ANNUAL REVIEW OF FINANCIAL ECONOMICS (/content/journals/financial) **Volume 12, 2020** (/content/journals/financial/12/1)

Credit Default Swaps: A Primer and Some Recent Trends

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Vol. 12:177-192 (Volume publication date November 2020)

First published as a Review in Advance on August 14, 2020

ABSTRACT

The credit default swap (CDS) remains an important class of derivatives contract despite the declining activity in the single-name corporate market. I provide a quick introduction to the contracts, the pricing formula used to interpret the market premiums, the development in trading volumes, and some key insights that are important for understanding its role in markets. I then take a closer look at the CDS-bond basis and the role of trading and regulatory frictions. Finally, the European sovereign debt crisis brought back in focus the notion of a quanto spread, which I explain.

Keywords

credit default swap (/search?option1=pub_keyword&value1="credit default swap"), CDS (/search?option1=pub_keyword&value1="CDS"), single-name CDS (/search?option1=pub_keyword&value1="single-name CDS"), index contracts (/search?option1=pub_keyword&value1="index contracts"), CDS-bond basis (/search?option1=pub_keyword&value1="CDS-bond basis"), trading frictions (/search?option1=pub_keyword&value1="trading frictions"), regulatory capital (/search?option1=pub_keyword&value1="regulatory capital"), sovereign CDS (/search?option1=pub_keyword&value1="sovereign CDS"), quanto spreads (/search?option1=pub_keyword&value1="quanto spreads")

Keywords

JEL G12 (/search?option1=pub_keyword&value1="JEL G12"), JEL G13 (/search?option1=pub_keyword&value1="JEL G13"), JEL G23 (/search?option1=pub_keyword&value1="JEL G23")

1. INTRODUCTION

A credit default swap (CDS) is a derivative contract that can be used to insure its holder against default of a bond issuer. CDS markets grew tremendously in the years leading up to the financial crisis of 2007–2008, but their role in subprime securitizations and the collapse of AIG—which was heavily involved in trading of CDS contracts—contributed to the opinion that CDS contracts were one of the culprits of the financial crisis. The review by **Stulz (2010)** takes a careful and critical look at this commonly held belief. Since the crisis, trading volume has decreased somewhat, but CDS contracts are still important for hedging credit risk and continue to be an important benchmark for measuring credit risk of bond issuers (corporations, financial institutions, and sovereign entities). Parts of financial regulation continue to use historical CDS premiums as an input for setting capital requirements, and financial regulation also still allows financial institutions to lower capital requirements through the purchase of CDS contracts. For these reasons alone, the contracts are not likely to disappear even if trading of derivatives in general is under pressure from postcrisis regulation. The huge popularity of CDS indexes is another reason for believing that the markets will persist.

In my view, some of the most interesting developments in research on CDS contracts lie in the area of trying to understand how the regulatory setting and other trading frictions affect the use and pricing of CDS contracts. Theory often succeeds by ignoring details on the actual specification and trading of contracts, because it is precisely by ignoring the gory details that we succeed in seeing the forest and not just the trees. An important current trend is to look a little more carefully at the trees, i.e., study how the contracts are actually traded, focusing on frictions imposed by regulation and by internal and external capital markets. This trend is a reflection of the experience from the crisis, which showed that many relationships that we thought of almost as laws (covered interest parity is a good example) broke down, and there was no way to understand such breakdowns without looking into the machine room of financial intermediaries, hedge funds, and other market participants. In the realm of CDS contracts, it is the so-called CDS-bond basis—to be explained below—that was originally thought of as a near-arbitrage relationship but which broke down violently during the crisis. Setting the stage for a discussion of this basis requires some details on how CDS contracts are traded, how the premium on a CDS contract is determined theoretically, and how CDS contracts can be used to obtain exposure to the credit risk of firms and sovereigns without actually buying their debt.

In this review, I give the reader what I think is the most direct path to grasping these important elements, with a reader in mind who is not already well versed in corporate bonds and CDS premiums. Since CDS contracts have been around since the mid-1990s, comprehensive and thorough review articles are already available that guide the reader through the empirical and theoretical literature (see, e.g., **Jarrow 2011**; **Augustin et al. 2014**; **Augustin et al. 2016**; **Culp, van der Merwe & Stärkle 2016**). These surveys provide a good overview of the literature, addressing how CDS premiums comove with each other and with credit risky bonds, what determines corporate and sovereign CDS premiums, and how the introduction and use of CDS contracts have affected leverage of firms and risk-taking by banks. This review aims to delve a bit deeper into selected sources and is in no way comprehensive.

2. DEFINING THE CONTRACT

We start by defining the CDS in the way the contract was traded in roughly the first two decades (1990s and 2000s) of its existence. This specification is still how we think of the contract, and in empirical work we translate the new specification of premiums into this old specification for reasons that are explained below.

2.1. How the CDS Used to Trade

A CDS contract is a contract in which the buyer (the buyer of protection) pays a periodic premium to the seller (the seller of protection) until whichever comes first, maturity of the contract or default of the reference entity of the CDS. The contract has a notional amount, and the purpose of the CDS is to insure the protection buyer against the loss that he would suffer if he held bonds issued by the reference entity with a face value equal to the notional amount of the CDS. Hence, in the event of a default of the reference entity before the CDS maturity date, the protection seller pays a compensation to the protection buyer that is equal to the difference between the notional and the recovery value of defaulted bonds with that notional. This payment can take the form of a physical delivery, in which case the protection buyer delivers to the protection seller defaulted bonds with a face value equal to the notional amount of the contract and in return receives the notional amount in cash from the seller. The payment can also take the form of a cash settlement, in which case the amount of cash exchanged is the difference between the notional and the postdefault value of the bonds. So, for example, if a 5-year CDS contract on XYZ has a running premium of 150 basis points (bps), to buy protection on, say, 1 million USD of notional, the protection buyer pays premiums that on an annual basis add up to 0.015 * 1 million USD = 15,000 USD. In practice, they are split into quarterly payments using the appropriate day count convention, and the numbers may then not add up to 15,000 exactly. In the event that XYZ defaults before the expiry of the contract, and if the recovery rate on debt is 0.4, the protection seller must pay (1 − 0.4) * 1 million = 600,000 USD to the protection buyer or take delivery of 1 million USD (face value) of eligible bonds and pay 1 million USD in return. Importantly, in this trading convention, cash is not initially exchanged (disregarding margin requirements, etc.). The premium is set in such a way that the initial market price of the contract is zero. I refer to a premium set in this way as a (fair) running premium.

