Safe-Haven CDS Premia

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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 equivalent to the capital requirement. 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. Bonds issued by high-rated sovereigns, like Germany or the United States, are considered as safe and money-like assets. Especially during times of financial distress, these bonds provide a safe haven for investors. The market for CDS on safe havens is large and CDS premia on these entities tend to move in opposite directions than the corresponding yield spreads. Therefore, we investigate the following two questions: Where does the demand for CDS on safe havens come from? And what drives safe-haven CDS premia?

CDS premia and yield spreads of the same entity differ for several reasons, like the capital required for arbitrageurs who wish to trade in CDS contracts and bonds. But even if the two measures are different, they are expected to be positively related – both responding with increasing spreads when the credit quality of the underlying issuer deteriorates. Figure 1 illustrates that this is not the case for Germany. Panel A 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. As the cases of Italy and France show, CDS premia and yield spreads are typically positively correlated.

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, like 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 incorporate these arguments into a general equilibrium model. The model is a modified version of the margin-based asset pricing model by Gârleanu and Pedersen (2011). There are two constrained agents in our model. First, a derivatives dealing bank who engaged into a derivatives transaction with a risk-free sovereign. Due to regulatory requirements, this derivatives transaction adds to the dealer's RWAs, thereby lowering his margin capital. To free this margin capital, the dealer can buy CDS on the sovereign. Note that we assume no default risk of the risk-free sovereign. In our model, the only reason for buying the CDS is due to regulatory requirements. Second, the seller of credit protection is not a derivatives dealing bank but an end user who has no exposure to the risk-free sovereign. 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 has a demand for safe and liquid assets. This demand is satisfied by buying bonds from the risk-free sovereign and by collateralized lending to the other agents.

The mechanism that explains the puzzling behavior of CDS premia and yield spreads discussed above is as follows. As the state of the economy deteriorates, margin constraints become binding and margin capital becomes more valuable. Since selling CDS requires some margin capital, the end user requires a higher premium for selling CDS. Note that this increase is purely driven by liquidity issues and not by an increase in credit risk. At the same time both constrained agents borrow less than they would do in an economy without binding margin constraints. Therefore, the supply of safe and liquid assets in the economy decreases.[1] To lower the risk-averse agents demand for safe and liquid assets the risk-free rate has to decrease. Comparing this risk-free rate to the risk-free rate in an economy without margin constraints shows that yield spreads decrease. Calibrating our model shows that a positive CDS premium occurs as soon as margin requirements become binding and increase with a deteriorating state of the economy.

To confirm the underlying assumptions of our theory, we provide 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 a 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. Second, we 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 to buy CDS instead of holding 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. Third, we discuss practical issues regarding Basel III and the implementation of the new regulations in regional law.

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

[1] We need to implicitly assume that the amount of government bonds stays constant during economic downturns. This assumption is reasonable because governments don't start issuing more bonds immediately when economic conditions deteriorate.

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 a significant explanatory variable for bond yields. The reason for this observation might be that Great Britain does not qualify as safe haven. However, as of today Great Britain and Portugal are the only two sovereigns in our sample who started posting collateral in their derivatives transactions during the sample period. Therefore, derivatives dealers have less incentive to buy CDS on great Britain and our theory does not apply.

We conclude our empirical analysis by addressing the following concern. 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 we compare a proxy for the convenience yield of German government bonds with the 5-year CDS premium in Figure 2. From the figure, it is obvious 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.

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, 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 key friction in our model is a borrowing constraint as studied by, among others, Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). While our model is a modification of Gârleanu and Pedersen (2011), the friction can also be interpreted as a leverage or Value at Risk (VaR) constraint. This idea has been studied by Adrian and Shin (2010) and Adrian and Shin (2013) who provide evidence from bank balance sheets that leverage constraints influence banks' lending behaviour. Two other articles dealing with leverage constraints are He and Krishnamurthy (2013), who consider raising equity capital as key constraint for financial intermediaries, and to Adrian, Moench, and Shin (2013), where intermediaries leverage is a priced risk factor. Bongaerts, de Jong, and Driessen (2011) also model demand effects on CDS premia, but in corporate CDS contracts and due banks' hidden exposure to certain corporations.

The difference between CDS premium and yield spread is commonly referred to as 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 (2010), 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 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 new regulatory requirements in Section 2. Afterwards, we develop a model that is capable of explaining the apparent disconnect between CDS premia and yield spreads for safe sovereigns in Section 3. We then confirm key model assumptions in Section 4. To verify key model implications, we study a sample of 10 different sovereigns in Section 5. Section 6 concludes.

2 The New 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 which leaves dealer banks exposed to counterparty credit risk. The new regulatory requirement, also known as Basel III (see Basel Committee on Banking Supervision (2011)) introduces a new charge for this counterparty credit risk. This charge either adds to banks' risk-weighted assets or can be hedged using CDS contracts. As foundation for our model in Section 3, we provide an overview of the new regulatory requirements for this counterparty risk in this section.

The mitigating of counterparty credit risk is an important part of financial regulation. Banks were already required to account for the credit risk of their derivatives counterparties before the default of Lehman Brothers and the announcement of Basel III. To account for this credit risk banks need to 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. We follow the formulas in Basel III to show how CVA is computed:[2]

$$\text{CVA} = \text{LGD} \sum_{i=1}^{T} \mathbb{P}(\tau \in (t_{i-1}, t_i)) \text{Exposure}(t_{i-1}, t_i), \tag{1}$$

where we introduce τ as the default time of the counterparty.

The summation in Equation (1) is over all future revaluation dates until maturity of the derivative at time T. At these dates the bank estimates the risk of its position with the counterparty using the following three ingredients. First, LGD which is the percentage loss in case of a default of the counterparty. Second, the probability of default at each future revaluation date. Basel III requires this probability to be computed as:

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

where s_i is the CDS premium on the counterparty for a CDS with maturity date i. Third, the banks exposure to the counterparty at each revaluation date. This 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) is computed as average of discounted exposure at time t_{i-1} and discounted exposure at time t_i. We give an example of how to compute this exposure in Section 4.2.

The new CVA capital charge is computed as a value-at-risk (CVA VaR) with a confidence level of 99% :[3]

$$\text{CVA\_VaR} = m \times \text{WorstCase} \times \text{CS01}, \tag{2}$$

[2]See Basel Committee on Banking Supervision (2011), page 31. Note that this formula is used in the context of CVA VaR computations, the actual CVA computation deviates from that.

[3]We follow Gregory (2012), page 390 with this formula. Different banks might use dif-

where m is a supervisory multiplier which is at least 3. WorstCase is given as

$$annual\ CDS\ volatility \times \sqrt{\frac{10}{252}} \times \Phi^{-1}(0.99). \quad (3)$$

CS01 represents the sensitivity of CVA towards a one-basis-point change in the CDS premium. Again, we give a concrete example of CS01 in Section 4.2. To make the measure even more conservative, the bank also has 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. The two quantities are added to get the contribution to risk-weighted assets arising from the counterparty exposure:

$$RWA = 12.5 \times (CVA\ VaR + CVA\ Stressed\ VaR). \quad (4)$$

Overall, CVA VaR is the sensitivity of CVA towards changes in the counterparty's CDS premium multiplied by the probability of an extreme move in CVA. 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 CDS with a notional amount N or taking an addition to its risk-weighted assets equal to approximately xN, where x is a fraction of the notional computed according to Equation (2). We use this simplification in our model and show why it is a reasonable approximation in Section 4.2.

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ferent 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.

