collecting tax revenues are less likely to default and face lower borrowing costs, as reflected in sovereign CDS spreads. In another study, Lee et al. [2013] document that average annual sovereign CDS spreads are negatively related to the degree of property and creditor rights and disclosure requirements (i.e., spreads are on average lower for countries with stronger property and creditor rights and more stringent disclosure requirements).[28]

A role for currency volatility in sovereign credit risk is advocated by Carr and Wu [2007], who develop a joint valuation framework for sovereign CDS and currency options with an empirical application to Mexico and Brazil. Strong positive contemporaneous correlations between CDS spreads and both the foreign options delta-neutral straddle implied volatilities and risk reversals are suggestive of the fact that economic or political instability leads to both higher sovereign credit risk and currency return volatility.[29] Hui and Chung [2011] reverse the analysis and document information flow, in times of adverse market

[27] While Aizenman et al. [2013] study 60 countries from 2005 to 2010, they focus primarily on the GIIPS countries.

[28] Eyssell et al. [2013] argue that both local (the Chinese stock market index and its real estate interest rate) and global determinants (VIX, U.S. default spreads, global stock market returns) are important determinants of China's sovereign CDS spread, but that the role of global factors has become more important over time.

[29] An interesting finding in light of the debate on the role of global and country-specific risk factors is that there are additional systematic movements in the credit spreads that the estimated model fails to capture.

conditions, from the sovereign CDS spreads of eleven eurozone countries to the dollar-euro currency option prices. They further find that sovereign spreads have predictive power for the implied volatility of dollar-euro currency options and this relationship is stronger for deep-out-of-the-money options, which are suggested to have reflected euro crash risk during the sovereign debt crisis. Hui and Fong [2011] document evidence of information flows from the sovereign CDS market to the dollar-yen currency option market during the sovereign debt crisis from September 2009 to August 2011. Similarly, Pu and Zhang [2012b] shows that the differences between U.S. dollar- and euro-denominated sovereign CDS spreads (quanto-spread) for ten eurozone countries can predict the bilateral euro-dollar exchange rate returns up to a period of ten days, while Santis [2013] argues that the difference between the euro-dollar quanto spread of a eurozone member country and that of a benchmark country such as Germany can quantify the re-denomination risk, i.e., the risk that a country will leave the euro zone. Gray et al. [2007] apply contingent claims analysis to price sovereign credit risk and compare their results to observed CDS spreads. While the public balance sheet is one input to the model, exchange rate volatility appears to be a fundamental factor in the framework. Plank [2010] proposes a structural credit risk model where sovereign default probabilities depend on foreign exchange reserves, as well as a country's exports and imports. Pavlova and de Boyrie [2014] document the information flows between currency carry-trade returns of nine Asian-Pacific economies and changes in the iTraxx SovX Asia Pacific index from September 22, 2008 to August 19, 2011.[30] Finally, Huang and MacDonald [2013] show that a tradable sovereign credit risk factor, which goes long (short) countries with high (low) CDS spreads, is able to explain a substantial fraction of the cross-sectional variation in currency carry trade returns. High-yield currencies load positively on this sovereign risk factor, while low-yielding currencies yield negatively on it.

[30] More-specifically, the authors provide evidence of bi-directional Granger causality and asymmetric volatility spillovers, as negative innovations in carry trade returns increase credit spread volatility more than positive innovations.

Ismailescu and Kazemi [2010] find asymmetric effects of credit rating announcements on the sovereign CDS spreads of 22 emerging economies.[31] While investment-grade countries are more responsive to negative credit rating announcements that are anticipated and reflected in CDS spreads before the announcement date, speculative-grade countries respond largely to (unanticipated) positive announcements. The authors further show that a one-notch increase in the rating of a country increases the CDS spread of another country on average by 1.18%, and this effect is stronger for countries who share a common creditor.[32] Afonso et al. [2012] complement the evidence in Ismailescu and Kazemi [2010] for 24 *developed* economies from the E.U. The authors find, among other things, that a negative rating announcement or outlook increases sovereign CDS spreads, on average, by 13 basis points, and that announcements for lower-rated countries "spill over" and affect the spreads of other higher-rated countries. Li et al. [2014] develop a theoretical rating-based framework for sovereign CDS where both a local and a global factor impact the rating transitions. Using the model of Doshi et al. [2013], Doshi et al. [2014] decompose a panel of 28 sovereign CDS into risk premia and expected losses based on observable covariates, of which two are global (U.S. interest rate and VIX) and two are local (country's lagged one-year stock market return and the currency-implied exchange rate volatility). Finally, Dockner et al. [2013] study the predictability of weekly excess sovereign zero-coupon bond returns using three factors implied by the term structure of sovereign CDS spreads: a market factor, based on a linear combination of the first three principal components implied by the one-year forward interest rates obtained from the CDS term structure of Germany; a common credit risk factor obtained from the first principal component extracted from the first three principal components of the one-year forward rates obtained from the CDS term structure of 10 Eurozone countries; and a country-specific credit risk premium orthogonal to the common credit risk factor, which is obtained as the residual of the regression from

[31] In a prior paper, Cossin and Jung [2005] document that credit ratings become more informative following a crisis event.

[32] Arezki et al. [2011] document additional results on the relationship between rating changes and sovereign CDS spreads.

the country-specific principal components on the common credit risk factor. The results suggest that adding a common and country-specific credit risk premium to the market factor significantly increases the predictability of excess sovereign bond returns from an average R^2 of about 20% to 52%.

7.4.4 The role of risk factors

The debate in the academic literature revolves largely around the question of whether sovereign CDS spreads are determined to a greater extent by global risk factors, mostly associated with financial or macroeconomic risk factors from the U.S., or by country-specific fundamentals, most typically indicators of the health of the domestic economy and financial sector. Surveying the literature, it appears that the role of the risk factors underlying the fluctuations in sovereign spreads is time-varying, with country-specific factors, in particular the sovereign-bank nexus, playing a more important role in crisis periods. This argument is formalized in Augustin [2013], who shows that the term structure of sovereign CDS spreads is an informative signal about the relative importance of the underlying sources of risk. More specifically, a positive slope in good times indicates that variation in spreads is driven to a relatively greater extent by global risk factors, while the negative slope that we observe in distressed times is associated with country-specific shocks.[33] We anticipate that future research will focus on the time-varying properties of both sources of risk, and will incorporate the valuable information embedded in the term structure of spreads. This was first done by Pan and Singleton [2008] to disentangle recovery rates from default probabilities. Dockner et al. [2013] use information in the term structure of sovereign CDS spreads to improve the

[33] Augustin [2013] rationalizes the empirical relationship between the shape of the term structure and the explanatory power of local risk factors in an equilibrium model with recursive utility and long-run risk for CDS spreads. Time variation in the term structure consistent with observed stylized facts arises through the tension between global and local risk.

predictability of excess sovereign bond returns.[34] In general though, the surveyed literature focuses almost exclusively on the level of spreads.

Another aspect of the global-local tradeoff is that global factors seem to play a greater role at higher frequencies, as in Longstaff et al. [2011] for example, while country-specific fundamental risk factors often seem to dominate at lower frequencies, such as in Hilscher and Nosbusch [2010]. They show that the volatility of the terms of trade is fundamental to explaining annual sovereign bond yield spreads. We hope to see in future research a better understanding of how the time-aggregation is related to the transition in the explanatory power from global to local risk factors.

7.5 Contagion and spillovers

The popular press repeatedly referred to the danger of *contagion* and *spillovers* during the financial and sovereign debt crises. However, a precise definition of contagion has proved to be elusive. Our reading of the literature is that the actual existence of contagion is quite ambiguous and hard to prove; the existing findings depend largely on the precise definition of the concept and are fraught with problems of endogeneity. A crucial issue is the need to differentiate more clearly between the various concepts and ensure that they permit the identification of the contagion channels. To this end, we first study contagion effects across sovereign countries. We then review the literature that studies the relationship between sovereign and corporate CDS spreads.

7.5.1 Contagion across sovereign CDS

Beirne and Fratzscher [2013], for example, differentiate between three forms of contagion: Fundamentals contagion, regional contagion, and herding contagion. Fundamentals contagion is defined as an increase

[34] Interestingly, the authors conclude that "for several euro-zone sovereign bond markets, risk premiums are not driven by country-specific macro-conditions but only by a common euro-zone credit factor. Only in those countries with severe debt problems are bond risk premiums dependent on local macroeconomic conditions, as reflected in their CDS term structure". This evidence is confirmatory of the formalization in Augustin [2013].

in the sensitivity of financial markets to country-specific fundamentals, which the authors interpret as a "*wake-up call*" by investors. The authors find evidence of such patterns, in particular for the GIIPS countries.[35] There is, however, no indication of regional contagion (not even from the GIIPS to other countries), which is identified as an inflation of cross-country transmission of sovereign risk, in their findings. Moreover, there is only marginal evidence of herding contagion, also dubbed pure contagion, which can be measured at any point in time, based on the cross-country correlations of the residual sovereign risk that is unexplained by any country-specific or common global risk factors. Caporin et al. [2013] are also critical about the existence of sovereign contagion and argue that cross-country linkages in the sovereign credit risk of eight European countries are identical in normal and turbulent times. Using quantile regression techniques, they show that, conditional on the influence of common factors, shocks propagate linearly such that the effects of large shocks are no different from those of average shocks. Puzzlingly, robustness tests using bond yields suggest that the intensity of the propagation mechanism may even have decreased. The authors also provide evidence that pairwise correlations of sovereign CDS spreads have decreased with the deepening of the sovereign debt crisis.[36] Kalotychou et al. [2014] argue that "fast and furious contagion," i.e., immediate reactions to unusually large CDS spread changes, is primarily regional but not global in nature.[37]

Bai et al. [2012] attempt to understand the interaction of credit fundamentals and liquidity shocks during the sovereign debt crisis by studying spillovers and feedback loops between twelve European countries using a structural vector autoregression. They argue that contagion during the sovereign debt crisis was channeled primarily through the fundamental credit risk channel, as domestic credit shocks

[35] Evidence in favor of the "*wake-up call*" hypothesis is also provided by Manasse and Zavalloni [2013].

