Safe-Haven CDS Premia

Sven Klingler

David Lando*

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* Both authors are at the Department of Finance, Copenhagen Business School, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark (e-mails: sk.fi@cbs.dk and dl.fi@cbs.dk). We are grateful to Jesper Lund, Martin Oehmke, Lasse Pedersen, Martin Scheicher, Suresh Sundaresan, Matti Suominen, Davide Tomio, and participants in Advanced Topics in Asset Pricing at Columbia University, 21st Annual Meeting of the German Finance Association, Arne Ryde Workshop, Banco Portugal, ESSEC, and European Finance Association (2015) for helpful comments. We acknowledge support from the Danish Social Science Research Council and through our affiliation with the Center for Financial Frictions (FRIC), grant no. DNRF102 from the Danish National Research Foundation.

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Abstract

We argue that Credit Default Swap (CDS) premia for safe-haven sovereigns, like Germany and the United States, are driven to a large extent by regulatory requirements under which derivatives dealing banks have an incentive to buy CDS to hedge counterparty credit risk of their counterparties. We explain the mechanics of the regulatory requirements and develop a model in which derivatives dealers, who have a derivatives exposure with sovereigns, need CDS for capital relief. End users without exposure to the sovereigns sell the CDS and require a positive premium to compensate for the use of margin capital. The model's predictions are confirmed using data on several sovereigns.

CDS premia, Capital charges, Government Bonds; **JEL:** F34, G12, G15

1 Introduction

Credit Default Swap (CDS) premia are important indicators of the credit quality of most bond issuers. They are in fact often viewed as a cleaner measure of credit quality than the yield spreads observed on the underlying bonds themselves. This is in part because bonds are thought of as carrying higher illiquidity premia and because a larger amount of capital is required for arbitrageurs who wish to have a certain credit exposure using corporate bonds instead of CDS. But even if bond spreads and CDS premia do not measure credit risk only, they are expected to be positively related – both responding with increasing spreads when the credit quality of the underlying issuer deteriorates. CDS contracts on very high-rated sovereign issuers are a striking exception to this rule. Panel A of Figure 1 shows the time series of German five-year CDS premia and yield spreads. The two variables do not only differ in levels, they also move in opposite directions. Panel B shows scatter plots of the time series from Panel A and contrasts the behaviour of German spreads with the behaviour of French and Italian spreads both of which display the standard pattern of CDS premia and yield spreads which are typically positively correlated.

Bonds issued by high-rated sovereigns, such as Germany and the United States, are considered as both safe and liquid assets. For these reasons and especially during times of financial distress, these bonds provide a safe haven for investors and their yield spreads diminish. If we think that credit risk of safe haven bonds remains vanishingly small even during periods of market-wide distress, it is surprising that there is such a large market for CDS contracts on safe sovereigns, and that the premia behave so markedly different from bond spreads.

We argue in this paper that financial regulation is responsible for a large share of the demand for CDS on safe havens. More precisely, derivatives-dealing banks engage in OTC derivatives, such as interest rate swaps, with sovereigns. Most sovereigns do not post collateral in these transactions, which leaves the derivatives dealer exposed to counterparty-credit risk. Regulators measure the counterparty-credit risk using the sovereign's CDS premium. The risk either adds to the dealers' risk-weighted assets (RWAs) or can be hedged using CDS on the sovereign. Further, we argue that selling CDS, even on a supposedly risk-free entity, is not cost-free. The seller of the CDS is still required to use a share of his own capital to provide the initial margin. To compensate him for using his capital, the seller requires a positive CDS premium. If capital constraints are binding, for instance in times of financial distress, the seller requires a higher premium.

We start our analysis by incorporating these arguments into a simple one period model in which heterogeneous agents face different margin constraints. The constraints in the model are similar to those considered in, among others, Gromb and Vayanos (2002), Ashcraft, Gârleanu, and Pedersen (2011), and Gârleanu and Pedersen (2011). There are two constrained agents in our model. The first agent is a derivatives-dealing bank who is engaged in a derivatives transaction with a sovereign. Due to regulatory requirements, this derivatives transaction adds to the banks's RWA, thereby lowering its capital available for other investments. To free up capital, the bank can buy CDS on the sovereign. For simplicity and in order to characterize a premium that is independent of credit risk, we assume that there is no default risk associated with the sovereign. In our model, the only reason for buying the CDS is regulatory requirements. The CDS premia we compute for the default-free case would also enter into CDS premia of a credit risky sovereign provided that this sovereign has entered into a uncollateralized derivatives transaction with dealer banks. The second agent is an end user of derivatives, who has no exposure to the risk-free sovereign and acts as seller of credit protection. He weighs the benefit of receiving the CDS premium against the cost of having to invest less in the risky asset. In addition to the two constrained agents there is a third, unconstrained and more risk-averse, agent. This agent does not face a margin constraint and it ensures an equilibrium in the market for the risky asset. It is important that both the bank's and the end user's margin constraints are binding and that trading the CDS requires capital. The bank is willing to pay a premium for freeing up capital to increase its investment in the risky asset. The end user demands a premium for selling CDS protection because doing so reduces his room for investing in the risky asset. Hence, even if the seller of the CDS receives a premium with no risk of having to actually cover a default loss, the further constraint on his binding margin constraint is costly.

To confirm the underlying assumptions of our theory, we discuss the market for safe-haven CDS and practical issues with the new regulatory requirements. First, we show that the market for safe-haven CDS is large relative to other single-name CDS markets, but that only a small fraction of the sovereign bonds is insured by CDS. Afterwards, we show that derivatives dealers are net buyers of sovereign CDS. We then use data from Germany's interest rate swap holdings to provide sample calculations based on the new regulatory requirements. These calculations confirm that it is always preferable for the dealer bank to buy CDS to free up regulatory capital. Putting the resulting notional from our sample calculation in relation with the CDS volumes outstanding, we find that the CDS demand due to Basel III can account for more than 50% of the whole sovereign CDS volume outstanding, a number that is in line with industry research letters. We also discuss practical issues regarding Basel III, the implementation of the new regulations in regional law, and hedging practices of major derivatives-dealing banks.

To test our model results, we extend and formalize our analysis of the anomaly exhibited in Figure 1, using data on three risky European sovereigns (Italy, Portugal, and Spain), three less-risky European sovereigns (Austria, Finland, and France) and the largest four safe sovereigns (Germany, Great Britain, Japan, and the United States). In theory, bond yields should be driven by the risk-free interest rate and the credit risk of the bond issuer. While this relationship clearly holds for the risky and less-risky sovereigns in our sample, it does not hold for most of the safe sovereigns. For Germany, Japan, and the United States CDS premia are not a significant explanatory variable for bond yields. For Great Britain the CDS premium is significant, but only at a 10% level.

One could argue that the credit risk premium in safe-haven bond yields might increase during times of financial distress, but is simply offset by the convenience benefit of holding safe and liquid assets. This is not a likely explanation because CDS premia on safe government bonds are simply too large to be explained by credit risk only. To illustrate this point, we compare a proxy for the convenience yield of German government bonds with the 5-year CDS premium in Figure 2. The figure shows that the convenience benefit of holding German government bonds is not high enough to offset the credit risk implied by the CDS contract. We conclude our empirical analysis by formalizing this argument. We include a proxy for the convenience yield of safe haven bonds in our regression analysis and find that including this variable does not change the results of our analysis significantly.

Finally, we test whether proxies for regulatory capital are capable of explaining CDS premia. We find that for the risky sovereigns, Italy, Portugal, and Spain, CDS premia are mainly drive by credit risk. For the low-risk sovereigns Austria, Finland, and France, we find that both credit and regulatory capital proxies have strong explanatory power for CDS premia. Therefore, our theory does not only apply to safe-haven sovereigns but extends to entities with a low credit risk. For the safe havens Germany, UK, Japan, and the US, we find that regulatory proxies are significant and can explain up to 33% of the variation in CDS premia.

Related Literature

In theory, the anomaly in Figure 1 could not occur in a frictionless market where an increase in the CDS premium would also increase the corresponding bond yield. More precisely, the CDS premium and bond yield spread should be equal due to an arbitrage relationship. Hence, our article is related to the growing literature on the limits of arbitrage, as introduced by Shleifer and Vishny (1997) and studied by Gromb and Vayanos (2002) for the case when arbitrageurs need to collateralize their positions. Gromb and Vayanos (2010) survey the literature on limits of arbitrage and summarize the basic idea in these models. An exogenous demand shock for a certain asset occurs to outside investors and arbitrageurs, who both are utility-maximizing and constrained, and take advantage of the shock by providing the asset. The demand in our model is a demand for capital relief. In that sense, our article is related to Yorulmazer (2013).

The difference between the CDS premium and the yield spread is commonly referred to as the CDS-bond basis and there is a large strand of literature aiming to explain this basis. Empirically, the CDS-bond basis has been studied for corporates by, among others, Longstaff, Mithal, and Neis (2005) and Bai and Collin-Dufresne (2013). Fontana and Scheicher (2014), Gyntelberg, Hördahl, Ters, and Urban (2013), and O'Kane (2012) analyze the CDS-bond basis for European sovereigns. Our empirical analysis complements this strand of literature by showing that there is not only a CDS-bond basis for safe government bonds, rather CDS premia and yield spreads are completely unrelated. This result is related to the literature on the drivers of sovereign CDS premia. Previous studies like, Pan and Singleton (2008), Longstaff, Pan, Pedersen, and Singleton (2011), and Ang and Longstaff (2013) analyze sovereign CDS premia and explain them by global investors' risk appetite and systemic risk. While investors' risk appetite explains why risky sovereign CDS increase in times of market distress this explanation fails to explain why safe sovereign CDS increase at the same time. Our model gives an alternative explanation why safe sovereign CDS increase in times of market distress.

The remainder of this article is organized as follows. We provide an overview of the market for sovereign CDS and the new regulatory requirements in Section 2. In Section 3, we develop a model that is capable of explaining positive CDS premia, even for risk-free underlyings. We then provide further details on the new regulatory requirements in Section 4.1. We provide empirical evidence for our theory in Section 5. Section 6 concludes.

2 Stylized Facts and Institutional Background

Table 1 provides an overview of the CDS and bond volumes outstanding for 10 of the worlds largest sovereigns. We consider 4 of these 10 sovereigns as safe havens (Germany, Great Britain, Japan, and the United States). The sovereigns in Table 1 are ranked by CDS notional outstanding. The ranking is relative to all single-name CDS, including corporates and financials. Table 1 shows that the market for safe-haven CDS is a large, relative to other single-name CDS markets. It also shows that only a small fraction of the sovereign debt is insured using CDS. According to the ranking, CDS on Germany have the third highest net notional outstanding, followed by Japan on place 6, Great Britain on place 13, and the United States on place 32.

Figure 6 shows that from 2010 on, derivatives dealers are net buyers of sovereign CDS. This is interesting because in most other markets derivatives dealers act as net sellers of CDS contracts.[1] This observation is in line with concerns from the financial industry that there are no natural sellers of sovereign CDS.[2]

[1] Unfortunately, there is no information for the buyers and sellers of individual sovereigns available. Hence, we cannot claim that the variation of the notional amount of sovereign CDS bought by dealers can only be traced to financial regulation. It is also possible that, especially during the European debt crisis, the end-users' demand for CDS on risky sovereigns increased.

[2] See, for instance, US treasury borrowing and advisory committee report, May 2010 http://www.treasury.gov/resource-center/data-chart-center/quarterly-refunding/Documents/dc-2010-q2.pdf.