[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 The Model

Our model is a modified version of the margin-based asset pricing model of Garleanu and Pedersen (2011, henceforth GP). We incorporate the regulatory requirement from the previous section in the model, assume an entirely credit-risk free sovereign, and show how tightening capital constraints can be responsible for changes in the CDS premium.

3.1 Model Setup

The Assets

We consider a market with four different types of securities. First, there is a risky asset. To keep our model simple, we work with a generic risky asset that can be thought of as the market portfolio. The asset pays a dividend δ_t, that follows a geometric Brownian motion

$$d\delta_t/\delta_t = \mu^C dt + \sigma^C dw_t. \tag{5}$$

As in Lucas (1979) these dividends correspond to aggregate consumption in the economy. Further, the asset has a price that follows an Ito-process and needs to be determined endogenously:[5]

$$dP_t = (\mu_t P_t - \delta_t)dt + \sigma_t P_t dw_t. \tag{6}$$

To invest in the risky asset an agent has to use a margin m of his own wealth and is allowed to borrow $1-m$. This is true for both long and short positions. Further, there are two types of money-market assets. The second asset is identified by an uncollateralized lending rate r^u, which can be thought of as Libor rate. Not all agents can participate in uncollateralized lending and therefore this rate is often referred to as a shadow rate. The third asset corresponds to a collateralized

[5] Determining μ_t and σ_t endogenously is what complicates equilibrium calculations but as it turns out we can build on the equilibrium results in GP.

lending rate r^c. In contrast to r^u all agents can participate in this market. As in GP, the key idea is that these rates are equal in normal times and deviate in bad states of the economy. Fourth, there is a CDS contract on a credit-risk-free sovereign. The fair running premium on the CDS entered into at time t is denoted $s_t \geq 0$. The role of this CDS will become obvious later when we describe the different agents. At this point we note that, without any further assumptions, buying such a CDS would make no sense because it insures against default of a credit-risk-free entity. For the CDS, we make the realistic assumption that both long and short positions require an initial margin of $\tilde{m}$.[6] This assumption implies that if an end user sells a CDS with a notional $\tilde{\theta}$ on the safe sovereign, it needs to have $m\tilde{\theta}$ of cash to post as margin. This margin earns the collateral rate r^c.

Additionally to these assets there are safe-haven bonds. These are safe and liquid government bonds from one specific sovereign, which we assume to be entirely risk-free and which are the underlying of the CDS contract. To keep our model tractable we make the following assumption:

Assumption 1. *Safe government bonds have no haircut and the same maturity as collateralized lending.*

We use this assumption to follow the standard approach common in the literature to identify the government bond yield with the collateralized rate r^c. If both government bond and collateralized lending have the same maturity and there is no haricut on the government bond the two rates are equal. The mechanisms that drives these yields is as follows: There is a certain supply of safe assets in the economy. In this setup a fixed supply of safe government bonds and a vari-

[6] Among others Gârleanu and Pedersen (2011) made this assumption. A recent study by Duffie, Scheicher, and Vuillemey (2014) shows that the margin requirement for selling CDS is usually higher than the margin requirement for buying CDS. Given that demand pressure for CDS is an important ingredient in our model, assuming $m_{seller} > m_{buyer}$ would make our case even stronger. However, we assume for simplicity that both margin requirements are equal.

able supply of collateralized lending.[7] Hence, when the supply of collateralized lending decreases, the supply of safe assets in the economy decreases as well. To equate supply and demand the government bond yield needs to decrease as well to decrease the demand for safe assets.

Finally, we implicitly need a fifth asset which can be thought of as a derivative contract in which the risk-free sovereign is a counterparty. This derivative can be thought of as an interest rate swap (IRS) that a derivatives dealing bank and the risk-free sovereign can enter into. We consider IRSs because they are the most frequently used derivatives by sovereigns. Again, to keep our model tractable, we assume that this transaction takes place outside the modelling framework and the market risk of the derivative is perfectly hedged.

The Agents

There are three kinds of agents in our model. First, an unconstrained, risk-averse, agent who does not participate in the derivatives market and who does not engage in uncollateralized borrowing or lending. Think of this agent as an agent rich in cash who helps levered agents borrow against collateral. Following GP we call this agent a and assume that he has power utility with parameter γ^a. Further, there are two different types of less risk-averse or braver log-utility agents. Both log-utility agents can borrow or lend uncollateralized and can participate in the derivatives market. The second agent can be thought of as an end-user, who uses derivatives as an investment. We call this agent end-user or short e. As in GP, this agent faces a margin constraint of the following form:

$$m|\theta^e| + \eta^{u,e} - \tilde{m}\tilde{\theta}^e \leq 1, \tag{7}$$

[7] In reality the amount of government debt outstanding changes over time and after a crisis. However, since we are more interest in shorter time horizons, a fixed supply of government bonds is reasonable in our setting.

meaning that he has to put $|\theta^e|m$ of his own wealth in the risky asset position, $\eta^{u,e}$ in his position in the uncollateralized money market asset, and $-\tilde{m}\tilde{\theta}^e$ in the CDS contract. It is not necessary to use the absolute value for θ^e because the end user would only sell CDS contracts on the safe sovereign. As explained before, the CDS insures against default of a credit-risk-free entity and the end-user has no incentive to buy CDS.

The third agent can be thought of as a derivatives dealing bank and we call this agent derivatives dealer or short d. This agent is almost identical to the end-user. He has log-utility, can borrow or lend uncollateralized, and participates in the derivatives market. The only difference is that the dealer is engaged in an IRS with the safe sovereign. As mentioned above, we assume that the market risk of the IRS is perfectly hedged.

However, as we explain in more detail in the following section, financial regulation imposes a capital charge equal to a fraction x of his expected exposure $\overline{\theta}$ towards the sovereign. This is to mitigate the counterparty credit risk of his derivative position with the sovereign (even though the sovereign is assumed as risk free). This capital requirement can be reduced by holding CDS on the safe sovereign. Hence, the dealer's margin constraint is given as:

$$m|\theta^d| + \eta^{u,d} + x(\overline{\theta} - \tilde{\theta}^d) + \tilde{\theta}^d \tilde{m} \leq 1. \tag{8}$$

The fundamental idea in modelling the dealer's constraint is the same as in GP. The dealer has to use a fraction of his own wealth to invest in risky assets and derivatives. However, the interpretation of this constraint is different. The fraction $x\overline{\theta}$ is a constraint imposed by regulators. Financial regulation, as formalized in the Basel capital requirements, aims to make the banking system more resilient to financial distress by requiring it to fund a certain percentage of risk weighted assets with equity capital. The risk weight associated with an asset depends on its risk. For instance, AAA-rated government bonds have a risk-weight of zero while uncollateralized derivatives positions with the same safe sovereign get a positive risk weight. As stated in Basel III the capital requirement for uncollateralized derivatives positions can be reduced by buying CDS on this entity. We provide a detailed overview of these regulatory requirements in Section 3.