[36] A similar point is made in Billio et al. [2013]. Kalbaska and Gatkowski [2012], on the other hand, document an increase in pairwise correlations among nine European sovereigns based on exponentially-weighted-moving-average correlation measures.

[37] However, the authors also document evidence of "slow burn spillover" effects that passed through global risk factors rather than through time-varying sensitivities to the global risk factor.

affected aggregated foreign credit shocks and vice versa. While the authors find some evidence of liquidity contagion, since aggregate liquidity shocks affect domestic liquidity risk and are, in turn, affected by domestic liquidity shocks, there is no indication that these liquidity channels had an impact on country fundamentals. A decomposition of sovereign spreads suggests that the early rise in spreads from August 2008 to April 2010 was driven by a greater illiquidity component, while the second wave of the crisis from May 2010 to May 2012 was due to a rise in fundamental credit risk. Darolles et al. [2012], on the other hand, argue that contagion effects for 18 emerging markets were channeled through liquidity problems in the sovereign debt markets. This argument rests on the estimation of a state-space with time-varying asymmetric volatilities, which suggests that the state probabilities of high cross-country correlations coincide with high market illiquidity, proxied by the CDS-bond basis.

Benzoni et al. [2012] rationalize how contagion may occur through investors' perceptions of sovereign credit risk. Uncertainty about sovereign default probabilities leads agents to update their beliefs about all countries' default distributions, if one individual country is affected by a negative credit shock. This can cause credit spreads to co-move more strongly than would be justified based on macroeconomic conditions alone. Lucas et al. [2014] capture spillovers across countries through an increase in conditional default probabilities. Joint and conditional default probabilities of ten European countries are inferred from a copula-based framework that allows for time-varying volatilities and correlations across countries, as well as skewed and fat-tailed distributions of spread changes.[38] Brutti and Sauré [2012] show that the magnitudes of spillovers to 11 other European countries arising from financial shocks to Greece depend on the cross-country bank exposures to sovereign debt. Specifically, the difference in transmission rates between the country with the greatest and that with the lowest credit

[38]To be specific, the model incorporates a multivariate mean–variance mixture distribution, where the risk indicators jointly follow a generalized hyperbolic skewed t-distribution.

risk exposure to Greece is approximately 46%. Glover and Richards-Shubik [2012] endogenize international lending and borrowing relationships in a network model to show how financial contagion arises in a network structure. The authors use sovereign CDS spreads to fit their model.

Finally, Ait-Sahalia et al. [2014] account for contagion in a CDS pricing model by using so-called "Hawkes" processes for default intensities, which allow for both self- and mutually reinforcing jump processes. In other words, their multivariate credit framework incorporates shocks that are both "self- and cross-exciting". The objective of the modeling framework is to capture the clustering of large credit spread changes both across space and across time. The model is estimated using five- and ten-year CDS spreads in a panel of seven Eurozone countries from January 2007 to August 2012. The estimation suggests evidence in favor of self-excitation and asymmetric cross-excitation, the latter being able to generate systemic risk.

7.5.2 Spillovers between sovereign and financial CDS

Multiple papers that examine spillovers between the sovereign and banking sectors have developed in parallel with the literature on the relationship between sovereign and bank risk. Bruyckere et al. [2013] investigate contagion/spillovers between sovereign and bank risk for 15 countries and more than 50 banks through the lens of excess correlations, defined as the correlation in residual CDS spreads *after* the influence of country-specific and global risk factors has been removed. About 86% of all banks in their sample have statistically significant excess correlations, and the average excess correlation is 17%. The authors further show that excess correlations are greater between banks and their home countries (on average 3.2% greater than the excess correlations with foreign countries), and for the GIIPS and more indebted countries, as measured by debt-to-GDP ratios. Such excess correlations are explained by several bank and country-specific characteristics. Banks that are larger, less strongly capitalized, that depend on wholesale funding and that have a higher fraction of non-interest income display stronger excess bank-country correlations. The authors also use data from the European Banking Authority's stress tests to show that cross-country exposures arising from public bond holdings affect the excess correlations, which are 1.5 percentage points higher for a one-standard-deviation higher public bond exposure.

Alter and Beyer [2014] aggregate spillover indices, estimated from impulse-response functions in a VAR setting, between the sovereigns and banks of 11 E.U. countries, to form a contagion index. A decomposition of the contagion index into excess bi-directional spillovers confirms the existence of higher interdependencies between sovereigns and banks during the sovereign debt crisis.[39] Billio et al. [2013] evaluate time-varying dependencies and feedback effects across sovereigns, banks and insurance companies in Europe, the U.S. and Japan. Combining Granger causality, network analysis, and contingent claim analysis applied to CDS spreads, the authors attempt to quantify the dynamics of financial system interactions and systemic risk.[40]

7.5.3 The relationship between sovereign and corporate CDS

Governments have the discretion to expropriate corporate assets or impose foreign exchange controls. Given these circumstances, the borrowing conditions of companies are expected to depend on the creditworthiness of the local government. In addition, other environmental factors that influence the financial performance of the companies, such as the state of the economy and the efficiency of its legal institutions, may be reflected in the sovereign's credit standing. The fact that sovereign borrowing rates represent a lower bound for domestic borrowing rates is termed the *s*overeign ceiling. Over the last decade, however, there has been an increasing number of sovereign ceiling violations,

[39] More specifically, the contagion index is decomposed into four components that capture excess spillovers among sovereigns, among banks, from sovereigns to banks and from banks to sovereigns.

[40] See also Eichengreen et al. [2012], who study the time-varying dynamics of the common components across the 5-year CDS spreads of the 45 largest financial institutions in the US, UK, Germany, Switzerland, France, Italy, Netherlands, Spain, and Portugal from July 29, 2002 to November 28, 2008, in order to better understand the international transmission channel of the U.S. subprime crisis.

which means that companies have managed to decouple themselves and to borrow at better rates than their local government in the country of their domicile. The determinants of these sovereign ceiling violations are studied by Lee et al. [2013], who show that companies are able to de-link their risk profile from that of the local government if they hold foreign assets in jurisdictions with better property and creditor protection rights, and if they are cross-listed in countries with better disclosure requirements. The average difference-in-difference between corporate and sovereign CDS rates is reduced by 26 basis points through the combined exposure to these informational and institutional channels, with a stronger effect observed during the sovereign crisis.

Bai and Wei [2012] examine how property and creditor rights influence the direct risk transfer from the sovereign to individual companies, rather than the financial sector as a whole. They find that a rise of 100 basis points in sovereign CDS spreads is associated with a rise of 71 basis points in corporate CDS spreads. Strong property rights such as executive constraints, expropriation risk, or rule of law (but not contracting rights) depress the relationship between sovereign and corporate credit risk, while the results are stronger for state-owned institutions. Augustin et al. [2014] exploit the joint effects of the Greek government bailout during the eurozone crisis and the violation of the no-bailout clause in the 1992 Maastricht Treaty as an exogenous event to quantify how an increase in sovereign credit risk impacts corporate borrowing costs in Europe. They show that a 1% rise in sovereign credit risk increases corporate borrowing costs by 0.1% on average, and these results are stronger for countries sharing a common currency union, those that are more financially distressed, and those that have weaker property rights. In the cross-section of firms, the results are stronger if firms are more financially dependent and if they have greater public ownership. In a later paper, Bedendo and Colla [2013] confirm the result that greater sovereign CDS spreads are associated with higher corporate borrowing costs. They also show that this result is stronger for state-owned firms, for firms whose sales are geographically less diversified, and for firms that rely more heavily on bank financing.

7.6 The CDS-bond relationship and frictions

As argued in Section 4.1.1 above, the CDS spread should be equivalent to the spread of a floating-rate note priced at par over a risk-free interest rate [Duffie, 1999, Lando, 2004, Hull and White, 2000]. Empirically, however, the observed difference between the CDS and bond yield spread, the so-called CDS-bond basis, can substantially diverge from its theoretical arbitrage relationship because of various market frictions. If the cash and derivative markets have differential dynamics, we may ask which market is informationally more efficient and absorbs information at a faster pace. We review this issue in the first subsection below. Next, we review our current knowledge about liquidity in the sovereign CDS market. Following this, we survey the evidence on the determinants of the CDS-bond basis. We end by reviewing our current knowledge on the economics of sovereign CDS, which addresses how the existence or introduction of sovereign CDS impacts public bonds.