2.1 The Regulatory Framework

A significant part of large dealer banks' exposure to sovereign entities comes from interest rate swaps and other over-the-counter (OTC) derivative positions. Unlike financial entities, most sovereigns do not post collateral in OTC derivatives positions and this leaves dealer banks exposed to counterparty credit risk. The current regulatory regime, referred to in short as Basel III (see Basel Committee on Banking Supervision (2011)), contains a charge related to this counterparty credit risk. In essence, an uncollateralized OTC exposure, which is not hedged using CDS contracts, adds to a bank's risk-weighted assets. The size of the addition depends on a so-called CVA VaR measure which measures potential fluctuations in the value of the OTC exposure that are due to fluctuations in the credit risk of the counterparty.

We now explain the notions of CVA, CVA VaR and the implications for risk-weighted assets in more detail. This will be useful both for an important parameter choice in our model and for estimating the size of the demand for CDS contracts that might be driven by banks seeking reduction in CVA VaR-based regulatory capital requirements.

Banks were already required to account for the credit risk of their derivatives counterparties in their valuation of derivatives positions before the default of Lehman Brothers. To adjust the value of a derivative position the banks would compute the so-called Credit Value Adjustment (CVA), which measures the difference between the value of a derivative with a risk-free counterparty and a derivative with a credit-risky counterparty. Motivated by the large losses in values of derivatives positions that arose from deteriorating credit quality of counterparties during the crisis, Basel III introduced a capital charge to increase the banks' robustness to such losses. The Basel Committe defines CVA (see Basel Committee on Banking Supervision (2011), page 31) as follows:

$$\mathrm{CVA} = \mathrm{LGD} \sum_{i=1}^{T} \mathbb{Q}(\tau \in (t_{i-1}, t_i))\mathrm{EE}(t_{i-1}, t_i). \tag{1}$$

We have introduced τ as the default time of the counterparty, and we use $\mathbb{Q}$ to emphasize the fact that probability of default of the counterparty in the time interval is computed using CDS implied default probabilities, i.e., risk-neutral probabilities. Intuitively, the formula computes the loss of value in a derivatives position by summing up the value of potential losses in a series of time intervals representing all future revaluation dates until maturity of the derivative at time T. For each revaluation date, the value of the potential credit loss is computed as a product of loss given default (LGD), the probability that a default occurs in the time interval, and the expected exposure (EE). The exposure is positive if the derivative has positive value to the bank and zero otherwise. The exposure for the period (t_{i-1}, t_i), $\mathrm{EE}(t_{i-1}, t_i)$, is computed as an average of discounted exposure at time t_{i-1} and discounted exposure at time t_i. The exposure calculation captures the fact, that the bank will owe a defaulting counterparty the full value of the derivatives position if the position has positive value to the counterparty, whereas the bank will only recover a fraction of the value of the position if it has a positive value to the bank. We give an example of how to compute this exposure in Section 4.1. In Basel Committee on Banking Supervision (2011), the probability of default is defined as

$$\mathbb{Q}(\tau \in (t_{i-1}, t_i)) = \max\left[0, \left(\exp\left(-\frac{s_{i-1}t_{i-1}}{\mathrm{LGD}}\right) - \exp\left(-\frac{s_i t_i}{\mathrm{LGD}}\right)\right)\right],$$

where s_i is the CDS premium on the counterparty for a CDS with maturity date i. The maximum will ensure non-negative default probabilities. It is irrelevant for our computations where we use a constant CDS premium based on the five-year rate.

CVA VaR is a VaR measure which depends on the sensitivity of CVA to changes in the credit risk of the counterparty, i.e., the sensitivity of CVA to changes in the CDS premium. It takes the form:[3]

$$\text{CVA\_VaR} = 3 \times \text{WorstCase} \times \text{CS01}. \tag{2}$$

CS01 represents the sensitivity of CVA towards a one-basis-point change in the CDS premium. To simplify calculations we assume throughout the paper that the CDS term structure is flat and that CS01 measures the risk of a parallel shift. With this assumption, the credit delta CS01 is given as on page 33 of Basel Committee on Banking Supervision (2011):

$$\begin{aligned} \text{CS01} = {} & EE \times 10^{-4} \\ & \times \sum_{i=1}^{T} \left(t_i \exp\left(-\frac{st_i}{LGD}\right) - t_{i-1} \exp\left(-\frac{st_{i-1}}{LGD}\right)\right) \frac{D_{i-1} + D_i}{2}. \end{aligned} \tag{3}$$

WorstCase is given as

$$\textit{annual CDS volatility} \times \sqrt{\frac{10}{252}} \times \Phi^{-1}(0.99). \tag{4}$$

Thus, WorstCase $\times$ CS01 represents a linear approximation of a move in CVA which is not surpassed with a probability of 99% over a 10-trading day period (assuming normally distributed movements of the CDS premium). 3 is a supervisory multiplier, see Gregory (2012).

The exact same type of formula is used to compute a so-called *stressed* CVA VaR in which the maximum annual volatility observed over the last three years is plugged into the WorstCase part instead of the annual volatility computed over the last year. Having computed the CVA in both a normal version and a stressed version, the addition to risk-weighted asset, RWA, is conservatively set to be the sum of the two VaR measures:

$$RWA = 12.5 \times (CVA\ VaR + CVA\ Stressed\ VaR). \tag{5}$$

[3]We follow Gregory (2012), page 390 with this formula. Different banks might use different approaches to compute VaR. A more common way among banks with more than one counterparty would be to use historical simulation to compute the CVA VaR.

In Section 4.1 we will provide a stylized computation of CVA VaR and RWA based on the case of Germany as the counterparty.

The demand for CDS contracts on safe sovereigns is driven by the fact that derivatives dealers are allowed to hedge CVA VaR with CDS contracts which are only 'used for the purpose of mitigating CVA risk' (cf Basel Committee on Banking Supervision (2011), page 34).[4] That is, by entering a CDS with a certain notional, the bank can remove the contribution to RWA that comes from, say, an interest-rate swap contract with a sovereign counterparty. In summary, the bank has the choice between hedging its counterparty exposure using a CDS with a notional amount EE, that is equal to the expected exposure, or having to secure additional equity funding equal to xEE, where x depends on the RWA computed above and the fraction of RWA that the bank needs as equity capital. It is this trade-off that is fundamental to our model in the next section. In Section 4.1 we will approximate the actual need for CDS hedging that could be explained by dealer banks' interest rate swap positions with the German government as counterparty.

3 The Model

We start by analyzing a simple one-period model that focuses on determining the CDS premium. In this model, a bank has an incentive to purchase CDS protection on a riskless entity for capital relief purposes and an end user earns the CDS premium for providing the insurance but also uses trading capital to do so.

[4] A distinct feature of the new regulatory requirements is that 'the sensitivity of CVA to changes in other market factors, such as changes in the value of the reference asset' is not relevant (cf Basel Committee on Banking Supervision (2011), page 34).

3.1 The Assets

We assume that there are three different assets in the economy. First, there is a risky asset in unit supply with price normalized to one. The payoff of the risky asset at time $t = 1$ is given as $\tilde{r}$ and we assume that $\tilde{r}$ is normally distributed with mean $1 + \mu$ and variance σ^2. σ^2 is exogenous, but μ will be determined in equilibrium. Further, the risky asset has a margin requirement m for both buying and short-selling the asset. This means that an agent with initial wealth 1 can at most buy or sell $1/m$ units of the risky asset. Second, there is a risk-free asset which pays off $1 + r$ for each unit invested in it at time 0. We assume that the risk-free asset is in perfectly elastic supply and that r is an exogenously given constant. Third, there is a CDS contract on a risk-free asset with premium s and initial margin n^+ for buying the CDS and n^- for selling the CDS. The notional amount is determined in equilibrium. s, n^+ and n^- are all per unit of insured notional, so the relevant dollar amounts are obtained by multiplying the numbers with the notional amount on the CDS contract. We refer to a long position in the CDS as representing a purchase of insurance.

In order to keep our model simple, we assume that the CDS is written on a default-free underlying. Selling the CDS therefore gives a risk-free premium of s per unit of notional, and this would of course be an arbitrage opportunity if there were no frictions. The goal is to characterize an additional premium unrelated to credit risk of the reference security that a bank is willing to pay for capital relief purposes. We note that the assumption of no default risk is highly stylized, but not completely unrealistic. A recent article in Risk magazine[5] points out that derivatives dealers buy CDS protection for CVA hedging, even if they never pay off.

Despite the riskless nature of the reference entity, agents still have to post initial margin. This is in line with real-world margin requirements which exist

[5] Carver (2011), 'CVA desks to keep buying sovereign CDSs – even if they never pay out'

even for the least risky sovereigns. Selling CDS requires a margin that depends on the risk of the underlying plus a short-selling margin. The risk of the underlying is computed as a Value-at-Risk number, considering the past volatility. The short charge is to mitigate the risk of a joint default of the protection seller and the underlying entity.[6] The margin requirement can be thought of in the spirit of in Brunnermeier and Pedersen (2009), as being set by a different agent, like a regulator or Central Clearing Counterparty, who has a different information set than the agents in our model and who worry about tail risk events.

3.2 The Agents and Their Constraints

We assume that there are three agents. A risk averse agent A, a derivatives-dealing bank B, and an end-user of derivatives E. Agent $i \in \{A, B, E\}$ has a negative exponential utility, i.e. $u(W) = -\exp(-\gamma^i W)$ and initial wealth W_0^i. Each agent maximizes his expected utility of time-one wealth:

$$\max_{g,\bar{g}} \mathbb{E}[u(W_1^i)]$$
$$W_1^i = W_0^i(1+r) + g(\tilde{r} - r) - \bar{g}s,$$

where $g \in \{a, b, e\}$ denotes the dollar amount of wealth invested in the risky asset for each agent type, and $\bar{g} \in \{\bar{a}, \bar{b}, \bar{e}\}$ denotes the notional amount insured by the CDS for each agent type. So, for example, $\bar{b}$ refers to the dollar amount on which the bank has bought protection (if $\bar{b}$ is positive) or sold protection (if $\bar{b}$ is negative). Due to the exponential utility specification and the normality of returns, the problem reduces to the following mean-variance optimization:

$$\max_{g,\bar{g}} \left[g(\mu - r) - \bar{g}s - \frac{\gamma^i}{2}(\sigma g)^2 \right].$$

All agents maximize an expected utility of this form. Agent B and E are assumed to have the same risk aversion $\gamma^B = \gamma^E = 1$ and we denote agent A's risk-aversion by $\gamma := \gamma^A > 1$.

[6] See Duffie, Scheicher, and Vuillemey (2014) for further details.

The constraints of the agents differ. We assume throughout that the amount of wealth required to establish a position in the risky asset g is the same for long and short positions and given by $m|g|$. The wealth requirement for establishing a CDS position $\bar{g}$ depends on whether it is long or short and is given by $n^{+}\bar{g}$ if g is positive (buying protection) and $n^{-}|\bar{g}|$ if $\bar{g}$ is negative (selling protection). We now describe the constraints of the agents and state the main result describing the equilibrium CDS premium.