2.2. A Formula for the Running Premium

The theoretical setting for determining the running premium from assumptions on recovery and default probabilities is easy to explain if we adopt a few simplifying assumptions that are in fact used in practice. Consider a contract maturing at date T, and divide the time interval between 0 and T into quarters with the division points $0 = t_0 < t_1 < \cdots < t_{n-1} < t_n = T$. Premium payments happen on these dates. The assumptions we make now are the following:

1. An (eligible) bond issued by the reference firm recovers a fraction δ of its notional in default.
2. The settlement of a default that occurs in the time interval (t_{i-1}, t_i) happens at the midpoint $\frac{t_{i-1}+t_i}{2}$.
3. A discount function p is determined for riskless debt. We denote by $p(0, t)$ the time 0 value of a riskless payment of 1 received at date t.
4. The risk-neutral probability of the reference firm surviving past t is denoted $S(t)$.
5. The value at time 0 of a payment of 1 at date t, which occurs if and only if the reference firm has not defaulted, is equal to $p(0, t)S(t)$.

Before we state the formula for the running premium, a few remarks on these assumptions are in place. The implication of assumption 1 is that we know that the buyer of protection receives $1 - \delta$ times the notional amount insured in case a default occurs before maturity. In practice, the recovery rate is not known in advance, but then think of δ as a risk-neutral expected recovery rate. Assumption 2 collects the probability mass of the interval into the midpoint. It ensures that we can express the fair premium using only the survival function. If we insisted on discounting the settlement payment from the exact time of default, the expression for the running premium would involve integrating over the density of the default time. The approximation of the integral can be improved by using a finer subdivision of the time between premium payments. Assumption 3 specifies which riskless rate we are using. We return to this point below. Assumption 4 assumes that we know the default probability that accounts for the market price of default risk. This is of course only observable through prices; indeed, the formula for the running premium we are about to derive is used to infer this quantity from observed market data. Assumption 5 hinges on an assumption of independence between the drivers of the riskless rate and the event of default. There are tools for dispensing with this assumption, but the market uses this assumption all the time because empirically the relationship between riskless rates and default probabilities is ambiguous, and even when an effect is found, its influence on the fair premium is small.

With these assumptions, the determination of the fair running premium consists of setting the value of the protection seller's promise equal to that of the protection buyer's promise. The value of the protection leg of a CDS with maturity T, $\Pi^S(T)$, and notional amount of 1 is given as

$$\Pi^s(T) = \sum_{i=1}^{n} [1 - \delta]\, p\left(0, \frac{t_{i-1} + t_i}{2}\right)(S(0, t_{i-1}) - S(0, t_i)). \tag{1.}$$

We now turn to the present value of the running premium of the CDS. The premium in annual terms per unit of notional insured on a contract with maturity T is denoted $C(T)$. The quarterly payment made by the protection buyer per unit of notional is roughly equal to $0.25 \cdot C(T)$. In practice, the day-count convention is Actual/360, which means that the payment $c(t_i)$ at date t_i depends on the number of calendar days between t_{i-1} and t_i, which we denote $n(t_i)$. The payment per unit of notional is then $c(t_i) = \frac{n(t_i)}{360} \cdot C(T)$. The quarterly payment is "in arrears," i.e., it is made at the end of the quarter. We accommodate also the fact that in the event of default, a partial payment is made of the running premium that represents the fraction of a quarter that has elapsed since the last coupon date. Assumption 2 above is again invoked so that this payment can be assumed to equal $\frac{c(t_i)}{2}$ if the default occurs between t_{i-1} and t_i. We now get the following value of the premium payment (if paid as a running premium, i.e., there is no initial payment between the parties to the CDS at initiation):

$$\Pi^b(T) = \sum_{i=1}^{n} c(t_i) p(0, t_i) S(t_i) + \sum_{i=1}^{n} \frac{c(t_i)}{2} p\left(0, \frac{t_{i-1} + t_i}{2}\right)\left(S(t_{i-1}) - S(t_i)\right). \tag{2.}$$

The fair running premium $C(T)$ on a CDS contract with notional 1 and maturity T is found by choosing $C(T)$ such that the expressions for $\Pi^S(T)$ and $\Pi^b(T)$ are equal. The expression for the value contains an important concept for CD

S pricing, namely that of a risky annuity. If $C(T)$ is set to 1, the expression becomes the value of an annuity that pays 1 every year until maturity at date T but which is risky in that it is terminated if the reference firm defaults. The risky annuity will be useful below, so we define

$$\mathrm{RA}(T) = \sum_{i=1}^{n} \frac{n(t_i)}{360} p(0, t_i) S(t_i) + \sum_{i=1}^{n} \frac{1}{2} \frac{n(t_i)}{360} p\left(0, \frac{t_{i-1} + t_i}{2}\right) \left(S(t_{i-1}) - S(t_i)\right). \qquad (3.)$$

Hence, the present value of the protection payment can be expressed as the annual premium multiplied by the present value of a risky annuity.