7.6.1 Price discovery and informational efficiency

A survey of the *corporate* literature suggests a strong consensus that the derivative market is more informationally efficient than the cash market. Our reading of the mixed results from the *sovereign* literature, however, highlights disagreement and ambiguity on this issue. Several of the conflicting findings can certainly be explained by differences in the sampling periods, sample sizes, data frequency and data sources. However, details aside, other questions remain, especially given the growing importance of sovereign credit risk since the global financial and eurozone crises. Augustin [2014] provides a comprehensive list of the references that study this topic. Here, we limit ourselves to the main insights derived from these studies.[41]

Several authors argue that the informational efficiency is time varying and greater in the relatively more liquid of the two markets. Thus,

[41] The published references include Adler and Song [2010], Ammer and Cai [2011], Li and Huang [2011], Delis and Mylonidis [2011], O'Kane [2012], Coudert and Gex [2013], Calice et al. [2013], and Arce et al. [2013]. Two currently unpublished references that are often cited are Fontana and Scheicher [2010] and Palladini and Portes [2011].

according to Arce et al. [2013], price discovery is state dependent and a function of the relative liquidity in the two markets. The differential liquidity argument for price discovery is also brought to the fore by Ammer and Cai [2011], who show that CDS price leadership correlates positively with the bond-to-CDS ratio of bid-ask spreads, and negatively with the number of bonds outstanding. Coudert and Gex [2013] confirm the liquidity hypothesis for state-dependent price discovery and find that CDS played a more important role during the global financial crisis. These authors link their argument to market participation, given that a bearish bond investor will *stay out*, whereas a bearish CDS investor will *stay in* and purchase insurance. These arguments could be one explanation for the fact that the relative informational efficiency of the sovereign CDS market has increased over time, even as the market has matured.

Sapriza et al. [2009] also argue that the relative role of price discovery between the sovereign CDS and bond markets is state dependent, but the authors advocate a different channel than liquidity. In particular, they argue that the bond market displaces the leading role of the CDS market for price discovery in times when a country experiences adverse economic conditions, as measured by the International Country Risk Guide (ICRG) country risk index that combines various political, financial and economic risk indicators.[42]

Based on the existing findings regarding state-dependent liquidity, Calice et al. [2013] study cross-market liquidity spillovers and find evidence of time-variation in the intensity of transmission between maturities and across countries. In et al. [2007] examine the intensity of volatility transmission between the two markets. In contrast, Gündüz and Kaya [2013] study the absolute informational efficiency of sovereign CDS spreads, instead of the relative informational efficiency compared to bonds. Studying long-memory properties of spread returns and their

[42]Even though there is no formal evidence to support this hypothesis, the authors argue that informational efficiency switches across markets because local investors may have superior information in economically bad times, which they can use to trade in the bond market, while they are restricted from trading in the derivatives market. Nevertheless, we believe that this argument does not explain the dynamic relationship, as the same argument would hold even in economically benign times.

volatilities, the authors find no evidence of long memory in spread changes, but positive evidence of long memory in volatilities. The conclusion based on these results is that information is impounded into sovereign CDS spreads in a timely manner with weak-form efficient markets, and that default uncertainty is persistent.

7.6.2 Liquidity in the sovereign CDS market

The previous subsection emphasizes that the relative liquidity between the cash and derivative markets influences their respective roles for price discovery. These analyses implicitly assume that CDS spreads contain a liquidity premium component. This argument is generally accepted and considered in more recent research, even though earlier studies used CDS spreads as pure indicators of default risk, without any adjustments.[43] Yet, our understanding of liquidity and liquidity risk in the credit derivative market is still far from perfect, especially for the sovereign sector.[44]

Pan and Singleton [2008] report anecdotal evidence of the liquidity component of sovereign CDS spreads from discussions with market practitioners, especially at short-term maturities. While a liquidity component is not directly incorporated into their pricing model, the discrepancy between the observed and model-implied spreads of Mexico, Brazil, and Turkey is associated with the fact that large institutional investors allegedly express their views on sovereign credit risk by trading in short-term CDS contracts. Lei and Ap Gwilym [2007] review the determinants of CDS liquidity, proxied by bid-ask spreads, using a two-year data set of daily CDS dealer quotes from CreditTrade, of which approximately 10% are associated with

[43]For example, Longstaff et al. [2005] used CDS spreads as a benchmark of pure credit risk in order to infer liquidity characteristics from the bond market. Bai et al. [2012] and Beber et al. [2009] make the same assumption that sovereign CDS spreads are pure indicators of default risk. Pelizzon et al. [2013] use the sovereign CDS of Italy as the best, but admittedly imperfect, proxy for Italy's credit risk.

[44]A few recent papers that tackle liquidity and liquidity risk-related questions for corporate CDS are Tang and Yan [2007], Nashikkar et al. [2011], Bongaerts et al. [2011], and Junge and Trolle [2013]. Pelizzon et al. [2013, 2014] explicitly incorporate an adjustment for liquidity in their use of the Italian CDS spread as a measure of sovereign credit risk during the eurozone crisis.

sovereign reference entities. Overall, bid-ask spreads have narrowed over time and are found to be wider when characteristics typically associated with illiquidity or asymmetric information are perceived to be more prevalent. Thus, wider bid-ask spreads are associated with demand-supply imbalances, greater volatility, price clustering, weaker credit ratings, downgrade watch status, less popular maturities, and lower notional amounts outstanding, as well as CDS contracts that are written on subordinated debt and that reference the full restructuring credit event clause. Interestingly, the authors also find that the bid-ask spreads of speculative-grade *sovereign* reference entities are wider than those of similarly rated *corporate* reference entities, while no such gap exists for investment-grade issuers. The last result is corroborated in a study by Sambalaibat [2013], who documents that percentage bid-ask spreads in the sovereign CDS markets are about ten times larger than those in the underlying government bond market.

Badaoui et al. [2013] decompose sovereign CDS spreads and find a large liquidity risk component that represents about 44.32% of the entire spread in nine emerging countries: The size of the liquidity premium is not much smaller than the credit risk component.[45] In their related paper, Badaoui et al. [2014] extract the term structure of liquidity premia from the sovereign CDS spreads of Brazil, the Philippines and Turkey, which they find to be practically flat, and marginally higher at short and long horizons, with inversions during distress periods.

Finally, Pelizzon et al. [2013] study the dynamic linkages between liquidity in the Italian government bond market and the Italian sovereign credit risk, proxied by the Italian CDS spread. They find that the relationship between credit risk and liquidity depends on the level of credit risk, and also that information flows from credit risk to liquidity. More specifically, both contemporaneous and lagged CDS spread changes explain quoted bid-ask spreads in the interdealer market up to an endogenously determined CDS level of 500 basis points, above which both the speed and the intensity of the credit risk transmission

[45] The authors find a negative relationship between credit and liquidity risk, which leads to correlation risk that represents a tiny fraction of the spreads.

increases.[46] Furthermore, they show that the ECB's announcement of Long-Term Refinancing Operations (LTROs) was successful in attenuating the dynamic linkage between sovereign credit risk and liquidity.

7.6.3 The determinants of the CDS-bond basis

Liquidity is often considered to be a state variable determining whether the cash or the derivative market is informationally more efficient. On this premise, it is natural to believe that liquidity may be able to explain the short-term deviations from the strict arbitrage relationship that ought to hold between the two markets, in the absence of frictions. This insight is exploited by Arce et al. [2013], who provide some evidence that counterparty risk and differential liquidity between sovereign bonds and CDS, proxied by the ratios of percentage bid-ask spreads in the two markets, partially explain the CDS-bond basis. Levy [2009] finds similarly that both counterparty risk and liquidity have explanatory power for the pricing discrepancies between the two markets. This result regarding counterparty risk is somewhat at odds with Arora et al. [2012], who show for the *corporate* market that counterparty risk, while priced, is economically insignificant.[47] Kucuk [2010] attributes importance to liquidity effects and finds that CDS and bond bid-ask spreads, bond trading volume, notional amount outstanding, age and time to maturity can explain the basis gap. Fontana and Scheicher [2010], on the other hand, associate the sovereign basis primarily with common global factors, which reminds us of the debate about global and country-specific risk factors explaining sovereign CDS spreads, discussed above.

There are other frictions that may cause deviations from the no-arbitrage relationship between bond and CDS spreads. Ammer and Cai [2011], for example, document the role of the CTD option, which, following a credit event, gives the insurance buyer the option to deliver the cheapest among a set of defaulted debt obligations. This option

[46] Quantitatively, a contemporaneous 10-basis-point increase below (above) the threshold level of 500 basis points increases the quoted bid-ask spread by 7 (36) basis points. Lagged CDS spreads affect liquidity only below the threshold.