3.2 Implications for the CDS Premium

All investors $g \in \{a, e, d\}$ are infinitely-lived and maximize their expected utility of consumption:

$$\max_{C^g, \theta^g, \eta^{u,g}, \tilde{\theta}^g} \mathbb{E}_0 \left[\int_0^\infty e^{-\rho s} u^g(C_s^g) ds \right].$$

Since CDS are only traded between the two braver agents we first analyze their investment problem. Their dynamics of wealth are given as:

$$dW_t = \left(W_t \left(r_t^c + \eta_t^{u,g}(r_t^u - r_t^c) + \theta_t^g(\mu_t - r_t^c) - \tilde{\theta}^g s_t \right) - C_t \right) dt + W_t \theta_t^g \sigma_t dw_t. \quad (9)$$

As in GP, we first explore the braver agents' log-utility which makes them myopic and therefore reduces the optimization problem to a mean-variance problem:

$$\max_{\theta_t^g, \tilde{\theta}^g, \eta_t^{u,g}} \left[r_t^c + \eta_t^u(r_t^u - r_t^c) + \tilde{\theta}^g s_t - \theta_t^g(\mu_t - r_t^c) - \frac{1}{2}(\theta_t^g \sigma_t)^2 \right]$$

$$\text{s.t.: (7) if } g = e \text{ and s.t.: (8) if } g = d$$

Using the notation ψ_t for the Lagrangian multiplier and taking derivatives with respect to η^u and θ^g gives:

$$\psi_t = r_t^u - r_t^c \quad (10)$$

$$\mu_t - r_t^c = \sigma_t^2 \theta_t^g \pm \psi_t m \quad (11)$$

These two equations are equivalent to the derivations in GP. The first equation can be interpreted as 'shadow cost of capital' in the following sense. The uncollateralized rate r_t^u is the 'shadow rate' at which only risk-tolerant investors can lend to each other while r_t^c is the collateralized risk-free rate at which all agents can borrow or lend. The difference between these two rates increases as the relative wealth of the risk-tolerant agents decreases which, as we explain later, corresponds to bad states of the economy. The second equation is a standard-CAPM result adjusted for the margin constraint, which is positive if the agent is long the asset and negative if the agent is short the asset.

Considering the end-users investment problem with respect to selling the CDS leads to our first main result. Taking derivatives with respect to $\tilde{\theta}^e$ gives the following proposition.

Proposition 1. *To sell a CDS on the safe sovereign the end user requires a CDS premium of:*

$$s_t = \psi_t \tilde{m}. \tag{12}$$

Proposition 1 shows that there is a link between the CDS premium required by the end user to sell CDS and the shadow cost of capital times the margin requirement of the CDS. The end-user requires a positive premium even though there is no fundamental risk associated with this transaction. This is because selling CDS makes his margin constraint bind earlier and the required premium compensates for that. We note that the premium does not depend on the required CDS volume. The reason for this finding is that there is no fundamental risk associated with the CDS which leads to a linear relationship between the amount of CDS sold and the corresponding decrease in the end user's margin capital.

The next step is to check under which conditions the derivatives dealer is willing to buy CDS. Taking d's first-order condition (FOC) with respect to $\tilde{\theta}$ shows that he would buy CDS instead of taking a capital charge as long as the following inequality holds:

$$s_t \leq \psi_t (x - \tilde{m}).$$

Combining this result with the result from Proposition 1 leads to our second main result.

Proposition 2. *The derivatives dealer has a demand for CDS if*

$$x > 2\tilde{m}. \tag{13}$$

In this case it is always optimal for the dealer to buy CDS and $\tilde{\theta} = \overline{\theta}$.

Proposition 2 gives a sufficient condition for the dealer to buy CDS. If the cost for buying the CDS plus the associated margin requirement for obtaining CDS protection are lower than the amount of regulatory capital required, it is always optimal for the dealer to buy CDS instead of holding regulatory capital. Since $x(\overline{\theta} - \tilde{\theta})$ decreases linearly in the amount of CDS held it is either optimal for the dealer to hedge his whole position using CDS or not using CDS to hedge (in case Inequality (13) is not satisfied).

3.3 Equilibrium Rates

We calculate equilibrium rates under the following assumption.

Assumption 2. *Inequality (13) holds and* $x > 2\tilde{m}$.

We justify this assumption in the next section where we explain provide an overview of the relevant regulatory framework. Assumption 2 facilitates the equilibrium computation significantly because given $\overline{\theta} = \tilde{\theta}$ the two braver agents can be aggregated to one because then both agents face the same margin constraint and the CDS premium payment cancels out. We refer to the aggregate of both braver agents as agent b. Exploring log-utility again we can write the dynamics of agent b's consumption as:

$$dC_t^b / C_t^b = (r_t^c - \rho + (\mu_t - r_t^c)\theta_t^b)dt + \sigma_t \theta_t^b dw_t.$$

We know that aggregate consumption C_t is given by the stream of dividends as specified in Equation (5). That gives the dynamics of consumption for agent a as $C - C^b$:

$$dC_t^a = C(\mu^C - c^b(r^c - \rho + (\mu_t - r_t^c)\theta_t^b)dt + C(\sigma^C - c^b \sigma_t \theta_t^b)dw_t, \tag{14}$$

where $c^b := C^b/C$ is agent b's relative consumption. We can derive the dynamics of this state variable by applying Ito's lemma:

$$dc_t^b = c^b((r^c - \rho + (\mu_t - r_t^c)\theta_t^b - \mu^C - \sigma^C \sigma_t \theta_t^b + (\sigma^c)^2)dt + (\sigma_t \theta_t^b - \sigma^c)dw_t).$$

This is the key state variable in GP's analysis and is used as a proxy for the overall state of the economy. The intuition behind this is that risk-tolerant investors hold more risky assets than the risk-averse investors because they use a higher leverage. Hence, worsening economic conditions (falling asset prices) decrease the risk-tolerant investors' wealth more than the wealth of the risk-averse investors.

The next step is to compute r_t^c and s_t as functions of the state variable c^b. Using the fact that a is unconstrained and does only participate in collateralized lending, we know that his stochastic discount factor is given as:

$$\xi_t = e^{-\rho t}(C^a)^{-\gamma^a} \text{ with dynamics}$$
$$d\xi_t/\xi_t = \mu_t^\xi dt + \sigma_t^\xi dw_t.$$

Hence, assuming a dynamic of $d\xi_t/\xi_t = \mu_t^\xi dt + \sigma_t^\xi dw_t$ we know that $r_t^c = -\mu_t^\xi$. Applying Ito's lemma to ξ_t gives the following formula for r^c.

Proposition 3. *r^c is given as:*

$$r^c = \rho + \left(\gamma^a \frac{\mu^C - c^b \kappa \sigma \theta^b}{1 - c^b} - \frac{1}{2}\gamma^a(\gamma^a + 1)\left(\frac{\sigma^C - c^b \sigma \theta^b}{1 - c^b}\right)^2\right) \frac{1 - c^b}{1 + (\gamma^a - 1)c^b}, \quad (15)$$

where κ denotes the market Sharpe ratio.

To characterize the equilibrium rates we need to determine κ, σ, and θ as functions of the state variable. We first introduce the following notations:

$$
\begin{aligned}
x_t &:= \frac{C_t^b}{C_t^a/\gamma^a + C_t^b} \\
\gamma_t &:= \left(\frac{C_t^a}{\gamma^a C_t} + \frac{C_t^b}{C_t}\right)^{-1} \\
\overline{\kappa} &:= \gamma\sigma^C \\
\overline{\sigma} &:= \sigma^C + \frac{\zeta' c^b}{\zeta}(\overline{\kappa} - \sigma^C).
\end{aligned}
$$

The following proposition gives the equilibrium values for $\kappa(c^b)$, $\theta(c^b)$, and $\sigma(c^b)$ as functions of c^b, where we drop the dependence on c^b for notational convenience.