The End User

We think of the agent as having to deposit the amount of cash in a margin account where it earns the risk-free rate r. Hence, the maximum amount that the agent can invest in the risky asset is $\frac{W_0^E}{m}$, but this would rule out taking a position in the CDS market. Any non-zero position in the CDS contract will reduce the degree to which the agent can make a levered investment in the risky asset. Note that the end-user will take only long positions in the risky asset. Further, since we assume that the CDS never pays off to the protection buyer, the end-user will only consider selling the CDS in order to earn the CDS premium s. Therefore, the end-user's margin constraint can be written as

$$me - n^{-}\bar{e} \leq W_0^E. \tag{6}$$

The Bank

The only difference between the bank and the end user is that the bank has a different margin constraint. Motivated by the Basel III requirements, we assume that the bank has an interest rate swap with the safe reference entity of the CDS outstanding. This position adds to the risk-weighted assets of the bank and it reduces the bank's ability to lever its risky asset or take positions in the CDS market. As explained above, the contribution to risk-weighted assets depends in a complicated fashion on the expected exposure EE of the interest rate swap and it corresponds to reducing the initial amount of wealth that can be invested in the risky asset and the CDS by xEE, where $x > 0$ is a parameter that depends on the historical volatility of the CDS premium. The bank can free up capital by buying CDS, and buying a CDS with a notional equal to EE removes the effect of the capital charge entirely. This removal may be worth paying a positive CDS premium for, even without the possibility of a future payoff. The bank will not gain any capital relief from buying protection on a larger notional than EE. Rather than representing this as a kink in the margin constraint, we add to our optimization problem the constraint $\bar{b} \leq EE$.

In equilibrium, the bank must be long the risky asset. The bank must also have a non-negative position in the CDS market, since the only other agent involved in the CDS market is the end-user who will never want to buy protection but sometimes may want to sell. The bank's margin constraint can therefore be written as

$$mb + n^{+}\bar{b} \leq W_0^B - x(EE - \bar{b}). \tag{7}$$

The Risk-Averse Agent

We assume that the risk-averse agent's wealth is high such that he does not face any kind of funding constraint. His constraint is that he cannot invest in the CDS contract which implies $\bar{a} = 0$. Solving his mean-variance optimization problem is straightforward and gives

$$a = \frac{\mu - r}{\gamma\sigma^2}. \tag{8}$$

3.3 Equlibrium

We define an equilibrium in our model setup as follows.

Definition 1. *In the market described above, equilibrium is defined such that* *(i) Agents are maximizing expected utility*

$$\max_{g,\bar{g}} \mathbb{E}[u(W_1^i)]$$
$$W_1^i = W_0^i(1+r) + g(\tilde{r} - r) - \bar{g}s,$$

where the end user and the bank face the constraints (6) and (7), respectively, and the risk averse agent is unconstrained.

(ii) The market for the risky asset and the CDS clear:

$$a + b + e = 1 \tag{9}$$
$$\bar{b} + \bar{e} = 0. \tag{10}$$

With this definition at hand we are now able to state the solution of the model.

Theorem 1. *Let*

$$s^b = \frac{x - n^+}{m}\gamma\sigma^2 \left(1 - \frac{1}{m}\left(W_0^E - n^- EE\right) - \frac{1+\gamma}{\gamma}\frac{1}{m}\left(W_0^B - n^+ EE\right)\right) \tag{11}$$
$$s^e = \frac{n^-}{m}\gamma\sigma^2 \left(1 - \frac{1+\gamma}{\gamma}\frac{1}{m}\left(W_0^E - n^- EE\right) - \frac{1}{m}\left(W_0^B - n^+ EE\right)\right). \tag{12}$$

(i) If $0 < s^e < s^b$, then s^e is the unique strictly positive equilibrium CDS premium. In equilibrium, the bank buys protection from the end user on its entire expected exposure EE.

(ii) The excess return on the risky asset is given as

$$\mu - r = \gamma\sigma^2 \left(1 - \frac{1}{m}\left(W_0^E - n^- EE\right) - \frac{1}{m}\left(W_0^B - n^+ EE\right)\right). \tag{13}$$

The proof of Theorem 1 can be found in Appendix B. We close this section by showing that the equilibrium condition $0 < s^e < s^b$ is fulfilled under mild parameter assumptions. Assume for simplicity that $W_0^E = W_0^B$ and $n := n^+ = n^-$.

Then comparing Equations (12) and (11) shows that the equilibrium condition is satisfied if

$$x > 2n.$$

A conservative estimate for the initial margin posted in a safe-haven sovereign CDS would be $n = 5\%$. Therefore, $x > 0.1$ is a sufficient condition for the equilibrium condition to be fulfilled. We provide CVA VaR sample calculations in Section 4.1, showing that $x > 0.1$ is typically fulfilled throughout the sample period.

Discussion of the Model Implications

To interpret our results in Theorem 1, we first note that the equilibrium CDS premium can also be written in terms of the expected excess return:

$$s^e = \frac{n^-}{m}\left((\mu - r) - \frac{\sigma^2}{m}\left(W_0^E - n^- EE\right)\right). \tag{14}$$

Keeping the expected excess return fixed, we can immediately draw the following conclusions from Equation (14). First, an increasing expected exposure (EE) on the bank's swap position, which, in equilibrium, increases the demand for CDS protection, increases the premium. Second, a higher margin requirement for selling the CDS (i.e. a higher n^-), increases the CDS premium. However, it is important to keep in mind that the expression for the equilibrium CDS premium only holds if $s^e < s^b$. Therefore, if margin requirements become too high, this may cause a decreasing demand for CDS protection by the bank and therefore a lower CDS premium. Third, a higher initial wealth of the end user decreases the CDS premium. This is intuitive because a higher initial wealth implies that the end-user is less constrained and therefore more willing to supply CDS. Finally, a higher excess return implies a higher CDS premium. Therefore, our theory provides an alternative explanation for why stock returns are important in explaining changes in CDS premia.

Assuming that the expected excess return is fixed, Equation (14) implies that, a higher volatility of the risky asset decreases the CDS premium. This is because investments in the risky asset become less attractive as the volatility increases. In equilibrium, however, the volatility of the risky asset directly affects expected excess returns. Therefore, to better understand the effects of the other variables we need to note that changes in the model parameters also affect the equilibrium expected excess return. Using Equation (12) we can draw the following conclusions. First, higher risk aversion γ of the risk averse agent (who does not participate in the market for CDS) increases the CDS premium. Similarly, a higher volatility σ of the risky asset increases the CDS premium. These effects come from the relationship between expected excess returns and the parameters γ and σ. As is evident from Equation (13) these parameters increase the expected excess return.

Finally, we have three more variables that affect the equilibrium CDS premium through expected excess returns. These are changes in margin requirements for buying the CDS (i.e. a higher n^+), changes in the initial wealth of the bank, and changes in the initial margin for the risky asset. Assuming that $s^e < s^b$ is still fulfilled, an increase in the margin requirement for buying the CDS or a decrease in the bank's wealth decrease his investment in the risky asset. Therefore, equilibrium expected excess returns increase such that the demand for the risky asset by the other agents increases and markets clear. In turn, a higher excess return increases the CDS premium. Similarly, a higher margin requirement for buying the risky asset implies that the constrained agents can invest less money in the risky asset. Therefore, expected excess returns need to increase such that the risk-averse agent demands more of the risky asset.

3.4 Equilibrium with Credit Risk

In this section, we study how our model predictions change if the underlying entity can default with positive probability pd and illustrate the results in a numerical example. We assume that with probability $1-pd$, the underlying does not default and the protection buyer pays the CDS premium s to the protection seller. Further, with probability pd the underlying sovereign defaults and the protection buyer does not pay the CDS premium but receives an amount equal to the Loss Given Default (LGD) from the protection seller. As before, our goal is to characterize an addition to the CDS premium that comes from the demand for freeing regulatory capital and from funding constraints for selling CDS. In the following, we discuss two possible model specifications to incorporate credit risk.

In the first case, we assume that the agents are risk-neutral towards trading CDS. The idea behind this assumption is that the default-risky part of the CDS can be hedged at no cost and that pd corresponds to the risk-neutral default probability. Under this assumption agent $g \in \{b, e\}$ maximizes:

$$\max_{g,\bar{g}} \left[g(\mu - r - \sigma^2/2e) + \bar{g}((1-pd)s - pdLGD) \right],$$

subject to his respective constraints. The benefit of this specification is twofold. First, without binding constraints the CDS premium is given as $s = pdLGD$, the frictionless CDS premium. Second, the model can be solved similar to our baseline model. Replacing s with $(1-pd)s + pdLGD$ in the proof of Theorem 1 and afterwards solving for s gives the equilibrium CDS premium s^e and the upper boundary for the CDS premium up to which the bank demands CDS to free all its regulatory capital:

$$s^e = \frac{1}{1-pd}\left(\frac{n^-}{m}\gamma\sigma^2\left(1 - \frac{1+\gamma}{\gamma}\frac{1}{m}\left(W_0^E - n^-EE\right) - \frac{1}{m}\left(W_0^B - n^+EE\right) + pdLGD\right)\right)$$

$$s^b = \frac{1}{1-pd}\left(\frac{x-n^+}{m}\gamma\sigma^2\left(1 - \frac{1}{m}\left(W_0^E - n^-EE\right) - \frac{1+\gamma}{\gamma m}\left(W_0^B - n^+EE\right) + pdLGD\right)\right).$$

Analogue to the discussion in Section , if we assume $n^+ = n^-$ and $W_0^B = W_0^E$, the bank buys full protection if $x > 2n$. We provide sample calculations for 10 different sovereigns in Section 4.1.

In the second case we drop the assumption that agents are risk-neutral towards trading the CDS. In this case agent $g \in \{b, e\}$ is maximizing:

$$e^{-g(\mu - r - \sigma^2/2g)}(pde^{-\bar{g}LGD} + (1 - pd)e^{\bar{g}s}),$$

subject to his respective constraints. The problem with this set-up is that $s > pdLGD$ even if the end-user's margin constraint does not bind. Phrased differently, even without binding constraints the CDS premium is above the frictionless CDS premium. Therefore, we would need to formally distinguish between the risk-neutral default probability and the physical default probability. Further, this utility function does not lead to analytical tractable results. Instead of formally addressing these issues we present a numerical example and show that both model specifications lead to qualitatively similar results.

Numerical Example

We illustrate the results making the following parameter choices. First, we assume that agent A's risk-aversion is $\gamma = 5$, which is five times higher that the risk-aversion of the other two agents. The initial wealth of bank and end-use are set to $W_0^B = W_0^E = 0.2$ to obtain binding margin constraints. Second, trading the risky asset requires an initial margin of $m = 0.5$ and both buying and selling the CDS requires an initial margin of $n^+ = n^- = 0.05$. The choice of margin requirement is motivated by (Gârleanu and Pedersen 2011)), who assume a margin-requirement of 5% for investment-grade CDS. The high value for m captures the fact that trading the risky asset requires significant capital relative to trading the safe-haven CDS. Third, the default probability of the sovereign is $pd = 0.75\%$ with $LGD = 0.6$ which corresponds to a 'frictionless' CDS premium of 45 basis points, which is approximately the average German CDS premium in our sample period. Fourth, the bank either faces an addition to its risk-weighted assets of $xEE = 0.06$

with $x = 0.15$ and $EE = 0.4$ or buys CDS to free regulatory capital. Our choice of x is justified in Section 4.1, where we perform sample CVA VaR calculations for different sovereigns. EE is chosen as a large number relative to the bank's and end-user's wealth for illustrative purposes. Finally, the standard deviation of the risky asset is given as $\sigma = 0.2$, which is approximately the long-term mean of the S&P 500 implied volatility index VIX. The expected excess return is set to $\mu - r = 0.056$, which is the equilibrium excess return if the bank buys $\bar{b} = EE$ CDS for capital relief.

In this numerical example, the bank faces an addition of 0.06 to its RWAs due to its IRS position with the sovereign. Buying CDS to free this regulatory capital requires an initial margin of 0.02 which means that the bank can free 0.04 margin capital by doing so. In the risk-neutral specification, the upper bound on the CDS premium that the bank is willing to pay in order to free this capital is $s^b = 129$ basis points and the equilibrium CDS premium is $s^e = 87$ basis points.