[47] Arora et al. [2012] show that counterparty credit risk needs to be higher, on average, by 646 basis points to have a 1 basis point lower insurance premium.

is an attractive feature of the CDS contract for the protection buyer, which must compensate the insurance provider for this risk, and more so the closer a country is to default.[48]

Fisher [2010] provides two theoretical explanations for the positive bases that have been observed for many sovereign borrowers in recent years. He argues that the variation in the basis over time depends on the time-varying proportion of pessimistic investors. In a market with heterogeneous investors and an inelastic supply of insurance for government default, a large number of pessimistic investors rushing to buy default protection will create price pressure on CDS spreads and induce a positive CDS-bond basis. Another effect that amplifies the positive basis is the prospect of lending fees, which raise bond prices and lower yield spreads. Because of inelastic supply in the CDS market, pessimistic investors will need to short-sell cash bonds, which will allow bond holders to charge higher lending fees to short-sellers. Adler and Song [2010] further support the view that short-selling costs are partially responsible for persistent positive sovereign CDS-bond bases. Building on the Duffie [1999] pricing framework, they also correct for biases that can arise from bonds priced away from par, accrued spread, and coupon payments. Their theoretical framework demonstrates how accrued payments and bond prices below par can mechanically create a negative, or respectively a positive, basis.[49] Finally, Salomao [2013] argues that uncertainty about the triggering of the default event, based on the judgment of the Credit Derivatives DC, such as in the recent case of Greece, reduces the insurance value and could, therefore, explain a negative sovereign basis.

7.6.4 The impact of sovereign CDS on public bonds

We have previously highlighted that "naked" speculation in the sovereign CDS market was held responsible for derailing sovereign borrowing costs during the European sovereign debt crisis, by many

[48] Singh [2003] documents early evidence of the role of CTD options in sovereign CDS contracts. Jankowitsch et al. [2008] document supporting evidence of the CTD option for corporate CDS.

[49] Note that such frictions were also considered in the seminal paper by Duffie [1999].

politicians, regulators and other policy makers. A special report officially commended by the European Commission [Criado et al., 2010] argues that such claims were not sufficiently substantiated and were difficult to justify based on the existing empirical evidence. In spite of this recommendation, the German financial regulator BaFin decided to temporarily ban the purchase of uncovered credit insurance on euro-denominated bonds on May 19, 2010. A permanent ban was passed later by the E.U. in November 2012.[50]

The naked CDS ban has been academically supported by Portes [2010], who argues that naked CDS buying does artificially drive up borrowing costs. This opinion is, according to our interpretation, mostly backed up by the statistical evidence in Palladini and Portes [2011], showing that CDS spreads have superior price discovery for six European countries and that there is information flow from the derivative to the cash market. A different opinion is given by both Duffie [2010a] and Duffie [2010b], the author of which believes that the ban will have the unintended consequences of increasing execution costs, and lowering the quality of price information, and hence, market efficiency. Moreover, because of the empty creditor problem, a covered insurance holder may have reduced monitoring incentives, reducing the borrower's efforts for efficient investments. Thus, these channels would lead to higher, not lower, public borrowing costs.

Several researchers have studied the agency conflicts and incentives of governments in the presence of sovereign default insurance. While the agency conflicts are to a large extent similar in the sovereign and corporate contexts, we discuss below the the literature that focuses on the sovereign aspect, which was not discussed in Section 5. Goderis and Wagner [2011] argue that the existence of insurance contracts will lower the ex-ante probability of default, because the insurance holder can credibly commit to rejecting any restructuring offer made by the borrower in bad states of the world. Thus, the borrower must internalize more of the default costs in bad states, which incentivizes him to invest

[50] Even though the legislation became effective in November 2012, it was voted on in October 2011, and a final draft of the law was published in March 2012. For further details, see Sambalaibat [2013] and http://ec.europa.eu/internal_market/securities/short_selling_en.html.

more efficiently in the first place. On the other hand, the author also emphasizes that the probability of default can increase when multiple bond holders fail to coordinate and buy more insurance than is socially optimal. Salomao [2013] introduces sovereign insurance contracts with uncertain payoffs into a dynamic model with endogenous sovereign default. She illustrates how the existence of the insurance contract can increase the lender's bargaining power in the default states, incentivizing the borrower to default less often. This raises equilibrium debt levels and lowers borrowing costs in equilibrium. Sambalaibat [2011] focuses specifically on the effect of naked CDS on government bonds and finds that the ultimate outcome depends largely on the infrastructure of the insurance market. The parameterization of the model predicts that naked CDS buyers may induce either over- or underinvestment on the part of the borrower, associated with, respectively, lower and higher borrowing costs.

While the theoretical evidence on the impact of sovereign CDS on public bonds is mixed, the current empirical evidence draws positive conclusions. For example, Ismailescu and Phillips [2011] picture sovereign CDS as efficient monitoring tools, which may diminish the adverse selection costs for informationally opaque countries, allowing for enhanced risk sharing and encouraging greater market participation. Their conclusions are based on the findings that, after the initiation date of sovereign CDS trading, public bonds become more informationally efficient, especially for high-yield countries, and bond spreads decrease on average by 60 basis points, with stronger effects for less creditworthy governments. Sambalaibat [2013] studies how the CDS market affects the liquidity of the sovereign bond market in the context of a dynamic OTC search model with search frictions and endogenous entry of broker-dealers. Her model predicts that investors will migrate to the bond market if they are temporarily shut out of the CDS market, but that they will leave altogether if they are permanently restricted from trading in the CDS market.[51] She empirically

[51]Note that a key assumption for these results is endogenous entry. If the proportion of traders is held constant, these predictions are reversed. The predictions can be explained by the fact that, in the long run, CDS and bond markets are complementary. The ability to simultaneously search and trade with naked CDS and

validates these predictions by showing that liquidity in the sovereign bond market improved following the *temporary* German naked CDS ban, while it decreased after the *permanent* ban by the E.U. The temporary naked CDS ban by Germany on May 19, 2010 is also studied by Pu and Zhang [2012a], who provide descriptive evidence that, after the ban, the sovereign CDS and bid-ask spreads of the GIIPS countries continued to rise. On the other hand, the authors find that sovereign CDS spread volatility declined.

To summarize, the mixed results from the existing theoretical and empirical literature make it difficult to draw the conclusion that speculators in the sovereign CDS market were responsible for causing a spike in public borrowing costs during the eurozone sovereign debt crisis. We do believe that sustaining such an argument using price information alone is empirically challenging. Bolton and Oehmke [2013] do not concur with the allegation that hedge funds artificially drive up sovereign borrowing costs; they argue that this claim is hard to substantiate without a deeper analysis. We hope that future research will analyze this important policy issue from diverse angles, based on improved access to actual trading positions and public bond holdings, in order to provide clear policy guidance.

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bonds lowers the opportunity cost in the bond market, and thus naked CDS trading attracts traders into both bond and CDS markets.

8

CDS Indices

Stock market indices were developed in the late nineteenth century in the U.S. as barometers of the performance of the stock market. Since that time, indices have been created for stock markets in other countries and a variety of markets for bonds, foreign exchange, commodities, and more recently, credit derivatives. Apart from providing benchmarks for measuring performance, they also serve to improve liquidity and transparency. In a similar manner, CDS markets have experienced the development of synthetic credit indices which have fostered the aggregation of information and price discovery through product standardization.

There are now essentially two classes of credit derivative indices: those that are backed by single-name bond or loan CDS, and synthetic structured indices that are backed by pools of residential or commercial mortgage-backed securities (MBS). Within the first class of standardized credit indices, there exist two main families. The iTraxx family covers reference entities in Europe and Asia (both corporate and sovereign), and the CDX family covers those in North America and in emerging markets. Both families are owned and administered by Markit Group Limited.[1] In addition to standardized corporate and sovereign credit indices, there are also standardized credit indices for real estate securities. Probably the best known products for real estate are those backed by subprime home equity and commercial MBS, the ABX.HE and CMBX indices, respectively. The credit indices themselves are tradable products that can be tranched into risk categories of descending priority. Thus, investors have the opportunity to take an exposure to only part of the capital structure by investing in a tranche of the credit derivative index. These are the so-called *s*econd-generation indices (or derivatives on derivatives), typically tranche products that are backed by credit derivative indices.

Academic research has to a large extent focused on information embedded in credit indices backed by synthetic mortage risk, in particular because of the toxic role of mortgages during the 2007 subprime crisis. However, the indices based on corporate and sovereign credit risk are of equal economic importance. In the following subsections, we first review the mechanism and the market development of credit derivative indices, and then discuss the early literature, which has mainly focused on their statistical properties. We then follow up with a more extensive discussion on the academic papers that analyze the information embedded in the second-generation indices.

8.1 Market overview

Similar to the market for single-name CDS, the market for credit index products experienced spectacular growth in the period preceding the subprime financial crisis. Table 8.1, which is based on the semi-annual

[1] The origin of synthetic credit indices goes back to 2001 with the launch of the JECI and Hydi indices by J.P. Morgan, and TRACERS by Morgan Stanley. Both firms decided to merge their activities in 2003 to create the Trac-x indices, but they faced renewed competition with the creation of the iBoxx indices in 2004. Later in the year, both Trac-x and iBoxx merged to form the iTraxx and CDX families, which were administered by Markit. Markit took over the management of the indices in November 2007, and is now the market leader in the administration and handling of synthetic credit indices. See Markit [2014].

Table 8.1: Multi-name Derivatives by Rating: Notional Amount Outstanding ('000,000).

