Price Discovery in the Credit Markets

Andrey Pavlov[a]
Eduardo Schwartz[b]
Susan Wacther[c]

November 15, 2017

We derive the optimal credit default swap premium a financial institution requires to assume the default risk of fixed income instruments. This premium is a function of the institution's capital and current exposure. In most cases, an institution requires an increasing premium to assume additional risk. However, we show that an under-capitalized institution that already has substantial default risk exposure would engage in risk-shifting and assume more risk at lower rates. In other words, the presence of a financial institution with large default risk exposure in the market reduces the premium required to insure additional risk. Therefore, negative signals about the default risk of the debt instruments may vastly increases the quantity of insured instruments with no effect on insurance premium. In fact, default insurance premiums decline in the face of increasing demand. Consistent with this, prior to the recent financial crisis, the credit default swap issuance increased greatly, as did the volume of the underlying nontraditional mortgages, but the data suggests that required premiums stayed constant or declined.

Credit Insurance, Credit Default Swaps, Price Discovery

---

a. Professor of Finance, Beedie School of Business, Simon Fraser University, apavlov@sfu.ca.
b. Ryan Beedie Professor of Finance, Beedie School of Business, Simon Fraser University, eduardos@sfu.ca
c. Sussman Professor, Professor of Real Estate and Finance, The Wharton School, University of Pennsylvania.

1. Introduction

One of the main puzzles of the recent financial crisis is that the issuance of credit default swaps (CDS) on mortgage backed-securities increased substantially in the 2005 to 2007 period, while the premiums remained insensitive to the credit worthiness of the underlying mortgages or even declined (Levitin, Lin and Wachter 2017). For instance, Arentsen et. al. (2014, Table 3) document that the percentage of Mortgage-Backed Securities (MBS) with concurrent CDS coverage increased from 26% in 2004 to 54% in 2006, with the percentage as a portion of an increasing volume of MBS securities over the same period. Similarly, Fostel and Geanakoplos (2012, Figure 3) document a sharp increase in CDS issuance through the middle of 2008. In other words, the total volume of CDS issuance for MBS more than tripled in the 2004 – 2007 period, and remained high even through the first half of 2007, when the signs of a potential mortgage-related crisis became clear.

At the same time, as Stanton and Wallace (2012) document, the CDS premiums were not at all sensitive to the credit quality of the underlying MBS even as measured by readily available public information. Even more strikingly, Arentsen, et. al. (2015) document a higher default concentration in mortgage pools with concurrent CDS coverage.

In other words, CDS volume consistently increased during the 2004-2007 period with no change in the observable credit quality-adjusted spreads. When considering additional, unobserved, credit quality, as in Arentsen, et. al (2015), CDS spreads likely declined.

CDS is a way for a financial institution to assume the default risk of a fixed income security, such as a MBS tranche. The buyer of the CDS pays a premium to the financial institution for the assumption of default risk. Standard economic theory and intuition suggest that an increased demand for CDS leads to increased premiums. Increased demand for CDS (relative to the total fixed income market) suggests that investors are revising their default risk estimates and require more insurance. At the same time, a CDS issuer should increase the premium required to issue additional CDS because doing so puts the firm at risk. Yet, in the pre-crisis period, the CDS credit quality-adjusted spreads remained unchanged and even declined on an increasing volume.

Particularly striking is the finding of Arentsen et. al. (2014) that loans packaged in MBS that had CDS available substantially under-performed other securitized loans. Not only were financial institutions taking on more risk at lower premiums, but they were also apparently doing so with inadequate screening of the MBS they insured.

We develop a simple model of a financial institution that has a valuable intermediation business that generates positive profits. The financial institution can also issue CDS, which provides immediate revenues from the CDS spread, but exposes the firm to future losses if the underlying instruments experience default. When the CDS exposure is small relative to the capital of the institution, issuing additional CDS requires increased spread, just as standard intuition would suggest. However, if the financial institution already has a large CDS exposure and is under-capitalized, further issuance comes at a lower premium. The intuition behind this result is that the financial institution is likely to lose the profitable lending business if CDS losses become large even with the current exposure, so assuming further risk is of no consequence. Yet, if CDS losses do not materialize, the institution profits from the CDS spreads it collects.

The above risk-shifting argument is based on two assumptions. First, the financial institution is able to borrow at the risk-free rate, such as LIBOR or OIS, even if its capital (assets minus liabilities) is below the regulatory required level. Second, the buyers of credit protection do not price in counter-party risk. We justify these two assumptions by appealing to the fact that it is difficult for outsiders to observe the true financial condition of a complex financial institution. Empirically, firms such as Bear Sterns and Lehman Brothers were able to borrow overnight at very low rates up until the moment they collapsed.