We plot the supply $-\bar{e}$ and demand $\bar{b}$ for CDS as a function of the CDS premium in Figure 3 for the two model specifications. Note first that, without frictions, a CDS premium different from 45 basis points would be an arbitrage opportunity. However, both buying and selling CDS requires an initial margin and agents are constraint. Therefore, the equilibrium CDS premium differs from the no-arbitrage CDS premium. The end-user only starts purchasing CDS for $s < 5$ basis points and starts selling CDS for $s > 86$ basis points. The difference between the risk-neutral and risk-averse specification is that the CDS supply by the end user increases (decreases) at a lower rate as the CDS premium increases (decreases). In the risk-neutral specification, the bank demands CDS to free all its regulatory capital until $s > s^b$ while the upper boundary in the risk-averse specification is slightly lower.

We highlight three different equilibria in Figure 3. First, at (i), supply and demand of risk-neutral agents meet. Second, at (ii), supply and demand of risk-averse agents meet. Note that the CDS premium in this equilibrium is higher than in the risk-neutral case. This is in line with concerns from the financial industry that a lag of natural CDS sellers can increase the CDS premium. As explained above, the risk-neutral specification can be viewed as a case where agents are sophisticated and able to perfectly hedge the default risk while the risk-averse case corresponds to the situation where the agents actually take on the credit risk. Finally, (iii) marks the equilibrium in a specification without credit risk.

4 Linking CDS volume to CVA Risk

In this section, we use stress test results from the European Banking Authority (EBA) to document that a large share of the sovereign-CDS notional outstanding plausibly can be attributed to CVA hedging. Further, we perform detailed CVA VaR computations using Germany's interest rate swap holdings and explain the option-like feature embedded in the Expected Exposure. Our calculations also support the realism of the important equilibrium condition $s^e < s^b$ of Theorem 1. Finally, we discuss the implementation of the new capital charge into regional law and provide anecdotal evidence that derivatives dealers are already using sovereign CDS to hedge CVA.

4.1 CVA Sample Calculations

According to several industry research notes, a large fraction of the outstanding volume of sovereign CDS contracts is likely to be a consequence of financial regulation. For example, the fraction is estimated to be 25% in Carver (2011) and up to 50% in ICMA (2011). The goal of this section is to verify these numbers and to shed additional light on how CVA VaR affects banks' equity capital. We first use the results from a stress test, conducted by the European Banking Authority (EBA) in 2013, to get a first overview of sovereign OTC derivatives outstanding and the consequences for banks equity capital. Afterwards, we perform detailed sample calculations for the case of Germany.

Overview of Sovereign OTC Derivatives Outstanding

To get a first overview of sovereign OTC derivatives outstanding, we summarize the results of a stress test, conducted by the European Banking Authority (EBA) in 2013 for 10 different sovereigns. These stress tests report European banks' total OTC derivatives exposure towards sovereigns. Exposures of Non-European banks are not reported. The numbers refer to all OTC derivatives that a sovereign or a government-sponsored entity has with a derivatives dealing bank. We report the total notional value and the fair value of all derivatives with positive fair value for banks in columns 1 and 2 of Table 2. Additionally to that, we report the net fair value, computed as the difference between the fair value of all derivatives with positive value for banks and the fair value of all derivatives with negative fair value for banks.

The fair value of all derivatives with positive value for banks can be seen as a first-order approximation of the Expected Exposure. This number gives an indication of how deep the derivatives are in-the-money, without accounting for the option-like feature of Expected Exposure discussed below and without taking netting possibilities into account. The net fair value can be seen as a lower boundary for the Expected Exposure with the true expected exposure being above this number for three reasons. First, in case of a default, the derivatives that have positive value for the banks would decrease in value but the banks are still required to honour their liabilities towards the sovereign. Second, the EBA data only includes exposures that European banks have towards these sovereigns and does not account for exposures that non-European banks have. Third, the expected exposure is above the fair value because of the option-like feature discussed above, i.e. even an IRS which is currently at-the-money can have a positive expected exposure.

Since banks would need to buy CDS protection on a notional amount equal to the expected exposure to hedge their OTC derivatives exposure towards sovereigns, we can now check whether this is a significant portion of all sovereign CDS outstanding. To that end, we report the amount of sovereign CDS outstanding for the respective countries in column 4 of Table 2. Comparing these numbers with the net fair value of derivatives with positive fair value for banks, we see that the regulatory demand for CDS for Germany, Italy, and the United States, is above 50% percent of the total net notional of sovereign CDS outstanding. For the other sovereigns, the regulatory demand is lower than 50% but, as mentioned before, the net fair value is a first-order approximation, likely to understate the true Expected Exposure.

We next compare the CDS premium as of December 2012 for the 10 sovereigns to worst case, which is computed using Equation (4) and the CDS volatility over the past year. As we can see from the table, worst case ranges from approximately 30% of the CDS premium for the UK to almost 100% for Austria. The amount of equity capital that a bank would need to allocate to the CVA risk is reported in column 7 under Capital Requirement. We compute these numbers using the fair value, reported in column 2, as a proxy for the Expected Exposure. We explain how we compute these numbers in detail below, when we run sample calculations for the case of Germany. We next put these capital requirements in relation to the cost of hedging the CVA risk using CDS contracts. To that end, we reported the required margin of a CDS contract with notional value equal to the Expected Exposure in column 8 under CDS margin. We assume an initial margin requirement of 5% for the CDS contract.

Finally, we report $x(s_t)$, defined as the ratio between the CDS margin requirement and the capital requirement, in the last column of Table 2. As we can see the value ranges from lowest value of $x(s_t) = 0.052$ for the US to the highest value of $x(s_t) = 0.821$ for Portugal. If the margin requirement for buying and selling CDS is 5% of the notional amount,[7] the condition for existence of an equilibrium with positive CDS rates in Theorem 1 is that $x > 0.1$, and hence this condition is obviously fulfilled for 6 out of the 10 sovereigns in our sample. Note that an initial margin requirement of 5% is a very conservative approximation for safe sovereigns. Assume that the buyer of protection agrees to pay a CDS premium of 50 basis points over the next 5 years. The worst possible scenario for the protection seller would be that the CDS premium drops to zero and that the protection buyer defaults. In this case, his foregone profit would have been five time 50 basis points, which corresponds to 2.5%. Hence, it is conceivable that the equilibrium condition is fulfilled for most of the other sovereigns too.

Sample Calculations for the Case of Germany

Interest-rate swaps are the by far largest market for OTC derivatives, and it is therefore likely that the bulk of banks' derivatives exposures to sovereigns are in this market. For the case of Germany, we have data on swap-usage of the federal government. This allows us to compute an estimate of the expected exposure of banks to Germany that is related to the swap positions. In addition to the previous section, we explain the option-like feature of the expected exposure and explain every step in estimating the risk-weighted assets in detail.

The Bundesrepublik Deutschland Finanzagentur (Bund) is a government agency in charge of organizing the borrowing and management of Germany's debt. From the Bund, we have obtained data detailing the notional amount of interest-rate swaps in which the Bund is engaged. Table 3 contains the notional amount of the holdings of both payer-and receiver swaps, that are classified as 'capital market swaps' by the Bund.[8] We now use these figures to obtain an estimate of the total

[7]See Section 3.4 for a discussion of this number

[8]These are mainly Euribor swaps. The Bund is also engaged in Eonia swaps. The amounts outstanding for these contracts are not as large as the ones for capital market swaps and we do not report them in the Table.

expected exposure of the dealer banks due to these swaps. Our estimate is based on a relationship between the expected exposure and the value of a swaption, i.e., the right to enter into a swap at a future date. This connection is used for example in Sorensen and Bollier (1994), but it is useful to explain the basic idea in detail here. We refer to Longstaff, Santa-Clara, and Schwartz (2001) for more details on contract terms in swap and swaption contracts.

Let $S(c, r_t, t, T)$ denote the value at date t of a swap contract for the party receiving the fixed payment c per period until maturity T. r_t is a state variable which determines the term structure of interest rates at date t. In a short-rate model, it would just be the instantaneous short rate, but it could be a multidimensional state-variable as well. Let s_t denote the at-market swap rate at date t, i.e., the rate satisfying $S(s_t, r_t, t, T) = 0$. The value at date t of an at-market swap that was entered into at date 0 is then $S(s_0, r_t, t, T)$ and this value is positive precisely when $s_t < s_0$, and we write the exposure of the fixed receiver at date t as $\max(S(s_0, r_t, t, T), 0)$. This is precisely the value at date t of the option to enter into a swap as a fixed receiver at the rate s_0. We therefore approximate the expected exposure at t seen from time 0 using the value of a swaption.

We note that this is only a 'back-of-the-envelope' approximation for three reasons. First, the swaption value is a discounted value under a risk-neutral measure, and this may make it smaller than the expected undiscounted exposure under the physical measure. Second, we approximate the value of the receiver (and the payer option) using one half of the value of a swaption stadlle, i.e., the combination of an option to enter as a fixed receiver and the option to enter as a fixed payer at date t struck at the forward swap rate at date 0, which is the strike rate at which these two options have the same value. One half of the straddle therefore gives us the value of a receiver swap (or a payer swap) struck at the forward swap rate, but of course the swap entered into at date 0 is struck at the at-market rate which might differ from the forward swap rate. Third, we assume the expected exposure as viewed from date t to be constant over (future) revaluation dates and determined by the value at date t, of a 5-into-5 year swaption,i.e., an option which can be exercised in 5 years and which give the right to enter into a 5-year receiver swap.[9]

In sum, we approximate the expected exposure viewed from date t as:

$$EE_t = IRS\ Outstanding_t \times SwaptionValue_t. \quad (15)$$

The quotes in Table 3 refer to at-the-money swaption straddles based on Euribor rates and are obtained from the Bloomberg system. The price of the receiver swaption is half the value of the swaption straddle as explained above. We describe these quotes in more detail in the appendix. The resulting expected exposure is reported in column 6 (under EE) of Table 3.[10]

Next, we use the figures for Germany to compute the amount of equity capital that is required for maintaining the swap positions if no hedging is used. This requires computing the CVA and CVA VaR, and for that we make the following simplifying assumption. We assume a constant LGD of 0.6, a flat CDS term structure based on the premium s of the 5-year contract for Germany, and a constant expected exposure computed using the swaption argument above. We plug these assumptions into Equation 3 to approximate CS01. Note that CS01 captures the sensitivity of the value of the protection leg of a CDS contract to a parallel shift in the term structure of CDS premia. The notional amount is EE and the change is measured per basis point. We next compute historical volatilities of German 5-year CDS premia which allows us to compute both the

[9]This is arguably an overestimation because the expected exposure on a 10-year swap contract typically peaks at 5 years. An alternative would be to use the average of swaptions with 1-9 years to maturity to enter into an IRS with 9-1 years to maturity. We did that as well and found that using this average would reduce the swaption value by 60-120 basis points.

[10]We assume no netting between payer and receiver swaps in this calculation which might result in an overestimation of the expected exposure. However, it is likely that sovereigns do not allow for netting of their IRS positions between different banks to avoid additional exposure to the counterparty.

CVA Var and the stressed CVA Var following Equation (2). The results for CVA, CVA VaR, and stressed CVA VaR are reported in Table 3.

We first observe that the CVA VaR and stressed CVA VaR are typically more than 3 times higher than the CVA itself. The reason for this higher CVA VaR is that additionally to the CDS premium, the historical volatility is also an input parameter. That explains why, despite a lower CDS premium in 2012 relative to 2010, the CVA VaR in 2012 is higher than in 2010. Also, recall that to compute the stressed CVA VaR, we replace the year-end annualized CDS volatility with the maximum volatility over the last three years in Formula (2). As we can see in the column under stressed VaR in Table 3, stressed CVA VaR could be as much as three times higher than the actual VaR.