Obviously, the fair running premium should increase when the default probability of an issuer increases, and it should also increase if the expected loss in default is higher. For a given reference entity, the running premium also depends on maturity. The typical pattern is that the premium increases with maturity, but for distressed reference entities, the slope often inverts and premiums for short-term contracts exceed those of long-term contracts. The slope is intimately connected with future default probabilities conditional on survival (see, e.g., **Lando & Mortensen 2005**).

2.3. How the Contract Is Currently Traded

Imagine that an investor had bought protection for 5 years at a market-determined premium of 150 bps. Imagine that the CDS premium subsequently changes to 200 bps on the same contract and the same maturity; then the investor may wish to cash in on the fact that protection can now be sold at 200 bps. Although it might be possible to contact the counterparty of the original contract and negotiate a settlement to terminate the contract, it may be the case that another market participant offers better terms on a new contract, and therefore it is better to offset the old contract by selling protection on the same amount of notional to another counterparty. In a default, the investor would now have hedged their position (the settlement on the bought and the sold contract cancels out), and—ignoring all issues of counterparty risk—they would earn the difference between the 200 bps received and the 150 bps paid. The value of this is precisely that of a risky annuity encountered above, since it only runs to the maturity date of the CDS contracts if there is no default. Pricing this uses the RA(·) function defined above and therefore is not model-free.

To facilitate cancellation of offsetting positions, a change in trading convention was introduced in 2009. Contracts then started trading with fixed running premiums. In the US market, the possible running premiums were set at 100 bps for firms with low credit risk and 500 bps for high-credit-risk firms. To compensate for the difference between the fixed premium and the fair running premium, an upfront payment was introduced. Intuitively, if the true credit risk of the reference entity is such that the fair running premium is 150 bps, then the buyer of protection compensates the seller initially for having to pay only 100 bps. Returning to our example above, the investor would pay an upfront premium initially to enter into a CDS with a running premium of 100 bps, which reflects the present value of the risk annuity of 50 bps. When the credit spread then moves to 200 bps, the selling of protection brings in a larger upfront payment than the one made initially, and the investor will pocket the difference between the two upfront pa yments. The running premiums of 100 bps will cancel out exactly; hence, the position is off the book. The profit recorded is directly measurable as the difference between the upfront payments and hence requires no model to determine. With bilateral contracts, counterparty risk is still an issue, if the contract is unwound with another dealer, but with centralized clearing the contracts offset completely. This institutional change helped facilitate so-called compression of CDS contracts by which a desired level of net exposure could be obtained through far lower notional amounts outstanding.

Despite the advantages from trading CDS contracts using upfront payments and fixed running premiums, it comes at the disadvantage that it is harder to infer from the contract terms what they imply in terms of survival probabilities. Also, as we shall see below, the running premium is better compared with yields on corporate bonds issued by reference firms; hence, a clearer picture emerges as to whether credit risk is relatively cheap in CDS markets compared with that in bond markets. To convert from fixed to running premiums, one has to solve the equation

$$\Pi^{\text{upfront}}(T) + C^{\text{standard}}(T)\mathrm{RA}(T) = C^{\text{running}}(T)\mathrm{RA}(T). \qquad \text{4.}$$

The left-hand side is the value of the upfront payment and the value of the risky annuity paying the standard coupon (100 or 500 bps in the US market). The right-hand side is the value of the fair running premium. The conversion is not model-free, since it must run through the inputs to the risky annuity RA(T). One first makes assumptions about the riskless rate and the recovery rate. With these given, a survival function is chosen such that the left-hand side of **Equation 4** matches the protection value in **Equation 1**. Since this determines RA(T), the running premium can now be found from **Equation 4**. Markit has published a market standard for performing this conversion (see **https://www.markit.com/converter.jsp (https://www.markit.com/converter.jsp)**).

2.4. The Legal Terms Are Not Trivial

The legal specification of a contract is not simple. The two key challenges are specifying what type of event is a trigger event, i.e., an event that entitles the protection buyer to receive compensation from the protection seller, and which obligations can be delivered in the event of default.

For corporate reference firms, the important credit events are bankruptcy, failure to pay, and restructuring. For sovereign references, moratorium or repudiation of debt obligations is added to the list of trigger events. The deliverable obligations for corporate reference firms are senior unsecured bonds, unless the contract specifically is written on subordinated debt. Over time, modifications have been made to standard contract terms to limit the maturity of deliverable bonds. These modifications are particularly relevant for contracts in which restructuring events count as a credit trigger. A restructuring event can be a soft credit event with no or very limited losses to existing bond holders—yet bonds can trade at a discount simply because interest rates have gone up or the credit spread has widened. With unlimited maturity of deliverable bonds, these effects can be pronounced, as experienced famously during the restructuring of the bank Conseco in 2000 (see **Packer & Zhu 2005**). Contracts in Europe tend to trade with a restructuring clause, because to give full capital relief, Basel III requires that the contracts contain such a clause (cf.

Basel Comm. Bank. Superv. 2017). US contracts typically trade without, since most restructurings take place using Chapter 11 bankruptcy proceedings, which qualify as bankruptcy events. Index CDS contracts (defined below) also trade without a restructuring clause.

Even after having determined which obligations are deliverable, cash settlement requires a method for determining the postdefault value of the deliverable bonds. Since 2009, an auction system has been in place with the purpose of obtaining a postdefault market price that determines the loss in default and that the contract holders have committed to use for cash settlement. **Helwege et al. (2009)** focus on price discovery in these CDS auctions, whereas **Chernov, Gorbenko & Makarov (2013)**; **Gupta & Sundaram (2015)**; and **Du & Zhu (2017)** all raise concerns about the format of the auctions.