Proposition 4.

$$\sigma = \overline{\sigma} - \frac{\zeta' c^b}{\zeta} \frac{\overline{\sigma}}{1 - \frac{\zeta' c^b}{m\zeta}} \left(\frac{\overline{\kappa}}{\overline{\sigma}} - \frac{1 - \tilde{m}\tilde{\theta}}{m}\right)^+ \tag{16}$$

$$\kappa = \overline{\kappa} - \frac{x}{1-x} \frac{\overline{\sigma}}{1 - \frac{\zeta' c^b}{m\zeta}} \left(\frac{\overline{\kappa}}{\overline{\sigma}} - \frac{1 - \tilde{m}\tilde{\theta}}{m}\right)^+ \tag{17}$$

$$\theta^b = \frac{\overline{\kappa}}{\overline{\sigma}} - \left(\frac{\overline{\kappa}}{\overline{\sigma}} - \frac{1 - \tilde{m}\tilde{\theta}}{m}\right)^+ . \tag{18}$$

The differential equation to determine the price-to-dividend ratio ζ is given in the appendix.

We note that these formulas differ from the results in GP because of the different margin constraint in our setting. From the proposition it is also obvious that $\kappa = \overline{\kappa}$, $\sigma = \overline{\sigma}$, and $\theta = \overline{\kappa}/\overline{\sigma}$ are the equilibrium values of these variables in an economy where margin constraints never bind. We can now derive a formula for the uncollateralized lending rate r^u.

Corrolary 1. *Agent b's shadow cost of capital is given as*

$$\psi = \frac{\sigma^2}{m} \left(\frac{\kappa}{\sigma} - \frac{1 - \tilde{m}\tilde{\theta}}{m}\right)^+ \tag{19}$$

and the uncollateralized lending rate r^u can be computed as:

$$r^u = r^c + \psi.$$

From this corollary it is obvious that $r^c = r^u$ if margin constraints are not binding. We conclude this section by stating a formula for the frictionless risk-free rate.

Corrolary 2. *If margin constraints are never binding we obtain the following for the risk free rate r :*

$$r^c = \rho + \left(\gamma^a \frac{\mu^C - c^b \overline{\kappa}^2}{1 - c^b} - \frac{1}{2}\gamma^a(\gamma^a + 1) \left(\frac{\sigma^C - c^b \overline{\kappa}}{1 - c^b} \right)^2 \right) \frac{1 - c^b}{1 + (\gamma^a - 1)c^b}. \quad (20)$$

Further, $r = r^c = r^u$.

3.4 Model Calibration

We use the same parameters as GP to calibrate our model. The parameters are $\mu^C = 0.03$, $\sigma^C = 0.08$, $\gamma^a = 8$, $\rho = 0.02$, $m = 0.4$. Additionally, we assume that both buying and selling the CDS requires an initial margin of $\tilde{m} = 0.1$. We compute yield spreads for the safe sovereign as the difference between the collateralized rate r_t^c and the frictionless risk-free rate using Equations (15) and (20). The CDS premium is computed according to Equation (12). We assume that $\tilde{\theta} = 0.025$, meaning that 2.5% of agent b's wealth are dedicated to selling CDS on the safe sovereign.[8]

Figure 3 exhibits the results of this calibration. Both CDS premium and yield spread are computed as functions of c^b, the relative consumption of the $b-$agent.

[8]We use the following approximation to come up with this number. According to the Federal Reserve Bank of St. Louis, dealer-broker net worth was approximately 100 billion USD during our sample period. As we show in Table 1, the CDS notional outstanding for Germany, Great Britain, Japan, and the United States is approximately 25 billion USD. Assuming a margin requirement of 10% for selling the CDS gives the assumed 2.5%.

As explained above, a lower c^b indicates a worse state of the economy. Figure 3 shows that yield spreads decrease sharply as soon as margin constraints become binding, which happens for $c^b = 0.22$.[9] As c^b decreases below 0.12, the yield spread starts increasing again. This is because, as $c^b \to 0$ the model converges to an economy where agent b's binding margin constraint does not affect the equilibrium. The CDS premium, on the other hand, increases monotonically as soon as margin constraints start binding. As soon as margin constraints start binding, agent e requires a positive CDS premium. This premium increases with the shadow cost of capital.

Note that this mechanism is triggered by two effects. First, binding margin constraints increase the shadow cost of capital and thereby increase the CDS premium. The increase of the CDS premium in the model is only driven by the increasing shadow cost of capital and not by an increased credit risk of the safe sovereign. The second effect is that as b investors cannot engage in as much collateralized borrowing as they would like to. Hence, the supply of safe assets in the economy decreases.[10] In order to decrease the demand for safe assets the yield on r^c decreases. Since we assume that the bond yield moves in lockstep with r^c the convenience yield of the safe government bond increases.

Interpretation of the Results

We now compare the results of our model calibration to the time-series of German CDS premia and yield spreads from Figure 1. Qualitatively, our model is capable of explaining why CDS premium and yield spread tend to move in opposite directions during times of financial distress. As soon as margin constraints start

[9] This value depends on the fraction of wealth that agent b invests in CDS. The more CDS, the earlier his margin constraint for buying risky assets starts binding.

[10] We need to implicitly assume that the amount of government bonds stays constant during economic downturns. This assumption is reasonable because governments don't start issuing more bonds immediately when economic conditions deteriorate.

binding the CDS premium increases due to a higher shadow cost of capital and the yield spread decreases due to risk-averse agents' demand for safe assets. This finding is in line with German CDS premia and yield spreads, which tend to move in opposite directions during times of financial distress. Both the peak of the CDS premium and the low of the yield spread are reached at the end of 2011, which was the height of the European debt crisis.

Comparing the quantitative predictions of our model to Figure 1 shows some differences. The yield spread in our model decreases sharply and more than 3 times faster than the CDS premium as soon as margin constraints start binding. There are two reasons for this quantitative prediction. First, since we made Assumption 1, all rates in our model are instantaneous short rates. As noted by Krishnamurthy and Vissing-Jorgensen (2012), the convenience yield of short-term government bonds is higher and more volatile, especially during times of financial distress, than the convenience yield of long-term government bonds. Second, our model abstracts from any other drivers of the CDS premium, such as speculation or fears of a potential breakup of the Eurozone. In our model there is no credit risk and the CDS premium is an instantaneous rate. Hence, the seller does not require a risk premium to compensate him for potential future increases in the CDS premium. Instead, the CDS premium is purely driven by the seller's funding liquidity issues.

4 Sovereign CDS and Regulatory Requirements

In this section we justify key model assumptions. We first provide an overview of the amounts of sovereign CDS outstanding and its main holders. Afterwards, we use the regulatory requirements outlined in Section 2 to provide sample calculations for Germany that justify why buying CDS contracts can free a part of derivative dealers' margin capital. We conclude the section with a discussion of practical issues with the new regulatory requirements

4.1 The Sovereign CDS Market

We provide an overview of the sovereign CDS market in this section. We first show that the market for safe-haven CDS is a large, relative to other single-name CDS markets, but that only a small fraction of the sovereign bonds is insured using CDS. Afterwards, we provide some evidence that derivatives dealers are net buyers of sovereign CDS. The first observation shows that relatively small trades in the CDS market can impact CDS prices, while much larger volumes of bonds need to be traded in order to have an effect on yield spreads. The second observation supports our modelling assumption that derivatives dealers buy the CDS.

Table 1 provides an overview of the CDS and bond volumes outstanding for 10 of the worlds largest sovereigns. We consider 4 of the 10 sovereigns in our sample 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. 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. Further, putting the CDS net notional outstanding in perspective to the notional amount of bonds outstanding shows that only a small fraction of the sovereign debt outstanding is insured by CDS. We report the percentage of debt insured by CDS contracts in column 5 of Table 1. For most of the sovereigns in our sample, even the riskier ones, less than 1% of the debt is insured by CDS contracts. The four safe havens in the sample are also the four sovereigns with the smallest insured percentage of debt, ranging from 0.61% for Germany to 0.03% for the United States.