Given CVA VaR and stressed CVA VaR, the contribution to the banks' RWA is computed using Equation (5). Banks have to maintain a certain percentage of the RWA as equity capital. The exact percentage depends on several factors. There is a general common equity requirement of 7% of RWA, but for systemically important banks this is increased by between 1 and 2.5%. In addition, a countercyclical buffer between 0 and 2.5% may be imposed. We assume in our calculations a required buffer of 10%, and with this assumption the banks' required equity capital is reported under Equity Capital in Table 3. Putting the required equity capital in relation to the expected exposure, gives us a proxy for x. As Table 3 shows, the lowest value for x was 0.093 at the end of 2010. In 2011 it went as high as 0.14 and converged to 0.11 in 2013 and 2014. Hence, if we again assume an initial margin requirement of 5% for both, buying and selling CDS, the equilibrium condition in Theorem 1 is fulfilled for most of the sample calculations.

4.2 CVA Hedging is Done in Practice

The new CVA capital charge is subject to an extensive and still ongoing debate. The CVA capital charge was first announced in October 2010 in the first proposal of the new Basel capital requirements (Basel III) and has given raise to many discussions since. For example, among the most frequently asked questions about Basel III is the question: 'can you confirm inclusion of sovereigns in the CVA charge and ability to use sovereign CDS as hedge', which was answered as follows by the committee in November 2011: 'The Committee confirms that sovereigns are included in the CVA charge, and sovereign CDS is recognized as an eligible hedge.'[11] Hence, the new CVA capital charge applies to sovereigns too. This is an important clarification because other regulatory requirements treat sovereign bonds different from corporate bonds. It is worth noting, that while interest-rate swaps are in general moving towards central clearing, sovereigns have been exempt from this requirement. A recent article in the Financial Times[12] explains that, moving forward, there can also be a tendency for central clearing of OTC derivatives with sovereign counterparties.

Another part of the debate is whether the new CVA capital charge can cause pro cyclical effects. In particular, basing CVA VaR calculations on CDS volatility together with requiring CDS contracts as hedge has caused criticism from the financial industry. For instance, Risk magazine (Carver (2011)) and FT alphaville (Murphy (2012)) commented on this issue, arguing that this combination can create a 'doom loop'. The argument is that a higher CDS volatility causes more demand for CDS contracts which, in turn, fuels the volatility of the CDS contract. In the language of our model, a higher CDS volatility increases x, which in turn increases s^b and can therefore increase the demand for safe-haven CDS. This

[11] See document 'Basel III counterparty credit risk and exposures to central counterparties - Frequently asked questions'.

[12] 'Germany's debt office set for derivatives clearing' – June 4, 2015. See: http://www.ft.com/intl/cms/s/0/c84577c0-0acd-11e5-9df4-00144feabdc0.html.

higher demand further increases the CDS premium. Carver (2011) and Murphy (2012) further explain that the main problem is that there are no natural sellers of sovereign CDS to absorb this demand. Therefore, a small change in the demand for sovereign CDS can have a significant impact on prices. The problem that there are no natural sellers of sovereign CDS has also been discussed by the US treasury borrowing and advisory committee in a report from May 2010.[13] Further, as discussed before, another indicator of the lack of natural sellers of sovereign CDS is the fact that derivatives dealers are in fact net *buyers* of sovereign CDS (Figure 6). This lack of supply combined with the demand for sovereign CDS introduced by regulation can cause distortions in the sovereign CDS market. Carver (2011) conjectures that a disconnect between CDS premia and yield spreads for France in 2011 can be attributed to CVA VaR hedging. As a reason for this she quotes an official of the French debt management office: 'On the demand side [for sovereign CDS] we see mostly two types of players: hedge funds and CVA desks, as they move into line with Basel III. It's possible that some of the dislocation with the cash market is due to legitimate CVA hedging'. This conjecture is exactly in line with our theory. We study the disconnect between bond yields and CDS premia in more detail in Section 5.2.

A problem in studying the effect of the new regulatory requirement on CDS premia is that the new CVA capital charge has not yet been implemented in all regional laws. While Switzerland has implemented it as of 2013, the final rules for the US are still not finished. Further, the European Banking Authority (EBA) decided to grant an exemption from the CVA capital charge for sovereigns. According to Risk magazine ('Europe goes its own way on CVA'), this exemption came as a positive surprise for European banks. For instance, Royal Bank of Scotland stopped reporting the CVA charge for sovereigns which lead to an increase in their equity capital, indicating that they were already incorporating the

[13] See http://www.treasury.gov/resource-center/data-chart-center/quarterly-refunding/Documents/dc-2010-q2.pdf

CVA charge in their capital requirements. However, the exemption is heavily debated (see for instance ft.com 'JP Morgan under pressure in Basel spat', or Risk magazine: 'The CVA helter skelter: European supervisors could quash exemptions') and more recently the EBA has announced to review the exemption (see Risk magazine 'CVA switchback will hit bank capital ratios, EBA says' and EBA document 'Opinion of the European Banking Authority on Credit Valuation Adjustment (CVA)').

Although European banks are exempt from the rule and US banks are not obliged to implement the rules yet, there is strong anecdotal evidence that several major dealers already hedge the new CVA captial charge. Most prominently, Deutsche Bank reported in the first half of 2013 that it 'cut the risk-weighted assets (RWAs) generated by Basel III's capital charge for derivatives counterparty risk – or credit valuation adjustment (CVA) – from €28 billion to €14 billion'.[14] Another example is bank of America who states in its 2012 and 2013 annual reports that 'The Corporation often hedges the counterparty spread risk in CVA with CDS.' Further, Credit Suisse reports in its 2013 annual report an 'advanced CVA [that] covers the risk of mark-to-market losses on the expected counterparty risk arising from changes in a counterparty's credit spreads.' Overall, these examples show that major derivatives dealers already use sovereign CDS to obtain capital relief from the new CVA capital charge.

5 Empirical Evidence

In this Section we first do a regression analysis of the relationship between CDS premia and yield spreads for 10 sovereigns, exploring the questions raised by Figure 1. If CDS premia were a clean measure of credit risk, we would expect that an increase of one basis point in the CDS premium increases the corresponding bond yield by one basis point. A breakdown of this relationship supports our

[14]See Risk magazine: 'Capital or P&L'.

theory, by showing that CDS premia are not a pure measure of credit risk. Afterwards we test whether regulatory proxies are capable of explaining sovereign CDS premia after controlling for credit risk.

5.1 The Data

We study the relationship between CDS premia and bond yield spreads for 10 different sovereigns, using 5-year data based on weekly observations sampled every Wednesday. We study the period from January 2010 to December 2014 and restrict our considerations to sovereigns that have one of the four major currencies, US Dollar, Euro, Japanese Yen, and British Pound.[15] We further restrict our considerations to the 7 Eurozone countries with the most frequent quotes for both CDS premium and yield spread. The reason for starting our analysis in 2010 is that the new regulatory requirements were first announced in 2010. The 5-year sovereign CDS data are obtained from Markit. The CDS premium for the United States is denominated in Euro, all other CDS premia are denominated in US Dollar. We use the Bloomberg system to obtain 5-year bond yields and corresponding risk-free rate proxies. Bloomberg uses the most recent issue of the 5-year benchmark bond to compute the yield. If there is no benchmark bond with matching maturity available, no yields are reported. As a proxy for the risk-free rate, we use 5-year swap rates based on overnight lending. In these contracts one party pays a periodic floating rate based on the overnight lending rate and in return receives a fixed rate which is denoted the swap rate. We describe these rates (as well as all other data in this article) in more detail in the data appendix.

[15]We chose to focus on the four major safe-haven currencies for practical reasons. For instance, CDS contracts on Switzerland and Singapore are not among the top 1,000 DTCC most actively traded contracts and quotes exist only infrequently.

5.2 Credit Risk in Bond Yields

To test whether the credit risk in government bonds is reflected by CDS premia we run a regression of the following type:

$$\Delta Yield_t = \alpha + \beta^{CDS} \Delta CDS_t + \beta^{rf} \Delta rf_t + \varepsilon_t, \tag{16}$$

where $Yield_t$ denotes the bond yield, CDS_t the corresponding CDS premium, and rf_t the corresponding risk-free rate proxy. Using this specification instead of directly comparing yield spreads and CDS premia has the advantage that we can also check whether our proxy for the risk-free rate is reasonable and reflected in the bond yield. As explained above, in a frictionless world a one-basis-point change in the CDS premium or the risk-free rate should increase the bond yield by one basis point.

To get an overview of the results, we first sort the 10 sovereigns by their estimate for β^{CDS} from small to large. We then plot the parameter estimates and the 95% confidence interval for the estimates (corresponding to two standard deviations) in Figure 5. Panel (a) shows the estimates for β^{CDS} for the 10 sovereigns. As can seen from the figure, the sorting according to β^{CDS} also corresponds to our intuitive sorting. The relationship between bond yields and CDS premia for the safe-haven sovereigns Japan, US, Germany, and UK is lowest. In particular, none of the parameter estimates is significantly different from zero at a 5% confidence level. Then, β^{CDS} for Finland, France, and Austria, which we refer to as 'low-risk' sovereigns, is significantly different from zero but still well below one and below the estimate for the risky sovereigns, Italy, Spain, and Portugal. On the other hand, the estimates for β^{rf}, reported in panel (b), are all significantly different from zero (at a 5% confidence level) and are close to one. Notably, with the exception of Japan, Germany, and Finland, none of the estimates is significantly different from one at the 95% confidence level.

The Convenience Yield of Safe Havens

An alternative explanation for why the CDS premium is an insignificant variable for safe-haven bonds is that the CDS premium could be an accurate measure of credit risk but there are omitted variables like other financial frictions which we did not account for in Equation (16). What qualifies an asset as safe haven is its safety and liquidity. Hence, illiquidity of the bond is not a relevant friction in this context. On the contrary, safe-haven bonds typically carry a 'convenience yield' or 'liquidity premium', meaning that investors are willing to accept a lower yield for the convenience of holding a safe and liquid asset.

We start by discussing the convenience yield argument for the case of German government bonds. Due to implicit and explicit guarantees for German banks during the financial crisis and due to its responsibilities in the Eurozone it is reasonable to argue that German government bonds are not entirely free of credit risk. At the same time German government bonds are arguably the safest and most liquid Euro-denominated assets. Therefore, it is also reasonable to argue that German government bonds carry a convenience yield. As indicated by Figure 1, the CDS premium reaches a level of approximately 100 basis points at the end of 2011, while the yield spread decreases to approximately -40 basis points at the same time. If it was true that CDS are an accurate measure for credit risk, while bond yields are pushed down by the convenience yield, the convenience yield must have reached a level of approximately 140 basis points at the end of 2011. Formally disentangling the convenience yield of a government bond from its credit risk is a challenging task.[16] We approximate the convenience yield of

[16] In a different study, Krishnamurthy and Vissing-Jorgensen (2012) determine the size of the convenience yield of US treasury bonds as, on average, 72 basis points. The difference between their study and our study is that we compare the bond yield to a proxy for the risk-free rate while they compare it to investments in similar safe and liquid bonds. Since even the safest corporate bonds are not considered as risk-free the convenience yield we are interested in is smaller.