The most fundamental question of whether a triggering event has occurred can be subject to dispute, despite definitions listed in the standard contract. Buyers and sellers now agree to leave it to a so-called determination committee to determine whether a default has occurred and an auction should be held. Determination committees consist of elected members from various market participants. For more on the legal aspects, readers are referred to **Augustin et al. (2016)**.

A separate legal problem related to market manipulation concerns the attempts by sellers or buyers of protection to interfere with corporate decisions of the underlying firm. Sellers of protection have an incentive to help the underlying firm avoid default triggering events, and buyers of protection have the opposite incentive. **Danis & Gamba (2019)** list 13 such cases of CDS investor involvement occurring in the period 2013–2019.

3. FIVE KEY POINTS ON CDS CONTRACTS

Research on CDS contracts has evolved around a lot of issues, but a few key concepts and observations are essential for understanding previous and current research related to CDS markets.

3.1. A CDS Can Be Used to Mimic a Corporate Bond

A CDS contract can be used to buy exposure to a specific credit without actually investing in the corporate bond itself. This is often referred to as creating synthetic exposure to the bond. The idea is presented here in its simplest form. Imagine a riskless (government) bond with 5 years to maturity and a coupon of 2% trades at par. For simplicity, assume that the bond pays coupons annually, i.e., the bond costs 100 today, and delivers 2 every year until the maturity date, when it pays 102. Imagine that a CDS is trading on a risky firm with an annual (running) premium of 3%. An investor who buys the riskless bond and sells a 5-year CDS on the risky firm will receive a cash flow that closely resembles a par-valued corporate bond issued by the risky firm with a coupon rate of 5%. To see this, note that if the firm does not default in the 5-year period, the combined position earns an interest rate of 5% on the investment of 100 (remember, the CDS trades as a running premium and hence involves no cost at initiation). If the firm defaults within the 5-year period, the sold CDS means that the investor receives the defaulted bond and has to pay the notional amount. If interest rates have not moved too much, selling the fixed-rate government bond will finance the pa yment of notional, and the investor can sell the corporate bond at its postdefault market value. The example can be made more clean using a floating-rate riskless bond (or hedging the interest exposure with an interest-rate swap), which protects the investment in the riskless bond from interest-rate risk, ensuring that the sale of the riskless bond will produce the right amount of notional. However, other details complicate the picture, which we return to below.

The bottom line is clear, however. The exposure obtained from buying a government bond and selling a CDS resembles that of the underlying corporate bond. Since the extra coupon earned from the combined position is the CDS premium, this premium ought to be the same as the excess coupon a firm must pay over the riskless rate to trade at par value, i.e., a measure of the firm's credit spread.

3.2. In Practice, the Arbitrage Is Not Simple

Although the arbitrage involving trading of bonds and CDS contracts sounds simple, the devil is in the actual implementation. Two sets of complications arise: First, it is in fact often impossible to make the cash flows match. Second, even when cash flows seem to match closely, when viewing the contracts in isolation, funding requirements and trading costs blur the picture. This section focuses on the problems of creating matching cash flows and returns to the trading frictions below, when the ways of analyzing the CDS-bond basis are discussed.

The matching—which traders refer to as the sizing problem—exists when the bond trades away from par value. For this example, assume that the corporate bond has a notional amount of 100, an annual coupon of 2, and currently trades at 80. Assume for simplicity that the riskless rate is zero. We assume that the maturity of the bond is such that the bond yield is 6%. Assume that the CDS trades with no upfront payment at 5%, which suggests that we can make a profit by buying protection and buying the bond. Assume that we buy protection on the notional amount of 100. It is immediately obvious that the small coupon from the bond will not cover the standard premiums paid on the CDS simply because a large part of the yield pickup of the bond occurs when it pays off full notional at maturity. An early default would be beneficial for the negative basis trader, who quickly collects the full notional amount and has lived with the negative carry of the CDS premium exceeding the bond coupon for only a short time. A default toward the end (or not default) will still be profitable, but less so because the capital gain on the bond occurs at the end, and the negative carry has lasted for a longer time. One can show that the opposite case in which the underlying bond trades at a premium and has a high coupon produces a positive carry, and the trade will be most profitable if a default happens late or not at all, rather than early. I have deliberately kept upfront payments out of the picture here, but they play the same role in defining a time-dependent profitability pattern of a basis trade.

Note also that, in a sense, buying protection on the full notional may resemble overinsurance. If we assume a recovery rate of 0.5 on the bond, it means that the bond pays back 50 to its owner in the event of default, and this means that the CDS buyer receives the loss, which is also 50 in default. But 50 more than compensates the owner for the loss in default, because the loss from 80 to 50 is only 30. So a cheaper option is to buy protection on a notional of 60. This improves the carry profile, even if it may still not make the CDS premium paid for by the corporate bond coupo ns. But the resized coverage makes the investor vulnerable to lower-than-expected recovery on the bond, and should the bond go up in value, the CDS does not hedge the fall in price over the default event. The intricacies of basis trading are covered thoroughly by **Elizalde, Doctor & Saltuk (2009)**.

3.3. The CDS-Bond Basis

We have seen that there ought to be a close connection between the yield of a corporate bond and the CDS premium on the issuer of the bond, but we have also seen that it may not be straightforward to carry out a textbook arbitrage, i.e., a trading strategy with zero cost that generates a positive cash flow. Hence, it is not surprising that in practice the CDS premium and the spread on the underlying bond can be different. The difference is referred to as the CDS-bond basis:

$$\text{basis} = \text{CDS} - \text{yield spread},$$

where yield spread is the difference between the yield on a corporate bond and that of a riskless bond. The riskless rate is not as uncontroversial as one might think. We can easily observe yields on, say, US Treasury bonds, but it can be argued that the most liquid treasury bonds actually trade at interest rates below the riskless rate because of their value as collateral of the highest quality and the potential to earn an extra yield through repo specialness (see, e.g., **Krishnamurthy & Vissing-Jorgensen 2012**). One can argue in favor of using a swap rate instead.