	2006-H1	2007-H1	2008-H1	2009-H1	2011-H1	2012-H1	2013-H1
				Notional amounts outstanding ('000,000)			
Total contracts	372,512,700	507,907,140	672,558,460	594,552,690	706,883,610	639,395,680	692,908,170
Credit default swaps	20,352,307	42,580,546	57,402,759	36,098,169	32,409,444	26,930,572	24,349,452
Single-name instruments	13,873,445	24,239,478	33,412,115	24,165,086	18,104,619	15,566,357	13,135,290
(Fraction)	68.17	56.93	58.21	66.94	55.86	57.80	53.94
Multi-name instruments	6,478,863	18,341,068	23,990,644	11,933,083	14,304,825	11,364,215	11,214,162
(Fraction)	31.83	43.07	41.79	33.06	44.14	42.20	46.06
				Multi-name Products by Rating ('000,000)			
AAA to AA	–	—	—	—	743,280	736,678	508,559
(Fraction)	—	—	—	—	5.20	6.48	4.53
A to BBB	—	—	—	—	7,404,791	5,284,242	5,569,818
(Fraction)	—	—	—	—	51.76	46.50	49.67
BB and below	—	—	—	—	2,449,945	1,926,392	1,896,661
(Fraction)	—	—	—	—	17.13	16.95	16.91
Not Rated	—	—	—	—	3,706,826	3,416,923	3,239,133
(Fraction)	—	—	—	—	25.91	30.07	28.88
				Multi-name Index Products by Counterparty ('000,000)			
Multi-name index products	—	—	—	—	12,472,630	9,731,160	10,169,890
(Fraction of multi-name instruments)	—	—	—	—	87.19	85.63	90.69
Reporting dealers (net)	—	—	—	—	5,902,403	5,164,310	4,803,615
(Fraction)	—	—	—	—	47.32	53.07	47.23
Other financial institutions	—	—	—	—	6,496,000	4,526,000	5,296,000
(Fraction)	—	—	—	—	52.082	46.510	52.075
Central counterparties	—	—	—	—	3,279,276	2,646,715	3,495,309
(Fraction)	—	—	—	—	26.29	27.20	34.37
Banks and security firms	—	—	—	—	2,318,000	849,124	695,288
(Fraction)	—	—	—	—	18.58	8.73	6.84
Insurance and financial guaranty firms	—	—	—	—	66,849	87,738	78,248
(Fraction)	—	—	—	—	0.54	0.90	0.77
SPVs, SPCs, or SPEs	—	—	—	—	127,158	108,705	101,749
(Fraction)	—	—	—	—	1.02	1.12	1.00
Hedge funds	—	—	—	—	386,289	470,950	617,446
(Fraction)	—	—	—	—	3.10	4.84	6.07
Other residual financial customers	—	—	—	—	319,011	363,107	307,853
(Fraction)	—	—	—	—	2.56	3.73	3.03
Non-financial institutions	—	—	—	—	74,000	40,511	70,384
(Fraction)	—	—	—	—	0.59	0.42	0.69

This table reports the total notional amounts outstanding in millions of U.S. dollars of over-the-counter derivatives and the market share (in %), broken down by risk category, counterparty and rating. Data on total notional amount outstanding are shown on a net basis, that is transactions between reporting dealers are reported only once. Source: BIS.

OTC derivatives statistics available on the website of the BIS, illustrates that the gross notional amount outstanding in multi-name instruments grew from approximately \$6.5 trillion at the beginning of 2006 to \$24 trillion at the end of the first half of 2008. The market subsequently took a dive and has since fluctuated in the ballpark of \$11 trillion in gross notional amount outstanding. Over time, this reflects a market share of the overall credit derivative market ranging between 30% and 46%. The biggest fraction of the multi-name instruments is accounted for by A to BBB-rated instruments, representing a market share of 52% in 2011, whereas sub-investment-grade products account for approximately 17% of the market. The remaining market share is associated with unrated products. Detailed statistics on index products are, unfortunately, only available since the beginning of 2011, but Table 8.1 shows that they make up most of the trading volume in multi-name products, with values ranging from \$12.5 trillion in 2001 to \$10.2 trillion in 2013. As the statistics further illustrate, about half of this market consists of reporting dealers, the other half being more or less equally shared between central counterparties, and banks and security firms. Hedge funds, on the other hand, represent only 3% of the entire gross notional amount outstanding in 2011, and 6% in 2013.

Table 8.2 provides an overview of the break-down of multi-name credit derivatives statistics based on maturity and sector. In contrast to single-name corporate CDS, where liquidity is largely concentrated in five-year contracts, multi-name products are primarily traded in maturities of one year or less. As can be seen in Panel A, at the beginning of 2013, the fraction of very short-term instruments was 25% of the total gross notional volume in all OTC credit derivatives, and about 57% of all multi-name products. In the same year, maturities above five years account for \$3.2 trillion, or 13.3% of all OTC credit derivatives, and maturities between one and five years represent, with \$1.9 trillion, about 7.8% of the entire OTC credit derivative market, in terms of gross notional amount outstanding. Panel B reports the statistics by sector. The biggest fraction of trading volume is accounted for by securitized products and sector products, which have consistently represented 57% or more of the total multi-name market since 2011. The

Table 8.2: Maturity structure of multi-name credit default swaps: notional amount outstanding ('000,000).

		Panel A: Multi-name Products by Maturity ('000,000)			
	Total	**MultiName (Frac. %)**	**1y or less (Frac. %)**	**Over 1y up to 5y (Frac. %)**	**Over 5 years (Frac. %)**
2004-H2	6,395,744	1,278,979 (20.00)	—	—	
2005-H1	10,211,378	2,901,090 (28.41)	—	—	
2005-H2	13,908,285	3,476,247 (24.99)	—	—	
2006-H1	20,352,307	6,478,863 (31.83)	—	—	
2006-H2	28,650,265	10,770,985 (37.59)	—	—	
2007-H1	42,580,546	18,341,068 (43.07)	—	—	
2007-H2	58,243,721	25,757,449 (44.22)	—	—	
2008-H1	57,402,759	23,990,644 (41.79)	—	—	
2008-H2	41,882,674	16,142,745 (38.54)	—	—	
2009-H1	36,098,169	11,933,083 (33.06)	—	—	
2009-H2	32,692,683	10,775,633 (32.96)	—	—	
2010-H1	30,260,923	11,767,291 (38.89)	—	—	
2010-H2	29,897,578	11,752,998 (39.31)	—	—	
2011-H1	32,409,444	14,304,825 (44.14)	8,148,066 (25.14)	2,449,945 (7.56)	3,706,826 (11.44)
2011-H2	28,626,407	11,761,224 (41.09)	6,127,616 (21.41)	2,133,225 (7.45)	3,500,396 (12.23)
2012-H1	26,930,572	11,364,215 (42.20)	6,020,917 (22.36)	1,926,392 (7.15)	3,416,923 (12.69)
2012-H2	25,068,701	10,759,762 (42.92)	5,390,489 (21.50)	2,317,049 (9.24)	3,052,236 (12.18)
2013-H1	24,349,452	11,214,162 (46.06)	6,078,374 (24.96)	1,896,661 (7.79)	3,239,133 (13.30)

(Continued)

Table 8.2: (*Continued*)

	Panel B: Multi-name Products by Sector ('000,000)				
	Multi Name	**Multi Name Sov (Frac., Growth)**	**Multi Name Fin (Frac., Growth)**	**Multi Name NonFin (Frac., Growth)**	**Multi Name Sec (Frac., Growth)**
2004-H2	1,278,979	—	—	—	—
2005-H1	2,901,090	—	—	—	—
2005-H2	3,476,247	—	—	—	—
2006-H1	6,478,863	—	—	—	—
2006-H2	10,770,985	—	—	—	—
2007-H1	18,341,068	—	—	—	—
2007-H2	25,757,449	—	—	—	—
2008-H1	23,990,644	—	—	—	—
2008-H2	16,142,745	—	—	—	—
2009-H1	11,933,083	—	—	—	—
2009-H2	10,775,633	—	—	—	—
2010-H1	11,767,291	—	—	—	—
2010-H2	11,752,998	—	—	—	—
2011-H1	14,304,825	158,516 (1.11, —)	2,915,513 (20.38, —)	8,083,088 (20.53, —)	8,293,409 (57.98, —)
2011-H2	11,761,224	111,272 (0.95, -29.80)	2,566,443 (21.82, –11.97)	7,000,437 (15.39, –38.39)	7,273,741 (61.85, –12.29)
2012-H1	11,364,215	137,548 (1.21, 23.61)	2,630,633 (23.15, 2.50)	6,793,025 (14.33, –10.02)	6,967,557 (61.31, –4.21)
2012-H2	10,759,762	142,632 (1.33, 3.70)	2,566,835 (23.86, –2.43)	6,420,181 (15.26, 0.83)	6,408,318 (59.56, –8.03)
2013-H1	11,214,162	144,955 (1.29, 1.63)	3,202,852 (28.56, 24.78)	6,404,402 (13.59, –7.20)	6,342,604 (56.56, –1.03)

Panel A of this table reports the total notional amount outstanding in million U.S. dollars of multi-name credit default swaps by remaining maturity as well as their respective market shares in parentheses (in %). Panel B reports the total notional amount outstanding in million U.S. dollars of multi-name credit default swaps by sector as well as their growth and respective market shares (in %) as a fraction of total multi-name credit default swaps (in parentheses). *Sov* refers to Sovereigns, *Fin* to Financial Firms, *NonFin* to Non-Financial Firms and *Sec* to Securitized Products and Multiple Sectors. Data on total notional amount outstanding are shown on a net basis, that is transactions between reporting dealers are reported only once. The remaining contract maturity is determined by the difference between the reporting date and the expiry date of the contract and not by the date of execution of the deal. *Source*: BIS.

second-biggest trading volume in multi-name products is concentrated in products written on financial institutions, representing between 20% and 29% of the market between 2011 and 2013. A similar magnitude of trading is reported for multi-name products on non-financial institutions, while the index market for sovereign CDS has remained fairly small, with a gross notional amount outstanding of $145 billion in 2013, or 1.3% of the entire multi-name market.