In addition to the above two direct risk-shifting assumptions, major CDS issuers also engage in too big to fail, or too interconnected to fail, risk-shifting, as noted by Markose, et.al. (2012). While we do not model this aspect of risk-shifting in our model, we note that the possibility of such risk-shifting at the social level makes the negative consequences we show in our work potentially even more significant. Furthermore, Bolton and Oehmke (2011) show that CDS underpricing affects creditor behavior and potentially leads to inefficiently high incidence of costly bankruptcies.

Our approach can be viewed as a formal treatment of many conclusions Stulz (2010) and Zingales (2008) reach on CDS research and contribution to the crisis. Specifically, their work points out that some (many) CDS issuers did not have the ability to bear the risks they took on.

Our work shows that such seemingly irrational behavior is actually justified and should have been expected.

We begin by describing the model setup in Section 2. Section 3 provides the solution of the model and Section 4 gives some illustrative examples to graphically show the main insights of the paper. Section 5 concludes.

2. Model Setup

In this section we develop a simple model of a financial institution which has only two distinct sources of revenue: traditional lending and issuance of credit default swaps (CDS). The traditional lending is a profitable business (positive expected profit), consistent with the assumption that financial institution charters or brands are valuable and once obtained represent positive NPV projects. Specifically, we assume the risk-neutral change in the capital stock due to the cash flow generated from the traditional lending business is:

$$dX = (\mu - \Omega)dt + \sigma dz, \qquad (1)$$

where X denotes the current capital of the lender, which without loss of generality is normalized to be zero at the minimum capital requirement, μ is the expected arithmetic growth in capital when the lender is in business, Ω denotes the risk premium required by investors in the company, σ is the volatility of capital flows from normal business operations. With the risk premium adjustment, Ω, Equation (1) is the risk-neutral process for capital, *X*.

We choose an arithmetic Brownian motion for the lender's capital changes to allow for the possibility of negative levels of capital (below the minimum capital requirement).

Lenders/insurers do not cease operations the moment their capital falls below their minimum requirements. Instead, they continue operations through borrowing from other financial institutions or central banks.

More importantly, long-standing financial institutions are able to continue operations and earn income even with negative capital. To some extent this reflects the correct belief that the franchise still has value and shareholders may contribute additional capital over time to mitigate the shortfall. When the capital shortfall becomes substantial, this belief is no longer correct as the business approaches its abandonment boundary. However, lender/insurer customers, even sophisticated customers, are unlikely to correctly infer the abandonment boundary, and even unlikely to know that the capital deficiency is large. This is one of the two frictions that ultimately drives the results of our model.

In addition to the traditional lending/insurance business, the financial institution we model can issue credit default swaps (CDS) which pay certain premium continuously but expose the capital of institution to potential default with some probability which we model as a Poisson jump. Adding CDS to the traditional lending modifies the process for capital as follows:

$$dX = (\mu + Ck - \Omega)dt + \sigma dz - Cgdq, \tag{1}$$

where C denotes the total issuance of CDS, k denotes the CDS premium continuously collected by the issuer, g denotes the exposure of the lender in case the underlying security defaults, and dq denotes the Poisson jump process with jump probability λ.

The institution is allowed to pay dividends to shareholders only if its capital exceeds the minimum capital requirement, normalized to zero in this case. If the capital falls below the minimum capital requirement, shareholders are required to contribute capital to the institution.

The exact form of the dividend policy, especially the required capital contributions, is not crucial for our model. However, some contribution from shareholders that is proportional to the size of the capital shortfall is necessary for our conclusions. Absent such required contribution, shareholders would have no incentive to contribute to the firm and the firm's capital could become infinitely negative.

Notice that the requirement to contribute capital in our model does not violate the limited liability for shareholders. The capital contributions are required only if shareholders choose to continue operations. At each point, the shareholders can choose to liquidate the business, in which case they have no requirement for further capital contributions. Therefore, the capital contributions are required only if the institution continue operations and are discontinued at the endogenous abandonment boundary.

These assumptions allow a major financial institution to continue profitable operations even if their capital is below the minimum requirement. It also imposes a penalty on the shareholders that increases with the shortfall, inducing an endogenous optimal abandonment. These seem to be reasonable consequences of our assumptions.

For simplicity, and without loss of generality, we assume that dividends are paid at the rate $r\,X$, where r is the risk free rate of interest and where X can be positive (dividends) or negative (contributions), as long as the lender is in business.