Figure 4 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. Normally, it is non-dealers, or end-users, who have a demand for CDS. The data in Figure 4 is from the Depository Trust and Clearing Corporation (DTCC), who publishes weekly information on the amount of sovereign CDS bought and sold by dealers. Unfortunately, there is no information for the buyers and sellers of individual sovereigns available. Hence, we can not 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.

4.2 Sample Calculations for the Case of Germany

In this section, we provide sample calculations for the new CVA capital charge using data on Germany. We focus on the effect of interest-rate swaps (IRS) outstanding since these are the by far largest OTC derivatives. A recent ISDA study (ICMA (2011)) claims that as much as 50% of all sovereign CDS outstanding could be related to the new regulation. We confirm this number and further provide justification for Assumption 2 in our model. Table 2 shows that the Bundesrepublik Deutschland Finanzagentur (Bund) has a huge amount of capital market swaps (both payer- and receiver swaps) outstanding.[11]

Recall that the dealer computes an expected exposure towards its counterparty, which is positive if the position becomes a liability for the counterparty. Assume the dealer is paying a fixed coupon and receives floating payments from the sovereign in return. Then, from the bank's perspective, the sovereign has the option to default on the swap if interest rates increase. This risk is equivalent to the bank selling an option to the sovereign to enter an offsetting IRS.[12] The option to enter in a swap contract at a future time is called swaption. Since there are

[11] Additionally to that, 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.

[12] See Sorensen and Bollier (1994) for more detailed arguments.

no detailed information about the maturity or swap rate of the contracts, we use at-the-money swaption quotes to approximate the expected exposure assuming that the swap portfolio has an average maturity of 10 years. The swaptions have a maturity of 5 years and give the buyer the right to enter into an IRS with a five year maturity. The quotes in Table 2 refer to at-the-money swaption straddles based on Euribor rates. We describe swaption straddles and these quotes in more detail in the appendix. The price of at-the-money payer and receiver swaptions is equal and we can approximate the expected exposure as:

$$EE_t = Payer_t \times Swaption_t/2 + Receiver_t \times Swaption/2. \tag{21}$$

The resulting expected exposure is reported in column 6 (under EE) of Table 2.[13] To compute the CVA and CVA VaR, we make the following simplifying assumption. We assume a constant LGD of 0.6, a flat CDS term structure based on the value of the 5-year contract, and a constant expected exposure based on the above swaption.[14] With these assumptions, the credit delta CS01 is given as:

$$\text{CS01} = \text{LGD}\left(10^{-4}\sum_{i=1}^{T}\left(t_i \exp\left(-\frac{st_i}{LGD}\right) - t_{i-1}\exp\left(-\frac{st_{i-1}}{LGD}\right)\right)\frac{D_{i-1}+D_i}{2}\right)\text{EE}. \tag{22}$$

This formula is equivalent to the sensitivity of the value of the protection leg of a CDS on the risky counterparty to changes in the CDS premium. This justifies that the derivatives dealer can hedge his counterparty exposure by buying CDS with a notional amount equal to the expected exposure.

[13]We note that our assumption of no netting between payer and receiver swaps 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.

[14]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.

The last three columns of Table 2 report our results for the CVA, CVA VaR, and stressed CVA VaR. We first observe that the CVA VaR is typically 2-3 times higher than the CVA. The reason for this higher CVA VaR is that the VaR calculation is not based on the current CDS premium, but on its historical volatility. That explains why, despite a lower CDS premium in 2012 relative to 2010, the CVA VaR in 2012 is higher than in 2010. 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 last row of Table 2, stressed CVA VaR could be three times higher than the actual VaR.

Implications for the Dealers

Given CVA VaR and stressed CVA VaR, the dealer computes the contribution to its RWA using Equation (4) and has to maintain a certain percentage of the RWA as equity capital buffer. The exact percentage depends several factors. For instance, a systemically important bank needs a higher buffer. We learned from a CVA desk at a major bank that the percentage was 4% under Basel II and is expected to be between 10-15% under the new regulatory requirement. Assuming a required buffer of 10%, the bank would need 10.84, 10.07, and 8.79 billion US dollar of regulatory capital in 2011, 2012, and 2013 respectively. Putting these numbers in relation to the expected exposure, which was 12,028, 11,061, and 11,665 billion USD in 2011, 2012, and 2013 respectively, shows that a reasonable range for $x(s_t)$ is between 0.75 an 0.91.

The alternative to regulatory capital is using CDS contracts to reduce CS01. We made the simplifying assumption of a constant expected exposure and a flat CDS term structure. Assuming funding costs of 10% of the CDS notional (i.e. $m = 0.1$) implies that the bank has to use 1.20, 1.11, and 1.17 billion US dollar to hedge the CVA VaR in 2011, 2012, and 2013 respectively. Comparing these numbers with our estimates for the regulatory capital requirement shows that our Assumptions 2 is reasonable. To justify that the assumption is reasonable for higher CDS premia, we run the following plausibility check. In 2011 $x(s_t)$ was equal to 0.90 and, as reported in Table 2, the CDS premium on Germany was at a high level of 101 basis points. Assuming an expected excess return of 5% on the risky asset and keeping x constant, derivatives dealers would prefer hedging over regulatory capital if the CDS premium is below 400 basis points.

4.3 Practical Issues with Basel III

The new CVA capital charge is subject to an extensive debate. Basing CVA VaR calculations on CDS volatility together with requiring CDS contracts as hedge has caused criticism from the financial industry.[15] The argument is that this combination can create a 'doom loop' (Murphy (2012)), where a higher CDS volatility causes more demand for CDS contracts which, in turn, fuels the volatility of the CDS contract. Further, 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.'[16] 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.

Basel III was first announced in October 2010 and banks started to incorporate the new regulation in their policies afterwards. 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

[15] Among others, Risk magazine (Carver (2011)) and FT alphaville (Murphy (2012)) commented on this issue.

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

credit valuation adjustment (CVA) – from €28 billion to €14 billion'.[17] 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.' These examples show that even before the planned implementation in regional laws by January 2013, banks started hedging their CVA variance risk using CDS. The implementation in regional laws turned out to be slower than expected. As of today, the United States did not implement the new regulatory requirements and the European Union decided to grant an exemption from the CVA charge for sovereigns.[18] According to Risk magazine ('Europe goes its own way on CVA'), this exemption came as a positive surprise for European banks. For instance, the Royal Bank of Scotland stopped reporting the CVA charge for sovereigns which lead to an increase in their equity capital.

5 Empirical Results

In this Section we formalize the analysis of the relationship between CDS premia and yield spreads, started in Figure 1, and extend it to 10 sovereigns. After describing the data, we regress changes in the bond yield on changes in the risk-free rate and changes in the CDS premium. We conclude by running a second regression to verify that the convenience yield of safe-haven bonds is not an omitted variable that biases our results.

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. We study the period from September 2009 to September 2013 and restrict our considerations to sovereigns that have one of the four major currencies, US Dollar, Euro,

[17]See Risk magazine 'Capital or P&L'

[18]See Risk magazine 'Europe goes its own way on CVA'.

Japanese Yen, and British Pound. We further restrict our considerations to the 7 Eurozone countries with the most frequent quotes for both CDS premium and yield spread. The 5-year sovereign CDS data are obtained from CMA. 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 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.