8.2 Credit indices — a primer

The two main corporate credit derivative indices are the Markit iTraxx Europe Main (iTraxx Europe) and the Markit CDX North American Investment Grade (CDX.NA.IG).[2] These two indices reference the top 125 European and American investment-grade reference entities, respectively, in terms of CDS volume traded. The indices are equally weighted, so that each reference name has a weight of 0.8% in the index. Both indices are "rolled" over every six months on 20 March and 20 September when a new on-the-run series is created, which is quoted in parallel to the previous outstanding series of off-the-run indices. The traded maturities are three, five, seven and ten years for the iTraxx Europe; in addition, the CDX.NA.IG also trades in shorter maturities of one and two years. Payments are typically made on a quarterly basis and accrue on an Actual/360 basis. The coupons are standardized, usually 100 or 500 basis points, the difference being settled as an upfront payment between the protection seller and the protection buyer.

In addition to the main indices, both families have several sector-specific sub-indices. For example, the iTraxx Financial covers senior, and respectively subordinated, debt of 25 underlying financial reference entities. The Non-financials index covers the auto sector, consumers, energy, industrial and TMT (technology, media, and telecommunications) with 100 reference entities, while the iTraxx HiVol contains 30 single-name CDS with the largest spread reference entities from the iTraxx Europe Main. The iTraxx Crossover index comprises the 50

[2] We refer to Markit [2014] for further institutional details on credit derivative indices.

most liquid sub-investment-grade names. Finally, the iTraxx Europe CEEMEA contains 25 corporate and quasi-sovereign entities from the CEEMEA countries.[3] The iTraxx family also references Asian credit derivatives, the most common products being the iTraxx Asia Japan (50 corporate reference entities from Japan), the iTraxx Asia ex-Japan Investment Grade (50 names), the iTraxx Asia Australia (25 names) and the iTraxx Asia ex-Japan High Yield (20 names). Moreover, the iTraxx family comprises several sovereign credit derivative indices, namely the iTraxx Sovx Western Europe (top 15 sovereign entities by liquidity that trade on Western European documentation), the iTraxx SovX CEEMEA ex-EU (top 15 sovereign entities by liquidity that trade on emerging market documentation), the iTraxx SovX Asia Pacific (top 10 sovereign entities by liquidity in the Asia and Oceania regions), the iTraxx SovX Global Liquid Investment Grade (between 11 and 27 most liquid high-grade global sovereign entities), the iTraxx SovX G7 (up to 7 most liquid industrialized countries) and the iTraxx SovX BRIC (up to 4 most liquid BRIC countries). The last category of the iTraxx family is the iTraxx LevX, referencing the most liquid first-lien syndicated loans.

The North American counterparts to the European iTraxx indices are the CDX North America High Yield (100 single-name CDS), the CDX North America Investment Grade High Volatility (30 credits with largest spreads from CDX.NA.IG), the CDX North America Emerging Markets (14 sovereign names) and the CDX Latin America Corporates (20 Latin American corporate names). The counterpart to the iTraxx LevX is the Markit LCDX, which is a tradable index with 100 equally weighted underlying single-name senior secured loan CDS. Markit also administers a municipal index, referencing 50 CDS contracts on municipal reference entities.

The credit derivative market allows investors to synthetically invest or hedge different portions of the capital structure of a standardized credit portfolio. This is done by chopping the standardized indices into several so-called *tranches*. The most common tranche products are those written on the iTraxx Europe and CDX.NA.IG, but similar

[3]CEEMEA stands for Central and Eastern Europe, Middle-East, and Africa.

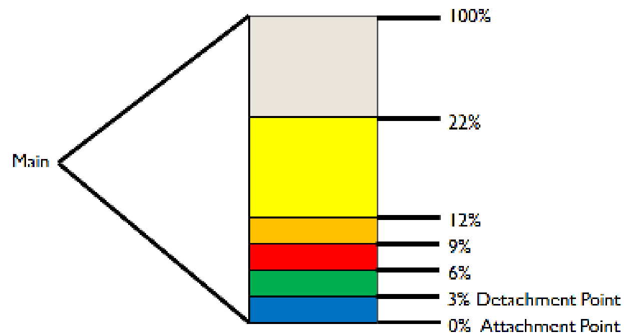

Figure 8.1: Standardized credit index Tranches: iTraxx.
This figure provides an illustration of the attachment and detachment points of tranches written on the underlying iTraxx Europe Main Index.

products exist for the other indices. A detailed explanation of the mechanism of tranche products can be found in Longstaff and Rajan [2008] and Coval et al. [2009], among many others, but we deem it useful to provide a stylized example of tranches on the iTraxx Europe index in Figure 8.1. The riskiest part of the index capital structure is the equity tranche, which will absorb the first losses on the underlying portfolio. Thus, the equity tranche can be compared to the equity capital of a company's balance sheet and the investor in the equity tranche is the residual claimant on the assets underlying the index. Each tranche is defined by an attachment and a detachment point. For the iTraxx Europe index, the detachment point of the equity tranche is at 3% of the capital structure. Thus, an investor taking credit exposure on the tranche directly superior to the equity tranche will only be affected if more than 3% of the companies (i.e., four reference entities) in the underlying basket default. Similarly, the tranche corresponding to the attachment and detachment points of respectively 6% and 9% will only suffer losses if more than 6% of the underlying basket defaults, corresponding to at least eight reference names. The safest tranche of the capital structure is typically called the super senior tranche, and is exposed only when, in the case of the iTraxx Europe, at least 28 companies in the underlying basket default altogether. While the mechanism for tranches written on the CDX.NA.IG is similar, the attachment and detachment points differ.

8.3 Early research on credit indices

One of the first researchers to investigate the statistical properties of credit derivative indices was Hans Byström, who reports that eight sub-indices for the iTraxx Europe family are serially correlated and exhibit substantial skewness and excess kurtosis [Byström, 2006]. Using the CreditGrades model, he relates model-implied and index spreads to show that the stock market has information that can predict contemporaneous and future empirically observed spreads. In related work, he uses the iTraxx Europe IG and HiVol indices to extract the market-implied term structure of aggregate risk-neutral default probabilities [Byström, 2005]. Furthermore, he investigates the tail behavior of the five-year iTraxx Europe CDS index and its sub-indices using extreme value theory in Byström [2007].[4] Related work is undertaken by Hung-Gay et al. [2008], who, in a VAR framework, investigate the lead-lag relationship in price levels and volatilities between the S&P500 and the CDX.NA.IG and HY indices, representing the aggregate stock and credit markets respectively. The authors conclude that the information flow between the stock and the credit market is more pronounced for the high-credit-risk category. That is, the lead-lag relationship is dependent on the underlying credit quality. Alexander and Kaeck [2008] find some support for the hypothesis that theoretical determinants suggested by structural credit risk models partially explain the time series variation in the iTraxx Europe indices. Estimating a Markov switching model, they find support for regime-dependency in the influence of the theoretically suggested determinants.

[4] In his work, Byström [2007] also conjectures on the creation of a hypothetical futures market on credit derivative indices and suggests that extreme value theory, specifically the peaks-over-threshold method, should be the preferred method for determining futures margins in this hypothetical CDS index futures market. The empirical results indicate that the extreme value theory-based margin levels in the CDS index market are much more accurate than those implied by the assumption of normally distributed price changes.

8.4 Second-generation indices

Much of the early research involving credit derivative indices focused primarily on their statistical properties. However, the subprime crisis motivated many researchers to study the pricing behavior of the indices in more detail and to analyze what kind of information can be extracted, in particular from tranches backed by synthetic pools of subprime mortgage risk. One of the reasons is that tranche products contain information about joint default probabilities, which is difficult to obtain from marginal default probabilities alone.[5] One of the major challenges in pricing tranche products is the statistical modeling of default correlation risk. Covering this part of the literature in detail is out of the scope of this survey. Here we will focus on those studies that have proposed pricing models with a direct economic or financial application.[6]

The importance of the creation of the ABX.HE subprime home equity loan price indices is emphasized by Gorton [2009], who explains how these indices allowed the market to aggregate and disseminate the information about the values of highly illiquid subprime mortgages once house prices started to fall. Importantly, the index enabled investors to express their negative views by shorting the market. While the aggregation of information enabled investors to gauge the quantity of risk in the market, Gorton conjectures that it did not allow them to determine the location of risk in the system, which is one of the reasons for the 2007 subprime crisis in the financial markets.[7] In related work, Gorton

[5] The determinants of implied correlations from iTraxx tranches are studied by Heidorn and Kahlert [2010]. These authors essentially show that realized correlations are significantly lower than implied correlations, and that the implied correlations are primarily correlated with gold prices and swap spreads.