German government bonds as the difference between the 3-month Eonia swap rate and 3-month bond yield. Our reason for using this proxy is that credit risk for a bond issuer with high credit quality is smaller for shorter maturities than for longer maturities. Hence, the 3-month German benchmark bond can be considered as almost credit risk free and the difference to the 3-month Eonia swap rate can be attributed to the convenience yield. We compare the proxy for the convenience yield with the CDS premium in Figure 2 and find that the convenience yield of German government bonds never exceeds the CDS premium in our sample. Hence, it is not conceivable to argue that CDS premia are simply dwarfed by the convenience yield.

To formalize this consideration, we construct the same proxy for the other three safe hafens and rerun regression (16) The results of this analysis are exhibited in Table 4. The convenience-yield proxy is only significant for Germany. For Great Britain the inclusion of the convenience yield reduces the significance of the CDS premium. Most notably, adding the convenience yield proxy does not increase the significance of the CDS premium for any of the four safe havens. Further, the R^2 values for Germany, the UK, and the US are all above 0.8 which mitigates omitted variable concerns.

5.3 Regulatory Frictions as Drivers of CDS Premia

After having established that the relationship between CDS premium and bond yield spread becomes weaker for safer sovereigns, we now test our hypothesis that regulatory frictions affect CDS premia. To that end, we choose proxies for x, EE, and W_0^B and run the following regression:

$$\Delta CDS_t = \alpha + \beta_1 \Delta YS_t + \beta_2 \Delta Swaption_t + \beta_3 \Delta CDSvol_t + \beta_4 \Delta Dealer_t + \varepsilon_t. \tag{17}$$

YS_t is the yield spread of the government bond discussed above. We include this variable as a proxy for credit risk. The remaining three variables are independent of the sovereign's credit risk and we refer to them as regulatory proxies in the following. $Swaption_t$ is the price of a 5-year/5-year swaption straddle and, as discussed in Section 4.1, can be used as a proxy for EE. $CDSvol_t$ is the historical volatility of the CDS premium over the past year. We use this variable as a proxy for x since it is the main ingredient in the computation of x (see Section 2.1). Finally, $Dealer_t$ is a proxy for the wealth of derivatives-dealing banks W_0^B. To construct this variable, we use the average of the Moody's KMV one-year Expected Default Frequency (EDF) for the 16 largest derivatives-dealing banks (G16 banks).[17] EDFs are a proxy for a firms' default risk which is computed by Moody's using information on the firms' asset and liability values. Since there is a strong connection between sovereign credit risk and bank credit risk,[18] for each of the 10 sovereigns, we regress the EDF average on the yield spread of the respective sovereign and use the residual of this regression as $Dealer_t$.[19] As explained in Section 4.2, there are no natural sellers of sovereign CDS. Therefore, we do not include any proxy for the end-user's wealth in our analysis. Table 5 reports the results of the regression specified in Equation (17), where we group the sovereigns according to their β^{CDS} from Section 5.2.

Examining the results for the fours safe-haven sovereigns in our sample, we find that the regulatory proxies are both statistically and economically significant. The R^2 of the regression ranges from 5% for the US to 38% for Germany. To

[17] These 16 banks are: Morgan Stanley, JP Morgan, Bank of America, Wells Fargo, Citigroup, Goldman Sachs, Deutsche Bank, Nomura, Societe Generale, Barclays, HSBC, Credit Agricole, BNP Paribas, Credit Suisse, Royal Bank of Scottland, and UBS.

[18] See, for instance, Kallestrup, Lando, and Murgoci (2013).

[19] Using the average EDF instead of the residual gives almost identical results. Further, we have experimented with another alternative specification that gave almost identical results. For each of the 10 sovereigns we have dropped the banks which are located in the respective country from the average. For instance, if we ran a regression for Germany we computed the the average EDF without using Deutsche Bank. Again, the results are almost identical to this modification.

confirm that the explanatory power comes from the regulatory proxies we run a separate regression of the CDS premium on the bond yield spread and report the ratio of the R^2 from this regression over the R^2 of the entire regression under 'Credit Ratio'. The credit ratio is zero fro Japan, US, and Germany, indicating that the entire explanatory power comes from the CDS premium. Turning to the statistical significance, we can see that for Germany and Japan all three regulatory proxies are statistically significant. For the UK, $Dealer_t$ is highly significant, while the other proxies are not. Further, the yield spread is significant at a 5% level and the credit ratio is 0.15. As mentioned before, the UK started posting collateral in their OTC derivatives transactions in late 2012. The posting of collateral mitigates counterparty-credit risk and, therefore, lowers the CVA capital charge and the dealer banks' incentive to buy CDS protection. Therefore, it is in line with our theory that regulatory proxies are less significant for the UK. For the US, the only significant explanatory variable is $Dealer_t$. One possible explanation for this finding is that the notional amount of CDS contracts on the US outstanding is relatively low, especially compared to the overall size of the US economy (see Table 1). This suggests that dealers are not active in using these contracts in large numbers for hedging purposes.

Turning to the results for the other three low-risk sovereigns in our sample we find that our regulatory proxies also have strong economic and statistical significance. With the exception of $Swaption_t$ for Austria, all regulatory proxies are statistically significant. The difference between this group and the group of safe-haven sovereigns is that bond yield spreads are statistically significant at a 1% level and contribute to the explanatory power of our regression with a Credit Ratio ranging from 0.07 for Finland to 0.5 for Austria. Overall, the results for low-risk sovereigns confirm our model implications for credit-rsiky sovereigns from Section 3.4 that both, credit risk and regulatory proxies, help explaining the variation in CDS premia. The finding is also in line with the anecdotal evidence provided in Section 4.2. An increased demand for sovereign CDS due to regulatory frictions, combined with a lack of natural sellers for these contracts can cause the CDS premium to increase, even if the fundamental credit risk remains constant.

Finally, turning to the three risky sovereigns in our sample, Italy, Portugal, and Spain, we first observe that yield spreads on bonds are clearly the major driver for CDS premia. The parameter estimate for the yield spread is statistically significant at a 1% level and the credit ratio ranges from 0.7 for Italy to 0.91 for Spain. The relatively low credit ratio for Italy can be explained by the fact that Italy has a large portfolio of interest rate swaps[20] and is arguably the least risky of the three risky sovereigns. Therefore, it supports our theory that regulatory proxies help explaining the variation in Italian CDS premia.

6 Conclusion

Financial regulation requires derivatives dealers to account for counterparty credit risk in their derivatives transactions with sovereigns. This counterparty risk either adds to dealer's risk-weighted assets or can be hedged using CDS contracts. We show theoretically and empirically that this friction is a major driver of safe-haven CDS premia. We provide a theory where the demand for CDS on safe havens is driven by these regulatory requirements. In our model, safe-haven CDS premia are not driven by credit risk but by the protection seller's funding liquidity, the demand to free regulatory capital, and expected excess returns. In order to obtain capital relief, derivatives dealers keep buying CDS even with an increased CDS premium.

Additionally to our results for safe-haven sovereigns, we find that the CVA hedging effect that we describe also affects CDS premia of low-risk sovereigns. Incorporating credit risk in our model shows that regulatory frictions add to the

[20]See, for instance http://www.bloomberg.com/news/articles/2015-04-23/italy-is-euro-area-s-biggest-swap-loser-after-deals-backfired.

frictionless CDS premium that comes from credit risk. In line with this theoretical result, our empirical findings show that for low-risk sovereigns both, credit risk and regulatory frictions, have a significant effect on the CDS premium.

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A Variable Descriptions

This appendix provides additional details about the data used for our analysis.

1. **Sovereign CDS Premia.** We obtain CDS premia with 5 year maturity on 10 sovereigns from Markit, who provides daily mid-market quotes. We use weekly mid-market quotes in our analysis sampled every Wednesday. In line with previous research (e.g. Fontana and Scheicher (2014)), we use the CDS premium of contracts with 'CR' as restructuring clause.

2. **Sovereign Bond Yields.** Sovereign bond yields for 5-year bonds are obtained from the Bloomberg system. Bloomberg uses the latest 5-year benchmark bond to compute the yield. Yields are computed for bonds with semi-annual (Italy, Great Britain, Japan, and the United States) and annual (Spain, Austria, Finland, France, and Germany) coupon payments. The day count convention is Actual/Actual.

3. **Risk-Free Rate Proxy.** We use swap rates based on overnight lending rates with the same 5-year maturity and the same currency as the bond yield. For European sovereigns, we use Eonia swap rates, for Great Britain we use Sonia swap rates, for Japan we use Tibor swap rates, and for the United States we use OIS swap rates. The day count convention for these swap rates is 360/Actual but we do not correct for this difference in day-count conventions when computing yield spreads. All rates are obtained from the Bloomberg system.

4. **CDS Amounts Outstanding.** Data on amounts of CDS outstanding are obtained from the Depository Trust Clearing Corporation (DTCC) who collects information about CDS amounts outstanding from dealers and buy-side institutions. For our study, we use the dealer and end-user gross sovereign CDS notional outstanding. Note that this variable is only available on an aggregated basis across *all* sovereigns and not on a counterparty level.

5. **Swaption Data.** The swaption quotes are basis point prices of swaption straddles. A swaption straddle is a portfolio of a long position in a receiver swaption, which gives its owner the right but not the obligation to enter a swap contract as fixed receiver, and a long position in a payer swaption, which gives its owner the right but not the obligation to enter a swap contract as fixed payer. Because at-the money swaptions refer to swap contracts with zero value, an application of the put-call parity shows that payer and receiver swaption have the same price. The data are obtained from the Bloomberg system.

6. **CDS Volatility** We use the same formula as in the new Basel capital requirements to compute this variable. More precisely, at date t, we compute the standard deviation of the changes in the CDS premium over the past

252 trading days.

7. **G 16 EDF** We obtain 1-year expected default frequencies (EDFs) for the 16 largest derivatives dealing banks, commonly referred to as G 16 banks, from Moody's Analytics. We then take the average of the 16 EDFs and orthogonalize the resulting time series on the respective yield spread of the sovereign we analyze.

B Proofs

Proof of Theorem 1

We start by deriving the agents' optimal portfolio holdings. The Lagrange function for the end user's optimization problem is given as:

$$\mathcal{L}(e, \bar{e}, \psi) = \left(e(\mu - r) - s\bar{e} - 1/2(\sigma e)^2\right) - \psi\left(me - n^- \bar{e} - W_0^E\right). \tag{18}$$

Taking derivatives of the Lagrangian in Equation (18) with respect to e and $\bar{e}$ implies the following first-order conditions (FOCs):

$$\frac{\partial}{\partial e}\mathcal{L} = \mu - r - \sigma^2 e - \psi m = 0 \tag{19}$$

$$\frac{\partial}{\partial \bar{e}}\mathcal{L} = -s + \psi n^- = 0. \tag{20}$$

From these FOCs (plugging the solution $\psi = s/n^-$ from (20) into (19)) we obtain end-user's risky asset holdings:

$$e = \frac{\mu - r - (s/n^-)m}{\sigma^2}. \tag{21}$$

Next, distinguish two cases. First, if the agent's margin constraint binds the FOC with respect to ψ holds with equality, i.e.,

$$me - n^- \bar{e} = W_0^E, \tag{22}$$

which implies that the end user chooses to use the wealth remaining after investing in the risky asset to supply CDS contracts:

$$\bar{e} = \frac{me - W_0^E}{n^-}. \tag{23}$$

Second, if the end-user's margin constraint does not bind, we must have $s = 0$. This follows mathematically from (20) and the fact that the Lagrange multiplier then must be $\psi = 0$. Intuitively, if the CDS premium s were strictly positive, the agent would always choose to sell CDS until his margin constraint binds, earning the CDS premium in addition to the riskless rate instead of merely earning the risk-free rate. With $s = 0$, the end user is indifferent between selling CDS or putting his remaining capital in the bank account. In this case he is indifferent between all feasible positions in the CDS contract

$$\bar{e} \in \left[0, \frac{me - W_0^E}{n^-}\right]. \tag{24}$$

We follow the same procedure writing up the Lagrangian for the bank's optimization problem:

$$\begin{aligned}\mathcal{L}(b, \bar{b}, \psi_1, \psi_2) = \big(b(\mu - r) - s\bar{b} - 1/2(\sigma b)^2\big) - \\ - \psi_1 \left(mb + n^+\bar{b} + x(EE - \bar{b}) - W_0^B\right) - \psi_2 \left(\bar{b} - EE\right)\end{aligned}$$