Summary statistics of our dataset are provided in Table 3, where we arrange the data into three different groups of sovereigns. The first group, consisting of Italy, Portugal, and Spain are risky sovereigns. The second group, consisting of Austria, Finland, and France, are less-risky sovereigns but do not have the safe-haven status of the third group consisting of Germany, Great Britain, the United States, and Japan. Table 3 offers a comparison of the summary statistics for the CDS premium with the corresponding yield spread. Except for the case of Portugal, the mean yield spread is smaller than mean CDS premium. Germany is the only sovereigns in the sample with negative mean yield spread. Further, the minimum yield spread is negative for all four safe sovereigns in the sample as well as for Austria and Finland. Great Britain, the United States, and Finland are the only two sovereigns in our sample where less than 200 observations for the CDS premium are available.

5.2 Credit Risk in Bond Yields

The two main drivers of bond yields are the risk-free rate and the credit risk of the issuer. To the extent that the CDS premium measures credit risk, we would expect the yield on government bonds to be significantly related to both, a measure of the riskless rate and the CDS premium. As indicated in Figure 1, this relationship seems to break down in the case of Germany. We now use regression analysis to check whether this breakdown applies to other safe sovereigns, and whether the expected relationship holds for other non-safe sovereign issuers. Table **??** reports parameter estimates and standard errors for regressions of the following form:

$$\Delta yield_t = \alpha + \beta_{rf} \Delta r_t + \beta_{CDS} \Delta CDS_t, \tag{23}$$

where $yield_t$ denotes the bond yield, r_t the corresponding risk-free rate proxy, and CDS_t the corresponding CDS premium.

The results of this analysis are exhibited in Table **??**. We first note that the estimate for α is insignificant and close to zero for all countries in our sample. Further, the proxy for the coefficient associated with the risk-free rate is significant (at a 1% level) and close to 1 for all sovereigns in the sample. Turning to the coefficient for the CDS premium the results are more diverse. For both, risky and less-risky sovereigns, the CDS premium is significant (at a 1% level). For risky sovereigns the parameter estimate is close to 1, and between 0.40 and 0.68 for the less-risky sovereigns. For the four safe sovereigns, the coefficient associated with the CDS premium is only significant for Great Britain. For the other safe sovereigns the CDS premium is insignificant and, for the US and Germany, the parameter estimate is negative. Finally, we note that although the CDS premium is not a significant explanatory variable for Germany and the United States, the R^2's for these countries are above 0.86. This is due to the strong correlation between the bond yield and the risk-free rate proxy. This is in line with our assumption that safe-haven bond yields carry an insignificantly small credit risk premium.

Apart from the group of safe sovereigns, CDS premia reflect the credit risk of the underlying entity. These findings indicate that, for safe sovereigns, either bond yields are not driven by credit risk or that CDS premia for these sovereigns are not a clean measure of credit risk. Great Britain is the only one of the four safe sovereigns where the CDS premium has a significant effect on the bond yield. This observation fits our theory because as of today Great Britain and Portugal are the only two sovereigns in our sample who post collateral in their OTC transactions and hence derivatives dealers do not need CDS to hedge their IRS exposure to Great Britain.

The Convenience Yield of Safe Havens

There are two possible explanations for why the CDS premium is an insignificant variable for safe-haven bonds. First, CDS premia for safe havens are influenced by factors different from credit risk. We provide a model supporting this hypothesis in the previous sections. Second, one might argue 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 (23). We show in the following that this is not a conceivable explanation. 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. Investors are willing to accept a lower yield for the convenience of holding a safe and liquid asset.

We first discuss convenience yield arguments 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 credit risk free. 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 spreads decreases to approximately -40 basis 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.

Disentangling the convenience yield of a government bond from its credit risk is a challenging task.[19] We approximate the convenience yield of German government bonds as the difference between the 3-month Eonia swap rate and 3-month bond yield and proceed accordingly for the remaining three safe sovereigns. 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 our considerations, we add the 3-month proxy of the convenience yield to Equation (23) and run a new regression based on the following equation:

$$\Delta yield_t = \alpha + \beta_{rf} \Delta r_t + \beta_{CDS} \Delta CDS_t + \beta_{CY} \Delta CY_t, \tag{24}$$

where CY_t denotes the convenience yield proxy. In this regression, we focus only

[19] 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.

on the four safe sovereigns in the sample. The results of this analysis are exhibited in Table 5. Surprisingly, the convenience-yield proxy is only significant for Japan where it also increases the significance of the CDS premium. For Great Britain the inclusion of the convenience yield reduces the significance of the CDS premium. Most notably, for Germany and the United States including the convenience yield does not change the sign and significance of the CDS premium. Hence, we conclude that CDS premia are not a clean measure of credit quality for safe sovereigns, even after controlling for convenience yield.

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 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. Selling CDS requires capital because of the initial margin requirement. As economic conditions deteriorate, margin capital becomes more valuable and the CDS seller requires a higher compensation for using his capital. In order to obtain capital relief, derivatives dealers keep buying CDS even with an increased CDS premium.

To back up our theory, we provide a detailed overview of the new regulatory requirements and sample calculations for the case of Germany. We find that more than 50% of the net notional of CDS on Germany outstanding could be traced back to regulatory requirements, a number confirmed by industry research letters. Regressing bond yields for different countries on a proxy for the risk-free rate and on the CDS premium, we find that safe-haven CDS premia are not related to bond yields. In the case of Germany there is a strong negative correlation between the CDS premium and bond yield spreads. Our model is capable of explaining this phenomenon. Bond yield spreads for safe havens are driven by the demand for safe and liquid assets while safe-haven CDS premia are driven by liquidity issues and regulatory frictions.

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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 CMA. CMA provides daily bid and ask quotes and we use

month-end mid-market quotes in our analysis. If there are no data available for the last trading day of the month, we use data from the previous trading day.

2. **Sovereign Bond Yields.** Sovereign bond yields for 5-year bonds are obtained from Bloomberg. 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 overnight swap rates with the same 5 year maturity as the bond yield if possible. 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. Sonia and Tibor rates are not available at the beginning of the sample. For these missing observations we construct a proxy for the overnight swap rates as follows. We use swap rates based on 6 month Libor rates in the respective currency and subtract the spread between the 5-year Libor swap in USD and the 5-year OIS swap rate. 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. DTCC posts weekly CDS volumes on their website.

5. **Swaption Prices and Data.** Swaption prices are obtained from Bloomberg. The swaption quotes are in basis points and refer to 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 refer to swap contracts with zero value, an application of the put-call parity shows that payer and receiver swaption have the same price.

B Proofs

The proofs of proposition 1 and 2 can be found in the text. Taking the Sharpe ratio $\kappa := \frac{\mu - r^c}{\sigma}$ as given, proposition 3 is a direct consequence of Ito's lemma. Note that we drop the subscript t in μ_t and σ_t to facilitate notations and that we have to determine both μ and σ as functions of the state variable in equilibrium.

Proof of Proposition 4:

This proof is basically a summary of proofs $2'$ and 6 in GP. The main difference in our results is that agent b's margin constrained is adjusted for selling CDS, i.e. $\theta \leq \frac{1-m\tilde{\theta}}{m}$.