Disregarding such measurement problems, if the basis is negative, as was the case to an extreme degree during the financial crisis, it suggests that investors can arbitrage this by buying protection and buying the risky bond while shorting riskless bonds. If the basis is positive, the arbitrage will involve shorting of the corporate bond and selling of CDS contracts. Both arbitrage strategies involve costs that we return to below.

3.4. Index Contracts Allow Synthetic Exposure to a Portfolio of Names

The most liquid market today involving CDS contracts is the market for so-called index contracts, which are contracts mimicking the purchase of protection on the same notional amount on each name in a portfolio of names. As with CDS, there is a combination of upfront and standard, running premiums. If one buys protection on an index for a notional amount of 100 million USD, and the index contains 100 names (as is the case, e.g., for the North American High Yield Index), it is equivalent to holding 100 contracts protecting 1 million worth of notional of each of the names in the index. If one of the names defaults during the life of the contract and the auction determines a recovery of 40%, the buyer of the index receives $(1 - 0.4) \cdot 1{,}000{,}000$ USD = 600,000 USD in compensation. After a default, the notional of the contract is reduced with the notional reduced to 99 million USD, and the quarterly premium is subsequently paid relative to that reduced notional. There are two families of indexes: the CDX indexes covering North America and emerging markets, and the iTraxx indexes covering Europe, Japan, Asia, and Australia. The CDS.NA.IG (North American, Investment Grade) index, which references 125 names of investment-grade firms, and the CDX.HY (North American High Yield) index, which references 100 high-yield firms, are the most heavily traded CDX indexes. The main European index is the iTraxx Europe index, which covers 125 investment-grade European names with liqu idly traded CDS. Every 6 months the composition of an index changes slightly, as typically a few issuers are replaced. The most liquid index contracts have a maturity of 5 years. In complete analogy with single-name contracts, an investor can obtain exposure to a portfolio of high-yield bonds by selling index contracts.

Today, index contracts are a popular vehicle for pension funds that sell index contracts to get exposure to a diversified pool of corporate credit. Compared with an outright purchase of the underlying bonds, there are several reasons for selling the index. It saves the cost of actively managing or paying an asset manager to manage a corporate bond portfolio. Every 6 months the investment bank selling the index will roll the index contracts, i.e., replace the off-the-run contract with newly issued 5-year contracts, such that the maturity profile remains the same. In this sense, the contracts serve as an important alternative trading venue for corporate credit in line with the findings of **Oehmke & Zawadowski (2016)** related to the single-name corporate CDS market. But even if every effort has been made to make single-name CDS contracts compatible with the index contracts, there is still a basis between the two: The index does not trade at exactly the same value as the sum of the constituent CDS contracts. This deviation is used by **Junge & Trolle (2015)** to construct a measure of liquidity in CDS markets.

3.5. Index Tranches and Index Options: Correlation and Volatility

The high liquidity in the index products lays the foundation for derivatives markets to exist on the indexes. Before the crisis, important derivative contracts involved so-called tranches of the index—today the index derivative market consists almost exclusively of index options. This section briefly describes both contracts and the risks they allow users to trade.

An index tranche allows the protection buyer to insure a particular layer (or *tranche*, derived from the French word for “a slice”) of losses in the underlying pool. A tranche on an index is characterized by its attachment point and detachment point. The attachment point determines the threshold that the total amount of loss in the underlying names has to exceed before protection payment kicks in. When the loss exceeds the detachment point, no more protection payment takes place. If, for example, buying a notional amount of 10 million on a tranche with an attachment point of 3%, one will receive nothing if losses in the underlying pool (taking recovery into account) do not exceed 3%; the full notional will be received if losses exceed 7%; and in between, the compensation is linear in the losses. Once losses have exceeded 3% (but not reached 7%), the protection buyer receives payment as new defaults occur and pays premium on a reduced notional. Index tranches and tranches made on so-called bespoke portfolios (i.e., names selected by a sponsor) were a huge business leading up to the crisis, and they were huge drivers of selling of single-name CDS contracts from sponsoring investment banks creating tranches. These tranches could be sold to investors focusing exclusively on the seemingly attractive yield that the tranches could offer compared with ratings, but ignoring the heavy element of systemic risk in the tranches, which means that they should have sold at a much higher discount. Trading in tranches is all about correlation. Where an index itself in principle can be priced from in formation of each CDS contract in the reference pool without worrying about their comovement, the price of tranches is all about correlation. Keeping the CDS premiums on individual names fixed, an increasing correlation will make senior tranches riskier and equity tranches safer.

Index options are options to buy or sell the entire index at a given price at some time in the future. Like options in general, they allow traders to express views on the level and the volatility of the underlying index.

4. CDS VOLUME DATA

What are the most recent trends in outstanding amounts, trading intensity, and market participants? We briefly review some statistics that are incomplete but indicative of recent trends.