Taking derivatives with respect to $b, \bar{b}$, and ψ_1 gives three equations in four unknowns:

$$\frac{\partial}{\partial b}\mathcal{L} = \mu - r - \sigma^2 b - \psi_1 m = 0 \tag{25}$$

$$\frac{\partial}{\partial \bar{b}}\mathcal{L} = -s - \psi_1(n^+ - x) - \psi_2 = 0 \tag{26}$$

$$\frac{\partial}{\partial \psi_1}\mathcal{L} = mb + n^+\bar{b} + x(EE - \bar{b}) - W_0^B = 0. \tag{27}$$

The solution is simple algebra and we find:

$$\begin{aligned}b &= \frac{\mu - r - \psi_1 m}{\sigma^2} = \frac{1}{m}\left(W_0^b - x(EE - \bar{b}) - n^+\bar{b}\right) \\ \psi_1 &= \frac{\mu - r}{m} - \frac{\sigma^2}{m^2}\left(W_0^B - x(EE - \bar{b}) - n^+\bar{b}\right) \\ \psi_2 &= \frac{x - n^+}{m}\left((\mu - r) - \frac{\sigma^2}{m}\left(W_0^B - x(EE - \bar{b}) - n^+\bar{b}\right)\right) - s.\end{aligned}$$

A Lagrange multiplier $\psi_2 > 0$ implies that the bank is buying CDS to free all its regulatory capital and therefore $\bar{b} = EE$. This is the case if the CDS premium satisfies:

$$s < s^b := \frac{x - n^+}{m}\left((\mu - r) - \frac{\sigma^2}{m}\left(W_0^B - n^+ EE\right)\right). \tag{28}$$

If the CDS premium increases over s_b, the bank reduces its position in the CDS contract and we obtain $\bar{b} < EE$. Further, if the CDS premium increases above

$$\frac{x - n^+}{m}\left((\mu - r) - \frac{\sigma^2}{m}\left(W_0^B - xEE\right)\right),$$

the bank does not use any CDS for capital relief and $\bar{b} = 0$.

To compute equilibrium we focus on the case where $s < s^b$ and proceed in two steps. First, we determine the equilibrium CDS premium (as a function of the excess return) such that the end user meets the bank's demand to insure a notional amount equal to EE, i.e., (10) is satisfied with $\bar{b} = EE$. Second, we apply the market clearing condition in the risky asset (9) to determine the excess return $\mu - r$.

Insisting that the end user supplies the CDS protection demanded by the bank leads to

$$EE = \frac{W_0^E - me}{n^-}. \tag{29}$$

Plugging in the end-user's optimal risky asset holdings e, which depends on the CDS premium, gives the equilibrium CDS premium:

$$s^e = \frac{n^-}{m}\left((\mu - r) - \frac{\sigma^2}{m}\left(W_0^E - n^- EE\right)\right). \tag{30}$$

Note that this is only an equilibrium if s^e is smaller than s^b.

Using the equilibrium condition from Equation (9) and plugging in the values for a, b, and e gives:

$$\frac{\mu - r}{\gamma\sigma^2} + \frac{\mu - r - s\frac{m}{n^-}}{\sigma^2} + \frac{W_0^B - n^+ EE}{m} = 1.$$

Inserting the equilibrium rate s leaves us with an expression for $\mu - r$:

$$\mu - r = \gamma\sigma^2\left(1 - \frac{1}{m}\left(W_0^E - n^- EE\right) - \frac{1}{m}\left(W_0^B - n^+ EE\right)\right). \tag{31}$$

Finally, we then also have the CDS premium in terms of the model parameters given as

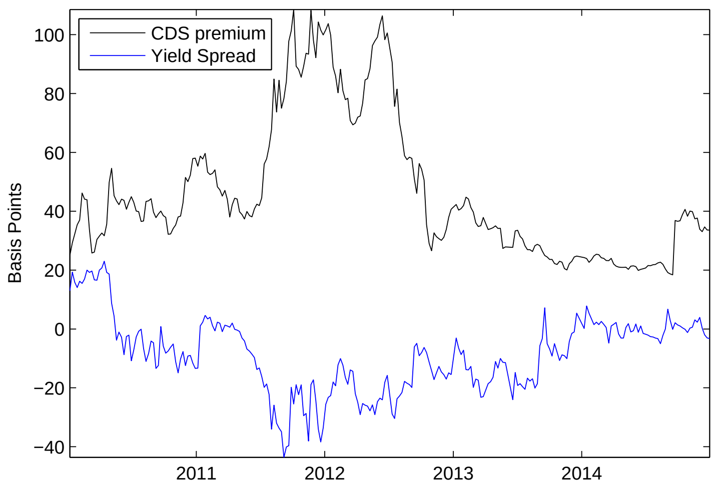
$$s^e = \frac{n^-}{m}\gamma\sigma^2 \left(1 - \frac{1+\gamma}{\gamma}\frac{1}{m}\left(W_0^E - n^- EE\right) - \frac{1}{m}\left(W_0^B - n^+ EE\right)\right). \tag{32}$$

Plugging in the value for $\mu - r$ into Equation(28) completes the proof. ■

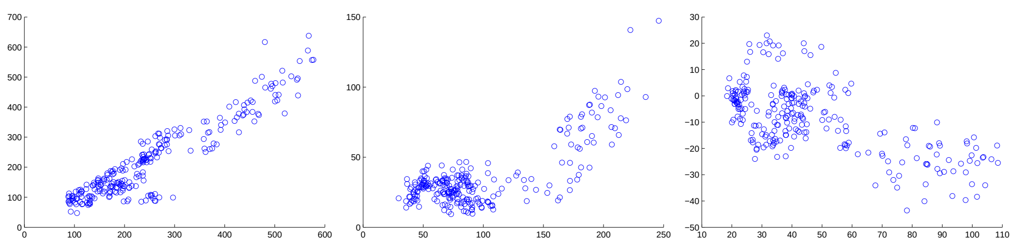
C Figures and Tables

Figure 1: The Relationship Between Credit Default Swap Spreads and Bond Yield Spreads

Panel A: Comparison of the time series of the five-year bond yield spreads and the five-year CDS premia for Germany. Yield spreads are computed as the difference between bond yields and the five-year Eonia swap rate. Both spreads are in basis points

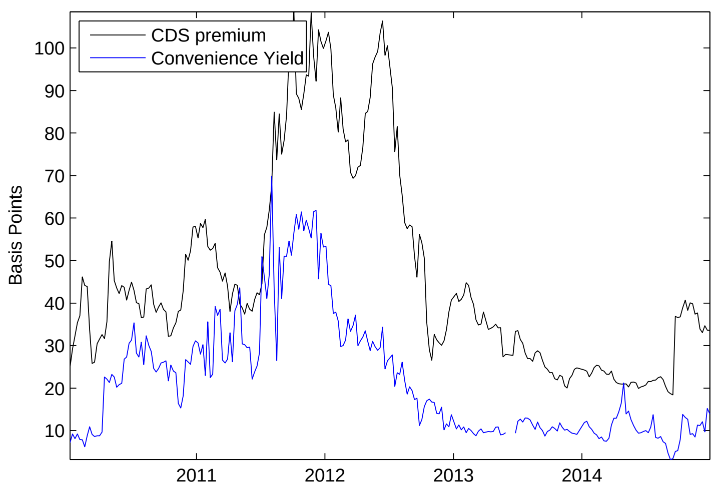


Panel B: Scatter plot of bond yield spreads and CDS premia for France, Germany, and Italy.



(a) Italy (b) France (c) Germany

Figure 2: Comparison of the CDS premium for Germany with a proxy for the Convenience Yield in German Bonds



Notes: The Figure shows the time series of the 5-year CDS premium and a proxy for the convenience yield in the German government bonds. The convenience yield is approximated as the difference between the 3-month Euribor rate and the 3-month German government bond yield. This proxy assumes that the 3-month government bond close to credit-risk free.

Figure 3: Illustration of the Equilibrium with Credit Risk

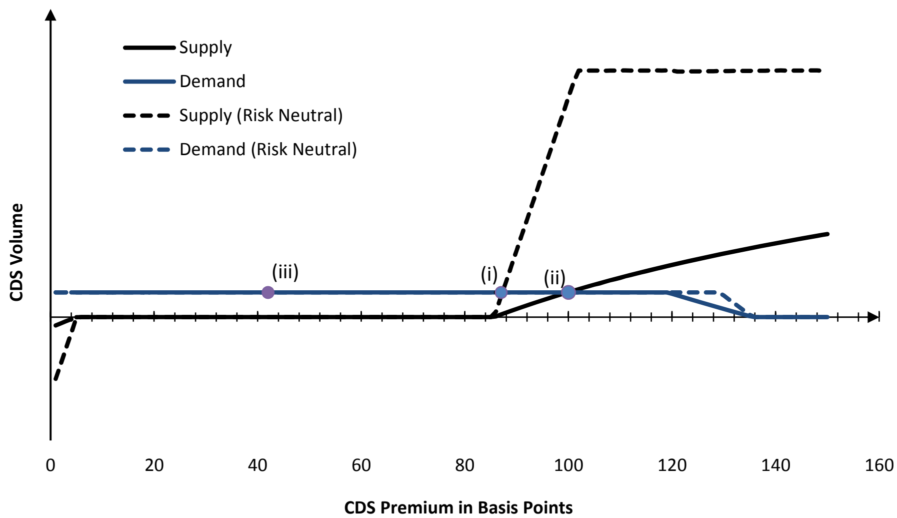
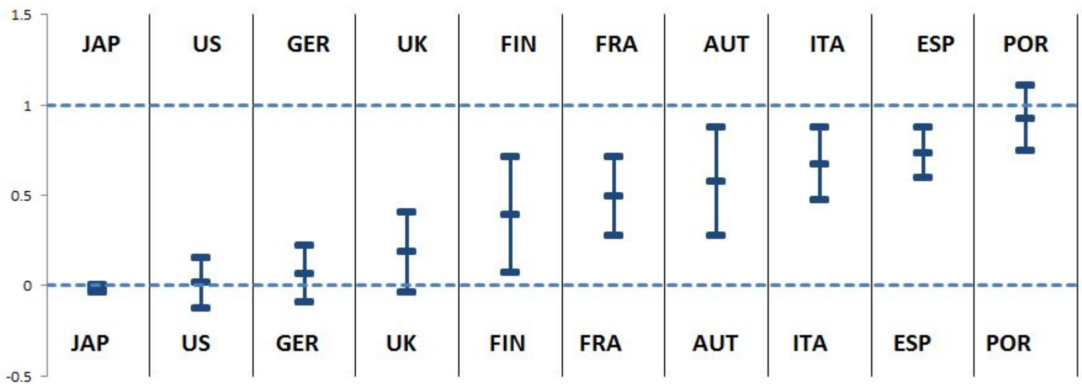