We start by further exploring the fact that a is unconstrained to get that the deflated price process $P_t\xi_t + \int_0^t C_s\xi_s ds$ is a (local) martingale. Applying Ito's lemma to that gives an ODE for the price-to dividend ratio because the drift of this process needs to be equal to zero:

$$
\begin{aligned}
0 =& 1 + \zeta\left(\mu^C - r^C - \gamma^a\sigma^C(1-c^b)^{-1}(\sigma^C - c^b\sigma\theta^b)\right) \\
& \zeta' c^b\left(r^c - \rho + \sigma\theta^b\kappa - \mu^C - \gamma^a(\sigma\theta^b - \sigma^C)(1-c^b)^{-1}(\sigma^C - c^b\sigma\theta^b)\right) + \\
& \frac{1}{2}\zeta''(c^b)^2(\sigma\theta^b - \sigma^C)^2.
\end{aligned}
$$

Boundary conditions for this ODE are the cases where $c^b = 0$ (an economy with

$a-$agents only) and $c^b = 1$ (an economy with $b-$agents only):

$$\zeta(0) = \left(\rho + (\gamma^a - 1)\mu^C - \frac{1}{2}\gamma^a(\gamma^a - 1)(\sigma^C)^2\right)^{-1}$$
$$\zeta(1) = \rho^{-1}.$$

Further exploring that agent a is unconstrained gives us the following standard CCAPM formula:

$$\kappa = \gamma^a \sigma^{C^a} = \gamma^a \frac{(\sigma^C - c^b\sigma\theta^b)C}{C^a}. \tag{25}$$

To calculate σ we use the price-to-dividend ratio ζ and the relationship $P_t = C_t\zeta(c^b)$. Applying Ito's lemma to that (we only need the diffusion part) gives

$$\sigma = \sigma^C + \frac{\zeta'(c^b)c^b}{\zeta(c^)}(\sigma\theta^b - \sigma^C). \tag{26}$$

In order to calculate θ^b we note that agent b faces the following mean-variance optimization problem with respect to θ^b :

$$(\mu - r)\theta^b - 1/2(\sigma\theta^b)^2$$
$$\text{s.t.: } \theta^b \leq \frac{1 - \tilde{m}\tilde{\theta}}{m}$$

Solving this problem gives:

$$\theta^b = \min\left(\frac{\kappa}{\sigma}, \frac{1 - \tilde{m}\tilde{\theta}}{m}\right) = \frac{\kappa}{\sigma} - \left(\frac{\kappa}{\sigma} - \frac{1 - \tilde{m}\tilde{\theta}}{m}\right)^+. \tag{27}$$

Note that this is the first time that our derivations deviate from those in GP due to the different margin constraint. We now have 3 Equations and 3 Unknowns. Following the procedure outlined in GP, we first insert Equation (27) into Equations (25) and (26) which reduces the problem to two equations. Distinguishing two cases, $\left(\kappa - \sigma\frac{1-\tilde{m}\tilde{\theta}}{m}\right)^+ = 0$ and $\left(\kappa - \sigma\frac{1-\tilde{m}\tilde{\theta}}{m}\right)^+ = \kappa - \sigma\frac{1-\tilde{m}\tilde{\theta}}{m}$ gives the formulas for κ, σ, and θ. ■

Proof of Corollary 1: In equilibrium both agents are long the asset. Therefore, Equation (11) implies:

$$\psi = \frac{1}{m}(\mu - r^c - \sigma^2\theta^b).$$

Plugging in the value for θ^b gives:

$$\psi = \frac{\sigma^2}{m}\left(\frac{\kappa}{\sigma} - \frac{1-\tilde{m}\tilde{\theta}}{m}\right)^+ .$$

Equation (10) gives us the relationship:

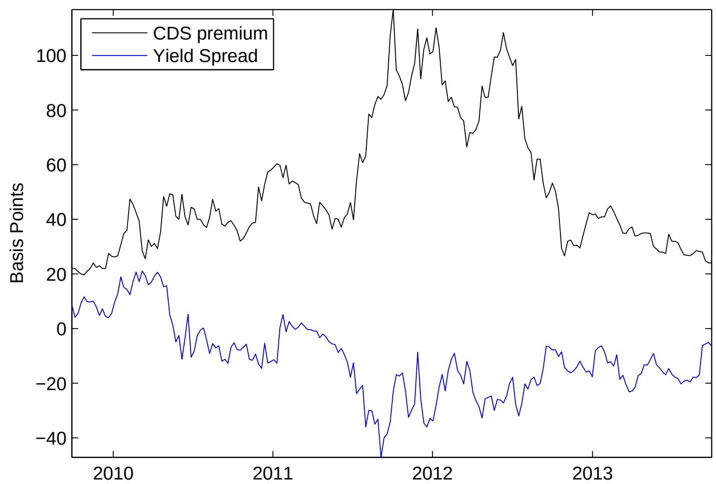
$$r^u = r^c + \psi. \quad \blacksquare$$

Proof of Corollary 2: If margin constraints never bind Equation (19) implies $\psi = 0$, which proves the first part of the corollary. Further, $\left(\kappa - \sigma\frac{1-\tilde{m}\tilde{\theta}}{m}\right)^+ = 0$. From that it is obvious that $\kappa = \overline{\kappa}$, $\sigma = \overline{\sigma}$, and $\theta^b = \frac{\overline{\kappa}}{\overline{\sigma}}$. These are the only places where the margin constraint enters r^c. $\blacksquare$

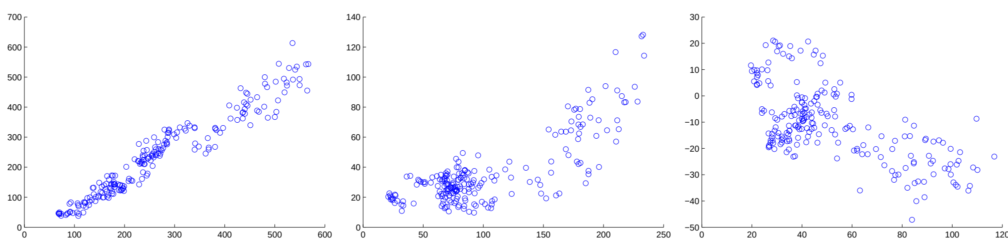
C Figures and Tables

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

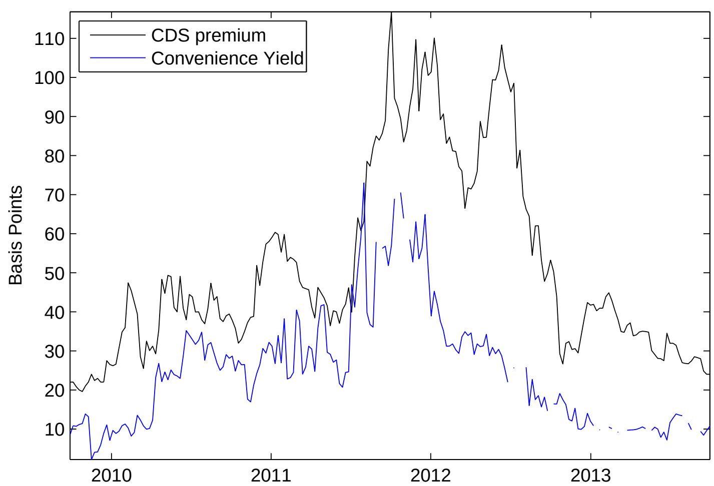


Panel B: Scatter plot of bond yield spreads and CDS premia for France, Germany, and Italy.