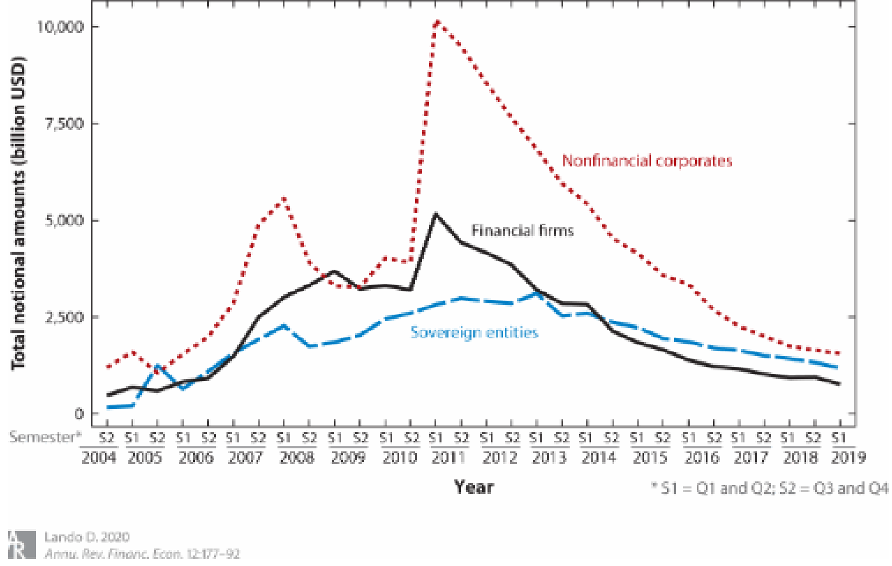
4.1. Publicly Available Statistics from the Bank for International Settlements and the Depository Trust and Clearing Corporation

How much are CDS contracts traded? As with several types of derivatives, the notional amounts are staggering, and we bear in mind that they are orders of magnitude larger than the actual market value of the exposures. Even in a default, the amount that actually changes hands (due to netting agreements) is far smaller than the notional. **Stulz (2010)** reports that, in connection with the Lehman bankruptcy, the outstanding notional of CDS registered in the Depository Trust and Clearing Corporation (DTCC) was 72 billion USD, and these contracts resulted in an exchange of cash of only 5.2 billion USD even if the loss paid by protection sellers was 91.375% of the notional.

Still, notional amounts do represent traded contracts and inform us of the activity. The Bank for International Settlements (BIS) publishes a biannual derivatives survey of the composition of CDS contracts traded. **Figure 1** shows the outstanding gross notional amounts reported by the BIS since 2004. Single-name CDS contracts have declined in volume since the crisis owing to both compression and less activity in the synthetic collateralized debt obligation (CDO) market. The single-name CDS market is now roughly evenly distributed between nonfinancial corporates, financial firms, and sovereigns.

Figure 1

Gross notional volumes of single-name credit default swap contracts split according to whether the reference entity is a nonfinancial corporate (*red dotted line*), a financial firm (*black solid line*), or a sovereign entity (*blue dashed line*). The numbers are based on survey data and contain some double counting because both the buyer and the seller may be reporting the same contract. Data from the Bank for International Settlements.



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The DTCC clears and settles CDS contracts, and supervisors now have access to all details on contracts for which one of the parties to the contract or the reference name is a supervised entity. For a recent study on the uses of CDS contracts based on data available for a US supervisor, readers are referred to **Boyarchenko, Costello & Shachar (2018)**.

DTCC also publishes aggregate statistics on trading volume and gross and net notional amounts. As of October 15, 2019, the DTCC's estimate of the total amount of single-name CDS contracts outstanding was 3.68 trillion USD. Sovereign reference entities accounted for 1.32 trillion USD. The amount of index contracts was significantly larger and measured to be 6.3 trillion USD.

4.2. Central Clearing Counterparties and Swap Execution Facilities

Postcrisis financial regulation has pushed CDS trading away from opaque over-the-counter (OTC) markets and toward centralized clearing of contracts in which the parties still agree to the contracts bilaterally but the clearing agent steps in as a counterparty to both the seller and the buyer of protection. **Duffie, Scheicher & Vuillemey (2015)** provide an early study of the central clearing of index contracts mandated by the Dodd-Frank Wall Street Reform and Consumer Protection Act (DFA), and the majority of single-name contracts are moving toward centralized clearing as well. Moreover, the DFA has mandated that trading in the most liquid index contracts take place via so-called Swap Execution Facilities (SEFs), a change that is aimed at increasing pretrade transparency and post-trade recording. The trading platforms allow several formats of trading (through a limit-order book, or so-called request-for-quote or request-for-streaming formats), as described by **Collin-Dufresne, Junge & Trolle (2020)** and **Riggs et al. (2020)**. The SEF data provide a unique opportunity to study the interplay between the chosen format of trading and the characteristics of the trades involved. This focus of research will be important going forward to understand how the changes in transparency affect market prices, trading volumes, and allocation of risk.

5. REVISITING THE CDS-BOND BASIS

Traditionally, because of the theoretical link that exists between CDS premiums and bond yield spreads, there has been a strong focus on the question of whether price discovery happens faster in one market than the other (e.g., see the early work of **Blanco, Brennan & Marsh 2005**) and, in particular, whether CDS contracts are a more precise measure of credit risk. In **Longstaff, Mithal & Neis (2005)**, the premise is that CDS spreads are a more precise measurement of pure credit risk, and the extent to which yield spreads exceed CDS premiums is regressed on proxies for corporate bond liquidity to argue that illiquidity is priced in corporate bonds. **Bongaerts, de Jong & Driessen (2011)** argue that an illiquidity premium priced in CDS contracts is also making the price to buy protection higher (and hence benefits the seller). But the huge size of the negative basis during the crisis, and the fact that it did not vanish completely after the crisis, has focused the attention on the trading frictions and regulatory frictions that allow a basis to exist.

The approaches I list here all have in common that they consider frictions that are faced by arbitrageurs trying to profit from a basis. A trader faces several trading frictions when trying to fund and maintain the trade. A trade will require capital to carry out, and there is a required return on capital that should be taken into account. When the trader is a regulated financial intermediary, binding regulatory constraints can be viewed as a source of trading costs.