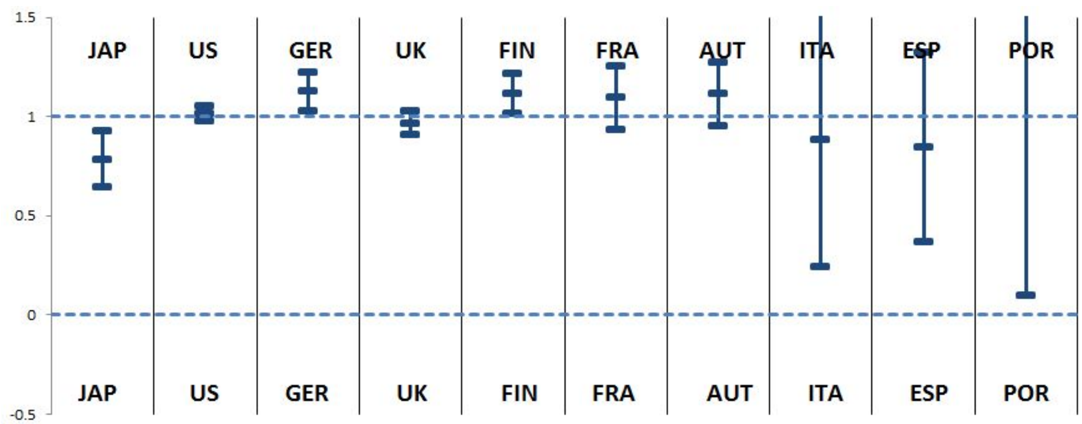
Figure 4: The Figure illustrates equilibrium in the market for CDS under two different model specifications. Black lines indicate supply of CDS by the end user and the blue lines indicate the demand for CDS by the bank. Solid lines refer to the model specification where agents are risk-averse towards trading CDS while dashed lines correspond to the model specification where agents are risk-neutral towards trading CDS. The equilibrium CDS premium under the risk-neutral specification is illustrated by the solid dot (i). The equilibrium CDS premium under the risk-neutral specification is illustrated by the solid dot (ii). The equilibrium CDS premium for the benchmark case with no default risk is illustrated by the solid dot (iii).

Figure 5: Explaining Bond Yields with Risk-Free Rates and Credit Risk

$$\Delta Yield_t = \alpha + \beta^{CDS} \Delta CDS_t + \beta^{rf} \Delta rf_t + \varepsilon_t$$



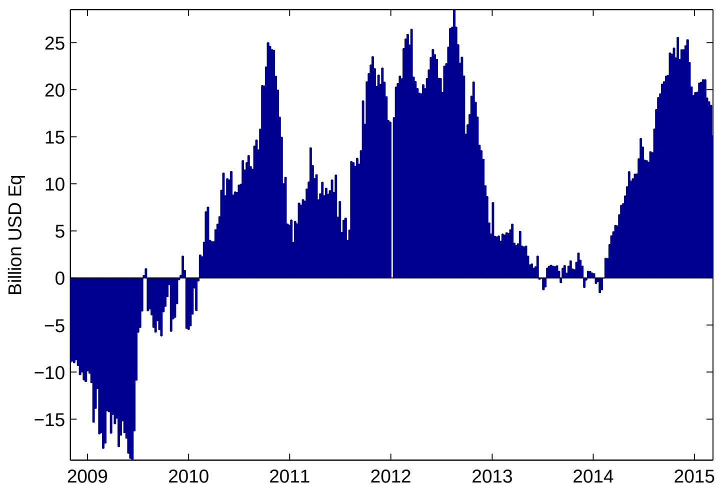
(a) Parameter estimates for β^{CDS}



(b) Parameter estimates for β^{rf}

Notes: The figure illustrates the parameter estimates and standard errors for β^{CDS} and β^{rf} for 10 different sovereigns. The middle bar is the parameter estimate, the upper and lower bar correspond to the 95% confidence interval, or to two standard deviations. The 10 countries are sorted by β^{CDS} from lowest to highest. All variables are for 5-year contracts. $Yield_t$ denotes the bond yield, rf_t denotes the risk-free rate proxy measured by swap rates based on overnight lending rates, and CDS_t is the CDS premium. In order to construct confidence intervals, we used Newey-West heteroskedasticity robust standard errors.

Figure 6: Net amount of CDS contracts on sovereigns bought by derivatives dealers



Notes: The Figure shows the difference between CDS contracts on sovereigns bought by derivatives dealers and the amount sold.

Table 1: CDS and Debt Amounts Outstanding for the 10 Sovereigns in our Sample.

Rank	Entity	Net Notional	Debt Outst*	Pct of Debt
1	Italy	16.92	1,989.43	0.85%
3	Germany	13.12	2,160.19	0.61%
4	France	11.74	1,833.81	0.64%
5	Spain	9.26	884.65	1.05%
6	Japan	9.19	9,759.64	0.09%
12	GB	5.84	1,700.54	0.34%
16	Austria	4.22	227.17	1.86%
19	Portugal	3.68	204.84	1.80%
24	USA	3.39	12,975.07	0.03%
47	Finland	2.19	103.15	2.12%

Notes: All amounts are given in billion USD equivalent. The ranks refer to the whole single-name CDS market (including banks and corporates). Source: DTCC, September 2013 and CountryEconomy.com (*data are from 2012)

Table 2: Example CVA Computations Based on EBA Stress Tests.

	Deriv with Pos Value (Mio USD)				Basis Points		Mio USD		
Date	Notional Value	Fair Value	Net Fair Value	CDS Outst	CDS	Worst Case	Capital Requir	CDS margin	$x(s_t)$
Germany	402,855	34,072	9,187	13,118	42	19	5,119	1,704	0.150
Austria	28,403	1,644	859	4,224	44	40	446	82	0.271
Finland	95,414	5,073	-1,164	2,189	30	14	441	254	0.087
France	47,938	3,210	568	11,742	92	46	751	160	0.234
Italy	106,959	19,136	17,969	16,916	284	118	9,478	957	0.495
Portugal	9,423	564	96	3,684	430	214	463	28	0.821
Spain	27,691	1,883	-224	9,259	291	118	754	94	0.401
UK	7,920	19,255	-923	5,842	42	12	1,380	963	0.072
Japan	17,471	5,269	776	9,189	81	20	477	263	0.091
US	77,995	54,710	2,973	3,389	36	10	2,865	2,736	0.052

Notes: OTC derivatives outstanding are originally provided in Euro by European Banking Authority in their stress tests from 2013. All other data are year-end 2012. CDS refers to the 5-year CDS premium for the respective sovereign. Worst Case and RWA are computed using Equation (4) and (5), assuming a 10% capital buffer. Margin CDS is the amount of capital that would be required to hedge the expected exposure, assuming a margin requirement of $n^+ = 0.05$. $x(s_t)$ is the capital required, if the expected exposure is unhedged, measured as a fraction of EE, where we use the fair value of all derivatives with positive fair value as a proxy for EE.

Table 3: Example CVA Computations for Germany.

	Basis Points			Mio USD				Mio USD			Mio USD		
	CDS	Worst Case	Swaption Straddle	CS01	EE	Payer IRS	Receiver IRS	CVA	CVA VaR	Strsd VaR	Equity Capital	Margin CDS	$x(s_t)$
2010	59	14	573	7.14	8,650	122,814	179,216	260	294	352	808	433	0.093
2011	101	23	691	9.66	12,028	152,230	195,741	311	654	655	1,636	601	0.136
2012	42	16	588	10.09	11,061	198,630	177,918	241	499	752	1,563	553	0.141
2013	26	8	674	10.19	11,116	169,329	160,504	198	257	759	1,270	556	0.114
2014	34	8	522	7.95	8,426	174,361	148,467	118	200	592	991	421	0.118

Notes: All data are year end. Swap amounts outstanding are originally provided in Euro by the Bundesrepublik Deutschland Finanzagentur (Bund) and US dollar swap amounts outstanding were computed using the Euro US dollar exchange rate. CDS refers to the 5-year CDS premium on Germany. Worst Case, CS01, and EE are computed using Equation (4), (3), and (15) respectively. CVA and CVA VaR are computed using Equation (1) and (2) respectively. Stressed VaR is computed based on the same formula as CVA VaR but using the maximum annual volatility over the last three years. Equity capital is computed using equation (5) assuming a 10% buffer. Margin CDS is the amount of capital that would be required to hedge the expected exposure, assuming a margin requirement of $n^+ = 0.05$. $x(s_t)$ is the capital required, if the expected exposure is unhedged, measured as a fraction of EE. It depends on the level and volatility of swap premia.

Table 4: Explaining Bond Yields with Risk-Free Rates, Credit Risk, and Convenience Yield

$$\Delta Yield_t = \alpha + \beta^{rf}\Delta rf_t + \beta^{CDS}\Delta CDS_t + \beta^{CY}\Delta CY_t + \varepsilon_t$$

	Rate		CDS		CY		R^2
Japan	0.8***	(0.07)	-0.01	(0.02)	0.07	(0.11)	0.69
US	1.02***	(0.02)	0.02	(0.07)	0.05	(0.11)	0.95
Germany	1.14***	(0.05)	0.08	(0.09)	0.16**	(0.07)	0.81
UK	0.98***	(0.03)	0.13	(0.14)	-0.2	(0.15)	0.84

Notes: All variables are for 5-year contracts. $Yield_t$ denotes the bond yield, rf_t denotes the risk-free rate proxy measured by overnight swaps, CDS_t is the CDS premium, and CY_t is the proxy for the bond's convenience yield, measured as the difference between the according 3-month overnight rate and 3-month bond yield. Standard errors in parenthesis are Newey-West heteroscedasticity robust. *Significant at 10%, ** Significant at 5% level, *** Significant at 1% level.

Table 5: Parameter estimates and t-statistics from the regression of changes in sovereign credit default swap premia on credit risk and regulatory proxies.

	Yield Spread	Swaption	CDS vol	G 16 EDF	Adj. R^2	Credit Ratio	# Obs.
Japan	0.01	0.04*	18.19***	13.32*	0.21	0.00	256
	(0.04)	(1.88)	(3.46)	(1.72)			
US	0.02	0	0.15	5.08***	0.05	0.00	256
	(0.18)	(0.18)	(0.23)	(5.03)			
Germany	0.02	0.04***	16.31***	17.1***	0.38	0.00	256
	(0.38)	(2.67)	(4.52)	(5.29)			
UK	0.15**	0.01	6.6	11.19***	0.2	0.15	256
	(2.56)	(0.66)	(0.97)	(5.09)			
Finland	0.12***	0.02**	16.94***	13.39***	0.54	0.07	241
	(4.01)	(2.18)	(11.12)	(6.93)			
France	0.57***	0.05*	17.86***	37.88***	0.59	0.44	256
	(8.80)	(1.80)	(6.21)	(8.21)			
Austria	0.42***	0.03	14.2***	26.07***	0.46	0.50	256
	(5.24)	(1.08)	(3.27)	(4.96)			
Italy	0.62***	0.1	15.1**	72.43***	0.63	0.70	256
	(11.02)	(1.55)	(2.09)	(6.08)			
Spain	0.78***	0.06	10.29	37.57***	0.64	0.91	256
	(14.96)	(0.87)	(1.37)	(3.75)			
Portugal	0.58***	0.12	8.34	111.02***	0.63	0.86	255
	(11.27)	(0.69)	(1.19)	(4.14)			

Notes: The table reports parameter estimates and Newey-West heteroskedasticity robust t-statistics for the indicated explanatory variables. Credit ratio denotes the ratio of the R^2 from which only the convenience yield is included to the R^2 from the regression in which all of the variables are included. The sample period is January 2010 to December 2014, using weekly observations sampled each Wednesday. *Significant at 10% level. **Significant at 5% level. ***Significant ant 1% level.