[6] For more references on the pricing of credit indices and their tranches, see among others, Duffie and Garleanu [2001], Hull and White [2004], Mortensen [2006], Hull and White [2008], Eckner [2009], Wang et al. [2009], Garcia and Goossens [2010], Eckner [2010], Berndt et al. [2010], Errais et al. [2010], Cont and Kan [2011], Azizpour et al. [2011], Giesecke et al. [2011], and references therein.

[7] See also Fostel and Geanakoplos [2012] for an explanation of how tranching may have inflated the housing mortgage bubble and how the CDS market may have helped burst it in 2007–2009. See Stulz [2010] for a general description of the role of CDS contracts during the financial crisis.

[2009] studies the ABX BBB cash basis, i.e., the difference between the synthetic and cash BBB subprime bonds.[8] He argues that the explosive widening of the basis arose because of excessive demand for the hedging of subprime mortgage risk. This argument is more thoroughly studied in Stanton and Wallace [2011], who study the pricing of AAA ABX.HE index CDS on baskets of MBS and conclude that market prices during the crisis were inconsistent with any reasonable expectation of expected future credit losses.[9] They further find that price changes of the AAA ABX.HE indices are only weakly correlated with the actual credit performance of the underlying loan pools, but highly correlated with short-sale imbalances in the stocks of the investment banks.[10] Because the short-interest ratio is meant to capture demand imbalances in the market for mortgage default insurance, the authors argue that capital constraints limited the supply of mortgage insurance, which kept the tranche prices artificially low. Their findings cast doubt on the use of these synthetic CDS indices as a valuation benchmark for marking-to-market loan portfolios.[11] Concerns that the ABX prices are unrepresentative of prices for the entire MBS market are also raised by Fender and Hördahl [2008]. Evidence of demand-based price pressure is provided more generally in a study of CDX.NA.IG index inclusions by Kitwiwattanachai and Pearson [2014], who suggest that temporary positive cumulative abnormal price changes in single-name CDS included in the benchmark index are caused by hedging demand from dealers trying to manage their inventory imbalances.[12] Junge and Trolle [2013]

[8]The BBB ABX.HE index 2006-01 vintage is used for the synthetic index and the on-the-run subprime bonds are substitutes for the cash component as the BBB subprime bonds referenced by the index are not traded.

[9]The authors document detailed information about the composition, quality and performance of the loan pools underlying the four vintages of the ABX.HE indices.

[10]The short-interest ratio is calculated as the market value of shares sold short divided by the average daily trading volume, and is meant to be a measure of short-selling in the investment bank sector.

[11]This argument is also supported by Bhat et al. [2011], who find empirical evidence that the CDS price dynamics of the AAA ABX.HE 2006-1 index are positively associated with sales of non-agency MBS by regulated U.S. financial institutions, and that this correlation dissipates after the temporary easing of the mark-to-market rules by the FASB on April 2, 2009.

[12]The authors study 23 index inclusions in total from January 2004 to May 2008.

average the wedge between CDS index prices and their theoretical fair values based on the index constituents across ten indices of the iTraxx and CDX families to compute a CDS market illiquidity measure. This illiquidity measure correlates with other commonly used measures of market illiquidity, such as, for example, the average bid-ask spread and a funding cost measure.

In contrast to Stanton and Wallace [2011], Fender and Scheicher [2009] find that changes in the credit performance of the underlying loans as well as macroeconomic and housing market variables do explain the observed price changes in the AAA ABX.HE index CDS. They find that the relationship of the index with housing price indices became particularly stronger during the financial crisis. The authors also find that risk aversion and decreasing market liquidity had an important influence on the evolution of the AA and AAA indices during the general deterioration of the financial market environment. Another author who disagrees with Stanton and Wallace [2011] by arguing that synthetic credit indices are useful indicators for reflecting the fair value of loan exposures is Vyas [2011]. The author studies the timeliness of the accounting write-downs of financial institutions during the subprime financial crisis by comparing the schedule of quarterly write-downs related to MBS, and structured credit exposures to the mark-to-market valuation implied by the synthetic credit indices backed by commercial and residential MBS. These results suggest that institutions that are better governed, that have been investigated by regulators and that face litigation pressures are more timely in writing down their losses. On the other hand, firms with higher financial leverage, tighter regulatory constraints, and more complex and less risky exposures are less timely in signaling their write-downs.

Longstaff and Rajan [2008] focus more directly on the pricing of tranches of the CDX investment grade index and develop a three-factor CDO pricing model accounting for three independent sources of risk: firm-specific risk, sector-wide risk and economy-wide risk.[13] As previously discussed, CDOs provide useful information about the joint

[13] Each source of risk is modeled as a separate Poisson process.

default probabilities, which cannot be inferred from the marginal probabilities individually. Hence, the authors use the model to infer the market's expectations about default correlations. They estimate jump sizes of, respectively, 0.4%, 6%, and 35%, corresponding roughly to situations in which, assuming a 50% recovery rate, either a single firm defaults, 15 firms default or about 70% of all firms in the economy are wiped out.[14] Using the intensity estimates, the authors decompose the level of the CDS index spread and find that, on average, 64.4% of the total CDX index spread reflects firm-specific default risk, sector-specific default risk represents 27.1% of the index, and economy-wide risk makes up for the remaining 8.3%. Bhansali et al. [2008] apply a linearized version of the model in Longstaff and Rajan [2008] to quantify the systemic risk component during the subprime financial crisis based on the information embedded in CDX investment-grade and high-yield indices and their tranches. Two findings stand out. First, the results seem to suggest that the increase in credit spreads during the 2007 subprime crisis arose mainly because of a dramatic increase in economy-wide risk. This makes the subprime crisis fundamentally different from the crisis in the automotive sector in May 2005, when economy-wide risk was small in comparison to 2007, and sector-wide risk increased substantially. Second, the equity tranche is mostly sensitive to firm-specific risk, while the senior and super-senior tranches are more responsive to the economy-wide risk. In that sense, the super-senior tranches may be interpreted as the market price for bearing economic catastrophe risk.

The argument that super-senior tranches in CDOs feature characteristics that resemble catastrophe bonds is articulated in Coval et al. [2009]. In other words, this means that the payoff function of such senior-tranche products is highly sensitive to the economic state in which default occurs. Thus, investors ought to take into account not only state prices, but also the distribution of payoffs across economic states. In reality, however, it seems that the compensation obtained

[14] Note that the CDX index is backed by 125 single-name CDS. Thus, one firm corresponds to 0.8% of the index. A single default multiplied by a 50% recovery rate yields 0.4%. A similar argument applies for the other categories.

from investing in super-senior tranches reflected only the expected payoffs, indicating that they were overpriced.[15] This view is not shared by Collin-Dufresne et al. [2012], who manage to reasonably fit tranche prices at all levels of subordination with an arbitrage-free framework that allows for jump dynamics. The authors emphasize that using information from the entire term structure of CDS spreads is an important ingredient in the successful pricing of CDO tranches. While the previous studies have a primary interest in the super-senior tranches, Longstaff and Myers [2014] focus on the equity tranche in the CDX.NA.IG and HY indices. The authors argue that CDOs may be viewed as synthetic versions of commercial banks by drawing analogies between the returns on the equity index tranche and the returns of common banks, which share strong similarities. First, unconditional moments of equity tranche returns are more similar to those of equity than fixed income. Second, these similarities are particularly pronounced for stocks from the financial and bank sectors. Third, among banks, the relationship is more similar for banks with larger balance sheets and higher ratios of commercial loans. About two thirds of CDS equity returns can be explained by fundamental factors.

Berndt and Obreja [2010] empirically investigate the idea that super-senior tranches in synthetic credit indices reflect economic catastrophe risk in the context of European corporate CDS returns. They show that nearly half the variation in European corporate CDS returns can be explained by a factor that mimics economic catastrophe risk. The catastrophe factor is constructed as a portfolio of CDS returns maximally correlated with realized negative innovations in the super-senior-tranche spreads of the iTraxx Europe index (12–22% cut-off). The factor construction is motivated by the fact that firm loadings on the first principal component of the correlation matrix of weekly CDS returns are high for firms with high credit quality and low equity volatility, but low for firms with low credit quality and high equity volatility. This suggests that the first principal component correlates substantially with firms whose payoff structure at default is closely tied to the economic state in which default occurs. In the cross-section,

[15] See also Coval et al. [2014].

average portfolio returns line up with the loadings on the economic catastrophe factor, indicating that it is a priced factor in European credit markets.

Longstaff [2010] takes the price information in the ABX indices of subprime MBS at face value to study the underlying nature of contagion during the subprime financial crisis. He compares the lead-lag relationships in a VAR framework between returns on the ABX indices of subprime MBS and those in other markets during the pre-crisis period (2006), the subprime crisis period (2007) and the global financial crisis period (2008). The conclusion is that contagion, defined as an increase in cross-market linkages, occurred through a liquidity channel, which spread from the less liquid subprime mortgage market to the more liquid Treasury market. Hypotheses of contagion through an information or risk aversion channel are ruled out.