A comprehensive analysis of basis trades is available in **Elizalde, Doctor & Saltuk (2009)**, and some of the key insights are used in **Bai & Collin-Dufresne (2019)** to analyze the costs and risk associated with carrying out the arbitrage trade. The fundamental idea is the following: Assume that the basis is negative so that the price of buying CDS protection is small compared with the yield spread earned on the bond. At time *t* the trader has to buy the corporate bond at its ask price B_t^{ask}. To fund this purchase, the trader can repo out the bond subject to a haircut of *h* meaning that the trader will be able to borrow the amount $(1-h)B_t^{\text{ask}}$ paying the rate *Repo*. The remaining part hB_t^{ask} of the purchase is funded at the bank's funding costs assumed to be a spread *f* over *Libor*. Finally, to buy CDS protection requires trading at the ask and posting a margin payment M_t, which also is assumed to be funded at the bank's funding rate. These are the direct costs. For the purpose of profit and loss calculation the following day, assuming that the position would have to be liquidated, the trader would have to exit at the bond's bid price and the CDS bid premium. A change in the CDS premium will multiply into a capital gain or loss, which depends on the CDS notional amount and the sensitivity of the CDS price to changes in the spread (its so-called risky duration). **Bai & Collin-Dufresne (2019)** also mention the influence of counterparty risk, i.e., the risk that the seller of CDS protection defaults in a state in which the contract has positive value to the buyer. In general, trading between financial intermediaries is supported by a so-called CSA (Credit Support Annex) to the ISDA (International Swap and Derivatives Association) Master Agreement, which regulates the positing of collateral precisely to mitigate default risk when the CDS becomes too much in the money. In addition, it requires strong assumptions on the correlation between default events of the reference entity and the parties to the contract (most notably the protection seller) to compute a significant analytic effect of counterparty risk. **Arora, Gandhi & Longstaff (2012)** analyze the question empirically by obtaining quo tes on CDS contracts from 14 different dealers, allowing them to study to what extent higher credit risk of the protection seller increases the CDS premium. They find that the effect is vanishingly small. All in all, the analysis suggests that the following factors will make the negative basis trade less attractive and hence contribute to pushing it in the negative direction:

- An increase in funding rates as measured by the benchmark Libor rate and the bank's own funding costs *f*
- A higher haircut (perhaps because of declining collateral quality of the bond) and a higher repo rate
- An increase of the margin requirement
- An increase in trading costs as measured through bid-ask spreads of bonds and CDS contracts

Bai & Collin-Dufresne (2019) then use proxies for these various risk factors and check if they help explain the cross-sectional variation of the basis in different periods around the crisis. I refer to the article for details on which proxies are used and which are significant. In general, a lot of measures—even counterparty risk—are significant during the crisis, but fewer are significant after the crisis. The findings provide important empirical evidence as to which drivers are significant. But can we make more explicit estimates of how large a basis can be expected to be?

Gârleanu & Pedersen (2011) model a trader who has to post margin to support trading positions in both a cash instrument and a cash flow mimicking derivative. When posting margin becomes a binding constraint—i.e., there is a shadow cost of margin capital—the fact that margins differ on the two positions also affects their equilibrium rates of return. Under certain assumptions, in their setting a margin-adjusted Capital Asset Pricing Model (CAPM) applies, under which the return of assets satisfies

$$\mu_i - r_f = \beta^i \lambda + m^i \psi. \qquad (5.)$$

The classical CAPM compensation for bearing systematic risk is supplemented by a product of a shadow cost of margin capital and the margin requirement on an asset. This implies, in particular, that if there is a margin differential between trading a corporate bond and a CDS, this should translate into a difference in expected returns. And even if yield spreads are not the same as excess expected returns, differences in yield spreads on the same cash flows come close. This means that if the margin for selling the CDS is 5% and it is 25% for the bond (think of the latter as the result of a repo haircut on the bond), then with a shadow cost of margin capital ψ equal to 0.1, the corresponding difference in yields becomes $0.1 \cdot (0.25 - 0.05) = 0.02$, which is compatible with observed values. Moreover, another direct prediction is that the CDS-bond basis should be higher for high-yield bonds simply because the margin differential is higher due to the much larger haircut when using a high-yield bond as repo collateral. If, for example, the haircut is 50% and the CDS margin is 0.1, this would imply a basis that is twice as large.

The arbitrageur for **Gârleanu & Pedersen (2011)** is akin to a hedge fund acting through a prime broker. **Boyarchenko et al. (2018)** consider the constraints imposed on financial intermediaries, who are the prime brokers, when trying to arbitrage the basis. A key constraint is the capital ratio, which puts a lower limit on the amount of equity (or equity-like) financing that the bank must have. The traditional capital ratio measures equity capital against risk-weig hted assets, whereas the so-called leverage ratio (and supplementary leverage ratio) uses total assets without risk weights in the denominator. Assuming that internal capital markets are set up in a way that requires deals to earn a certain return on the regulatory capital, a required profitability can be computed. A deal can have positive net present value, but if it consumes a lot of regulatory capital, according to this viewpoint, it will not be carried through. In the internal capital market of the financial intermediary, there is a threshold for accepting a trade, and this threshold is set by a return on the allocated regulatory capital. The question of which capital ratio is the binding one is difficult to answer, but one can compute the capital requirement accounting for the capital using each one as binding constraint. This is the approach taken in **Boyarchenko et al. (2018)**. That capital constraints do bind, or that capital flows slowly within the internal capital market of an intermediary, at least in the short run, is argued in **Siriwardane (2019)**.

Quantifying how limits to arbitrage (cf. **Shleifer & Vishny 1997**) affect CDS pricing is an important step. To know exactly how the constraints bind in practice is difficult. A bank will always seek to stay at a certain distance from the strict regulatory requirements on capital, and rules on how profitable a trade has to be must weigh in several regulatory ratios related to liquidity and capital. We still know fairly little about how this is and should be done. Also, when trading through centralized clearing, the margin setting is highly portfolio dependent, and the marginal effect of a new contract may be very different from that of a stand-alone transaction.