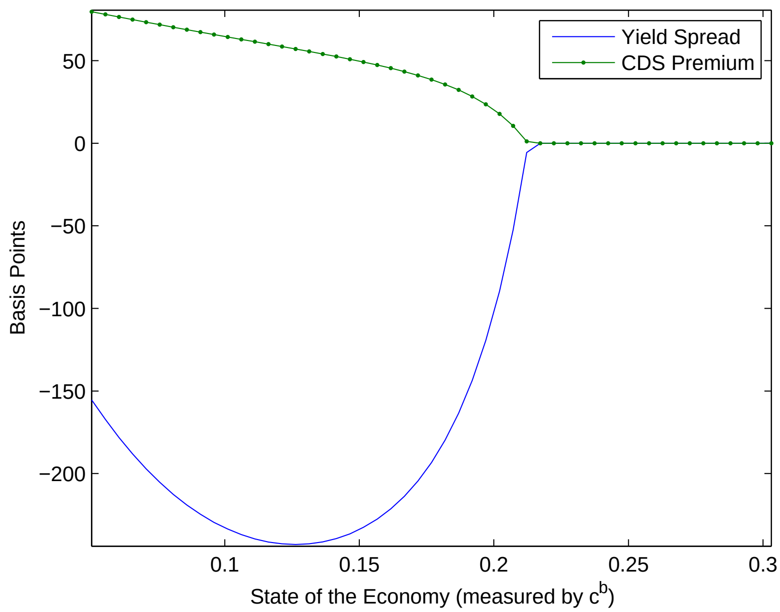
(a) Italy (b) France (c) Germany

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



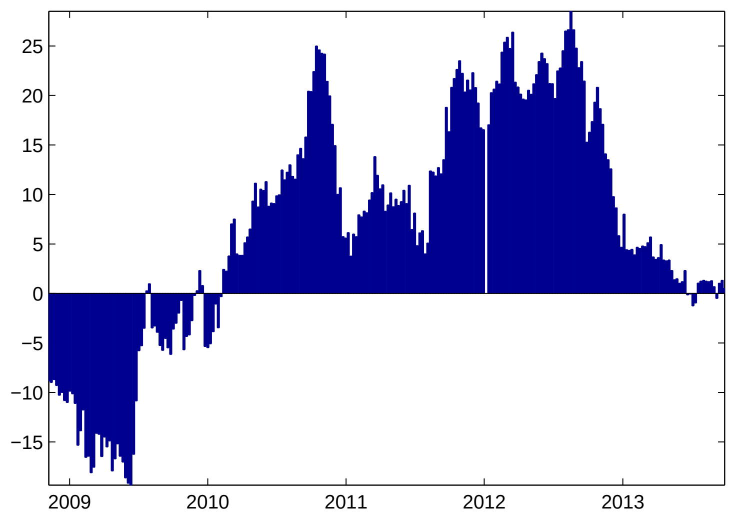
Notes: The Figure shows the time series of the 5-year CDS premium and a proxy for the convenience yield in the German government bonds. The convenience yield is approximated as the difference between the 3-month Euribor rate and the 3-month German government bond yield. This proxy assumes that the 3-month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

Figure 3: CDS premium and Yield Spread in the Model



Notes: This figure shows the yield spread between the yield of a safe sovereign bond and the frictionless risk-free rate (yield spread) compared to the CDS premium on the safe sovereign. On the x-axis is a proxy for the state of the economy c^b, which is the relative consumption of the risk-tolerant agent b relative to aggregate consumption. Before margin constraints bind both rates are equal to zero. As soon as margin constraints start binding the yield spread starts to decrease while the CDS premium starts to increase. In the model, yield spreads start to increase again for $c^b < 0.12$, this happens because for $c^b \to 0$ the model converges to an unconstrained economy.

Figure 4: 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 for Germany.

	Basis Points			Mio USD				Mio USD		
	CDS	Worst Case	Swaption Straddle	CS01	EE	Payer Swap	Receiver Swap	CVA	CVA VaR	Stressed VaR
2008	46	64	575	9.12	9,843	158,106	184,269	725	1,763	1,766
2009	26	93	507	7.34	7,665	131,957	170,463	329	2,053	2,283
2010	59	87	573	7.84	8,650	122,814	179,216	811	2,036	2,439
2011	101	142	691	10.16	12,028	152,230	195,741	1,870	4,334	4,335
2012	42	104	588	10.32	11,061	198,630	177,918	743	3,216	4,844
2013	24	53	658	11.21	11,665	174,021	180,664	457	1,771	5,261

Notes: If not noted otherwise all data are year-end. Swap amounts outstanding are originally provided in Euro by the Bundesrepublik Deutschland Finanzagentur (Bund). 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 (3), (22), and (21) 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. *Data are not year-end but from September 2013.

Table 3: Descriptive Statistics for Sovereign Credit Default Swap Spreads and *Sovereign Bond Yield Spreads (in Italics)*.

	Mean	Standard Deviation	Minimum	Median	Maximum	Serial Correlation	N
Italy	268.87	134.01	68.22	241.82	567.02	0.975	210
	236.22	*136.16*	*37.85*	*228.93*	*613.20*	*0.975*	*210*
Portugal	586.03	379.73	53.42	460.31	1,762.10	0.979	210
	632.56	*445.04*	*35.80*	*476.70*	*2,075.05*	*0.984*	*208*
Spain	289.31	123.88	67.95	264.84	620.30	0.970	210
	257.63	*126.22*	*38.75*	*254.70*	*677.30*	*0.963*	*210*
Austria	89.98	49.83	28.74	74.54	224.39	0.977	210
	39.35	*28.96*	*-1.45*	*36.93*	*167.75*	*0.923*	*210*
Finland	40.23	19.57	16.02	30.75	89.90	0.979	210
	11.18	*11.23*	*-9.20*	*10.53*	*41.45*	*0.813*	*194*
France	102.69	54.49	21.01	81.80	233.79	0.978	210
	36.21	*22.81*	*9.70*	*29.65*	*128.20*	*0.904*	*210*
Germany	51.60	24.65	19.62	42.41	116.82	0.975	210
	-10.64	*13.78*	*-47.15*	*-11.98*	*21.05*	*0.940*	*210*
GB	64.56	17.46	27.84	65.29	100.95	0.956	197
	8.49	*13.74*	*-36.00*	*7.90*	*45.10*	*0.921*	*210*
US	40.64	8.86	18.51	41.31	63.32	0.910	185
	5.80	*7.55*	*-18.05*	*8.00*	*18.60*	*0.931*	*210*
Japan	83.92	21.81	44.24	79.45	151.83	0.957	210
	9.98	*5.83*	*-4.55*	*9.50*	*20.95*	*0.911*	*207*

Notes: The table reports summary statistics for weekly spreads for five-year sovereign CDS contracts and five-year bond yield spreads (measured as bond yield minus five-year overnight swap rate) for the September 2009 to September 2013 period. All spreads are measured in basis points.

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

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

	Rate		CDS		R^2
Italy	1.02***	(0.22)	0.84***	(0.08)	0.6
Portugal	1.64***	(0.40)	0.98***	(0.06)	0.7
Spain	0.88***	(0.18)	0.94***	(0.07)	0.67
Austria	1.18***	(0.08)	0.68***	(0.15)	0.59
Finland	1.19***	(0.07)	0.39**	(0.19)	0.74
France	1.22***	(0.07)	0.59***	(0.09)	0.66
Germany	1.19***	(0.05)	-0.01	(0.09)	0.86
GB	1.04***	(0.06)	0.28**	(0.13)	0.79
US	0.99***	(0.02)	-0.08	(0.06)	0.94
Japan	0.85***	(0.09)	0.02	(0.03)	0.58

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, and CDS_t is the CDS premium. Standard errors in parenthesis are Newey-West heteroscedasticity robust. **Significant at 5% level, ***Significant at 1% level.

Table 5: 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
Germany	1.19***	(0.04)	-0.05	(0.09)	0.01	(0.09)	0.87
GB	1.12***	(0.07)	0.55***	(0.19)	0.05	(0.13)	0.83
US	0.99***	(0.02)	-0.07	(0.06)	-0.01	(0.14)	0.94
Japan	0.85***	(0.09)	0.04	(0.03)	0.59***	(0.22)	0.62

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 1% level, *** Significant at 1% level.