While most papers adopt a “top-down” approach to model dependence in credit portfolios, Feldhutter and Nielsen [2012] take a “bottom-up” approach and model the default intensity at the firm level as the sum of an idiosyncratic and a systematic risk component. Thus, default dependence arises only through the joint dependence on a common factor. Estimation results using CDS and CDO tranche spreads on the DJ.CDX.NA.IG index suggest that the common factor is slow-moving and not very volatile, while the idiosyncratic component of default risk appears to be about ten times as volatile as the common component, but less explosive than the systematic factor. Another interesting finding in line with Longstaff and Rajan [2008] is that idiosyncratic risk accounts for the biggest fraction of total risk, in particular over short horizons. The common component represents only about 6% of total default risk over the 6-month horizon, and 26% of total default risk over the 5-year horizon.

Christoffersen et al. [2014] examine dynamic level dependencies and tail dependencies in corporate credit at a weekly frequency (and compare them with the underlying equity), using 5-year CDS spreads of the 215 constituents of the first 18 series of the DJ.CDX.NA.IG index from January 1, 2001 to August 22, 2012. The firm-level dynamics, estimated using an ARMA(2,2)-NGARCH(1,1) model that allows for both skewness and kurtosis in the distribution of CDS returns, are linked through a dynamic copula implied by the skewed t-distribution (Dynamic Asymmetric Copula). Based on the authors' analysis, CDS spread level correlations are higher and experience more persistent increases during the financial crisis than equity return correlations. Credit correlations also react earlier and more strongly to macro-events than equity correlations, while tail correlations increase more than level correlations in general. Overall, the documented increase in correlations in the sample suggests a decrease in diversification benefits over time. Finally, the authors find that level and tail correlations are positively impacted by the VIX index, the aggregate level of credit spreads, and inflation, and negatively impacted by the level of interest rates. The copula correlations and tail dependence also impact upon the time-series dynamics of CDS spread returns, after accounting for leverage, interest rates, and equity volatility, i.e. determinants suggested by structural credit risk models.

Dieckmann and Plank [2011] are not interested in the housing market per se, but study the private-to-public risk transfer during the financial crisis. One of the hypotheses of the authors is that, if governments explicitly or implicitly assumed financial-sector liabilities during the crisis period, one might expect a country's CDS spread sensitivity toward the financial system to be larger if domestic banks were heavily invested in the subprime sector. In order to capture a country's exposure to the subprime sector, the authors use the ranked correlation in returns between the domestic financials and the ABX.HE index. However, countries' exposure to the subprime mortgage sector does not appear to matter given the measurement based on the ABX.HE index. Finally Mizrach [2012] studies jumps in the prices of ABX.HE index tranches and finds that these discontinuous movements are significantly related to market news.

9

Summary and Future Research

We have provided a survey of the academic literature on credit default swaps (CDS) since their inception two decades ago. Despite the relatively short history of the CDS market, we have gained a reasonable understanding of the market, although several avenues for further research remain. For example, the conceptual foundations of pricing are well established but there are a number of issues relating to the calibration of the models. In addition, the global financial crisis and the European sovereign debt crisis have highlighted several shortcomings of the CDS market and this awareness has stimulated a useful debate about the market structure, with many industry and regulatory changes having been made to remedy some of these apparent shortcomings, both at the level of the individual entity and the system as a whole.

The extant literature shows that corporate CDS do facilitate additional debt financing, because CDS make it easier for lenders to hedge their credit risk. Consequently, corporate borrowers increase their leverage and may be able to obtain looser loan covenants. However, this may also render firms more prone to bankruptcy risk. Banks, on the other hand, tend to extend more loans when they can access the CDS market. Much of this literature has been developed in the context of the global financial crisis, during which the CDS market went through considerable stress. The European debt crisis has sparked several research contributions that have improved our understanding of the relationship between sovereign and bank risk. This stream of research has been facilitated by the growth of the sovereign CDS market, and the sovereign default episodes have uncovered regulatory uncertainties pertaining to the CDS market.

There remain, however, many unresolved, yet important, research questions that need to be addressed in the future. The most pressing one relates to the aggregate welfare effect of the CDS market. The current evidence seems to suggest that high-quality firms benefit from the presence of the CDS market, in contrast to low-quality firms, which may be negatively affected. While current research typically studies individual market participants, or a group, in isolation, it may be beneficial to study all stakeholders jointly in a holistic framework, including CDS buyers and sellers and their underlying borrower-lender relationship, regulators and other stakeholders.[1] Theoretical work on how CDS affect the debtor-creditor relationship [Bolton and Oehmke, 2011] and end-users [Bolton and Oehmke, 2014] has stimulated research that seems to suggest that the existence of CDS increases bankruptcy risk. This has obvious consequences for corporate policy that we need to better understand, along the lines of, for example, Subrahmanyam et al. [2014b], who examine how the existence of CDS trading affects corporate cash holdings.

While the U.S. and E.U. are putting in place stringent rules on CDS trading, China is embracing the credit derivatives market with greater regulatory encouragement and spurring banks on to adopt more sophisticated financial innovations in credit risk management. However, it is interesting to note that, even with strong government support, the 2010 CDS market initiative in China has so far failed to realize its potential. In contrast, even under regulatory pressure, the credit derivatives market continues to grow, particularly in the U.S., and to a lesser extent, even in Europe. New credit derivative products are constantly being introduced to the market. For instance, J.P. Morgan offered an

[1] See Anderson [2010] for such a discussion.

exchange-traded fund (ETF) based on a basket of CDS in 2014. As documented by Ivanov et al. [2014], loan spreads have increasingly been tied to CDS spreads ever since this practice was first introduced in late 2008. We anticipate that future studies will further our understanding of why the CDS market is so resilient in the U.S., but not in other countries such as China.

Even though we do have a good understanding of CDS pricing, we continue to learn about market frictions that inhibit arbitrage between the CDS and the underlying bonds. In this context, the literature on liquidity and liquidity risk in CDS spreads has gained steam in recent years, and we expect this to continue. More transparency and the dissemination of CDS transactions data from the new Swap Data Repositories in the U.S. and elsewhere would help us better understand how frictions such as liquidity and counterparty risk play out in the data, just as the TRACE corporate bond data in the U.S. significantly improved our knowledge of these frictions in the corporate bond market. Having detailed information jointly about the CDS and the related bond market would also allow us to study the important question of why the two markets are not perfectly integrated.

Market segmentation across the loan, bond, and CDS markets is another topic that deserves further attention. In particular, the loan CDS market is still in its infancy. More data are still required if we are to gain a good understanding of this market, including the pricing and implications of loan CDS. It would be premature to judge how the new trading conventions introduced in 2013, under the auspices of the Dodd-Frank Act in the U.S. and the European Market Infrastructure Regulation, will perform in the long run. Moreover, market participants are still anticipating greater regulatory uncertainties ahead given the ongoing anti-trust investigations in the U.S. and E.U. against major market players such as Markit.

The sovereign CDS literature highlights a strong co-movement of spreads across countries. While this co-movement appears to be linked to global risk factors originating in the U.S., we are still unclear about the micro-foundations that lead to this factor structure. The literature on the sovereign bank-nexus has further highlighted the dependence structure between sovereign and local financial risk. Thus, we need to deepen our views on the time-varying dynamics between global and local risk factors that determine sovereign spreads. Using the information embedded in the term structure of spreads seems to be a useful direction, as pointed out by Pan and Singleton [2008] and applied by Augustin [2013]. Understanding the economics of sovereign CDS and their impact on the underlying cash market is particularly relevant in light of the current regulatory debate around the use of sovereign CDS by speculators and the pros and cons of constraints on "naked" CDS positions. Over time, we will gain more insight into the efficiency of the naked sovereign CDS ban in Europe. We look forward to future studies in this field that will allow us to deepen our understanding of the economics of this quickly developing and exciting market, based on new granular data on trading positions, and intra-day quotes and prices. Obtaining effective transaction prices to deepen our understanding of CDS is more generally relevant given the evidence of quote discrepancies across different data providers. Mayordomo et al. [2014a] compare single-name CDS quotes provided by the five major CDS data sources and find evidence of time-varying quote dispersion, which is not random, but related to disagreement in analysts' earnings forecasts, liquidity or firm size, but also to global risk factors.

Another important debate surrounds the role of CDS for macro-prudential regulation. Hart and Zingales [2011] propose the regulation of bank capital ratios by their CDS spreads, while Huang et al. [2009] propose the use of the information from CDS to assess the systemic risk of large financial institutions. Similarly, Flannery et al. [2010] argue that CDS spreads should replace credit ratings in financial regulations. Indeed, Chava et al. [2013] show that, in the presence of CDS trading, credit rating downgrades have less impact on stock prices. Veronesi and Zingales [2010] suggest the use of CDS as policy evaluation tools by interpreting the inversion of the term structure of bank CDS spreads as a proxy for the probability of bank runs. Rodriguez-Moreno and Pena [2013] argue that CDS-based systemic risk measures outperform those obtained from interbank rates or stock market prices. Future studies can examine the real effect and implications of CDS-based regulations.

We conclude by emphasizing that we are hopeful that research on CDS will flourish in various directions. The complexities of the market provide for interesting debates to come. Our hopes are that this survey can serve as useful starting point for those unfamiliar with the literature, and as a comprehensive summary that nurtures reflections for those who are well acquainted with the diverse world of CDS.

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