6. CDS CONTRACTS AND CAPITAL RELIEF

Financial institutions also use CDS contracts for the purpose of obtaining capital relief. The role that CDS contracts play in diversification was originally seen as a benefit of CDS contracts. They make it possible for a bank to better service a large borrower, because it can off-load a stressed credit line through a CDS. Moreover, the sellers of protection can obtain a more diversified exposure through the CDS contracts. But there is also the concern, addressed by **Yorulmazer (2013)**, that the contracts can be used for a regulatory arbitrage purpose, i.e., to obtain a lowering of regulatory risk weights that does not reflect truly lower risk. **Shan, Tang & Yan (2017)** argue that banks that use CDS contracts increase the size of assets, decrease their risk-weighted assets, and obtain a higher return on capital, suggesting that CDS contracts may indeed serve a role in regulatory arbitrage.

The use of CDS for capital relief also suggests (cf. **Yorulmazer 2013**) that CDS contracts can be traded at a price higher than the value derived from the credit protection itself. This hypothesis can be tested in connection with hedging of so-called Credit Value Adjustment (CVA) risk. CVA is an adjustment in mark-to-market value of a derivative security, which takes into account that the counterparty to the contract may default in a state where the derivative has positive market value. Banks face a capital charge against fluctuations in CVA but can get rid of this charge through CDS contracts. **Klingler & Lando (2018)** investigate the hypothesis that sovereign CDS premiums are higher because dealer banks hold large derivatives positions (interest-rate swaps in particular) with sovereign counterparties who do not post collateral, and the banks therefore have an incentive to hedge their CVA risk using sovereign CDS. This can help explain non-negligible CDS premiums on extremely safe sovereigns such as Germany.

7. THE PREMIUM ON SOVEREIGN CDS AND CURRENCY DENOMINATION

Among single-name CDS contracts, sovereign entities are consistently among the most frequently traded. The empirical literature on sovereign CDS premiums is enormous, and readers are again referred to the comprehensive reviews by **Augustin et al. (2014)** and **Culp, van der Merwe & Stärkle (2016)** and to the review by **Howell (2016)** that looks at sovereign CDS and has a particular focus on the European ban on buying naked protection on sovereigns through CDS contracts. The continued issue of very high government debt levels in several Euro areas makes it relevant to point to an important gauge of Euro-area stability that can be obtained from CDS markets. Academics and practitioners have long recognized the so-called quanto effect in sovereign CDS premia, which is the remarkable fact that the CDS premium on a sovereign depends on the currency denomination of the CDS contract. A large discrepancy may be a signal that one currency is expected to crash in connection with the default event of a sovereign. **Ehlers & Schönbucher (2006)** provide the first academic reference I am aware of that discusses this phenomenon, but it has also long been recognized among practitioners, as witnessed, for example, by **J.P. Morgan (2010)**.

If we imagine that deliverable bonds issued by a sovereign issuer will have the same loss rate in default independent of the currency denomination of the bond, it might seem intuitive that the CDS premium should also not depend on the currency of denomination. Loosely speaking, if one is aware that 60 USD are lost per 100 USD of notional on a dollar bond and that 60 Euros are lost on a 100 Euro notional Euro-denominated bond, and the bonds default at exactly the same time, why would one not pay the same in dollars to insure the dollar notional as paid in Euros to insure the Euro notional? The key observation is that Euro-denominated bonds are deliverable into the USD contracts (and vice versa) at the time of the auction and at the exchange rate prevailing at that time, which is, of course, after the default has been declared. If we imagine, for simplicity, that the Euro–USD exchange rate is 1 at initiation and is expected to be 1 at maturity of the CDS, then a 100-USD notional CDS contract will offer the same protection as a 100-Euro CDS on the sovereign. But if the Euro is expected to crash at the time of default and depreciate so that one has to pay 2 Euros for 1 USD, 200 Euros worth of bonds can be delivered into the CDS contract denominated in USD—twice the amount of what can be delivered into the Euro contract. Effectively, the USD offers protection on a larger notional; therefore, the USD premium should be higher. The difference can be used in practice to infer the market's perception of currency crash risk in connection with a default. But it is not that simple, for it can be shown that what is needed for a quanto spread to exist is only a correlation between the default probability of a sovereign and the exchange rate—hence, a currency crash is not the only explanation for the spread. Since correlation between the exchange rate and the default probability of one European sovereign can be influenced by the default of another European country, the problem really calls for a joint modeling of all Euro-area sovereigns, which is not easy to make tractable. I refer readers to **Augustin, Chernov & Song (2020)** and **Lando & Nielsen (2018)** for more on quanto CDS spreads.

8. CONCLUSION

The market for corporate single-name CDS contracts has been declining since the financial crisis, and the decline is a consequence not only of successful compression. The flow of CDS selling that came from synthetic securitizations has almost disappeared, but there are still important reasons to believe that both single-name and index CDS contracts will continue to exist. Both types of contracts are used as benchmarks and acknowledged for capital relief purposes in financial regulation. Also, there is considerable demand for synthetic credit exposure through indexes, and this demand spills over to single-name contracts, which are needed to replicate the index. Mandated trading through central counterparties and SEFs is an important area of current research that brings new evidence for how transitions from opaque OTC markets into more transparent platforms affect trading activity, liquidity, and trading costs.

DISCLOSURE STATEMENT

D.L. was chairman of the board of the Danish Financial Supervisory Authority while writing this article.

ACKNOWLEDGMENTS

I thank Zhuolu Gao for excellent research assistance. I also acknowledge conversations with Fabrice Tourre and Søren Bundgaard Brøgger. Support from the Center for Financial Frictions (FRIC), grant number DNRF 102, is gratefully acknowledged.

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