3. Model Solution

The risk-neutral no-arbitrage condition for the value of the lender, V, is:

$$rV(X)dt = rXdt + E(dV). \tag{2}$$

Applying Ito's Lemma for jump-diffusion processes we obtain:

$$E(dV) = \left((\mu + Ck - \Omega)\frac{\partial V}{\partial X} + \frac{\sigma^2}{2}\frac{\partial^2 V}{\partial X^2} \right) dt - \lambda(V(X) - V(X - Cg))dt. \tag{3}$$

Substituting (4) into (3) we obtain the following differential equation for the lender value, V:

$$rV(X) = \begin{cases} rX + (\mu + Ck - \Omega)\dfrac{\partial V}{\partial X} + \dfrac{\sigma^2}{2}\dfrac{\partial^2 V}{\partial X^2} - \lambda(V(X) - V(X - Cg)), & \text{if } X \geq \xi + Cg \\ rX + (\mu + Ck - \Omega)\dfrac{\partial V}{\partial X} + \dfrac{\sigma^2}{2}\dfrac{\partial^2 V}{\partial X^2} - \lambda V(X), & \text{otherwise} \end{cases} . \tag{5}$$

The top branch of Equation (5) corresponds to the differential equation that holds when one jump of X in magnitude Cg will still leave the capital of the institution above the abandonment value, while the bottom branch corresponds to the differential equation that holds when one jump takes the capital below the abandonment boundary. The abandonment boundary, ξ, is endogenous and corresponds to the value of X at which V(X)=0. Note that the top branch of Equation (5) captures the cases when capital is large enough to withstand one jump. Furthermore, the probability of two or more jumps in any fixed time interval (t, t+h) declines at a power of two in h, so it tends to zero when h becomes small (Merton, 1976, p. 128). Therefore, there is no need to consider capital levels that can survive two or more jumps as separate cases.

The solution to Equation (5) is:

$$V = \begin{cases} \dfrac{r(m+Ck)}{(r+\lambda)^2} + \dfrac{r}{r+\lambda} X + A_1 \exp(b_1 X) + A_2 \exp(b_2 X), & \xi \le X \le \xi + Cg \\ \dfrac{m+Ck-\lambda Cg}{r} + X + F \exp(hX), & \xi + Cg < X \end{cases} \tag{6}$$

where $m = \mu - \Omega$, ξ is the abandonment boundary at which shareholders optimally discontinue operations, and $A_1, A_2, F, b_1, b_2,$ and h are arbitrary constants. Substitute the value function from Equation (6) into Equation (5), one branch at a time. The top branch provides the following expression for b_1 and b_2:

$$b_{1,2} = \frac{1}{\sigma^2}(-m - Ck \pm \sqrt{(m+Ck)^2 + 2\sigma^2(r+\lambda)})$$

The bottom branch provides an implicit equation for h:

$$r + \lambda - \lambda e^{-Chg} = (m+Ck)h + \frac{\sigma^2 h^2}{2} = 0$$

which we solve numerically.

This leaves us with the constants $A_1, A_2, F,$ and ξ, which we solve using the value matching and smooth pasting conditions at the abandonment boundary, ξ, and at the abandonment boundary plus one jump, $\xi + C g$.

4. Results

In this section we graphically present the main insights coming out of the model. For all the numerical solutions reported below we use the parameters values presented in Table1.

Figure 1 depicts the value function for various levels of CDS issuance, C. If the lender does not issue any CDS, $C = 0$, then the value function represents a typical convex curve reflecting the abandonment option value, the value of the ongoing business, and the current capital, X. As the lender starts issuing CDS, i.e., $C > 0$, two things happen. First, the abandonment boundary increases and the value function has convex and concave parts. The increase of the abandonment boundary is significant and concerning from a social point of view. Not only the lender is riskier because of the CDS they issue, but also they are likely to abandon the business at increasingly lower deficits. Simply put, the lender transfers more and more of the CDS risk to its creditors.

Next, we solve for the required CDS premium, k, to induce the lender to issue CDS. Note that if the continuously collected premium, $k = \lambda g$, issuing a CDS has zero expected profit. This is the actuarially fair premium where the premium collected just compensates for the expected loss. However, the institution in our model would not be willing to issue CDS at this premium even if it were risk-neutral. The reason is that this is a zero expected return project that nonetheless introduces volatility, which, in turn, puts the valuable bank charter at risk. Therefore, λg represents a lower bound for the required CDS premium.

We solve for the required premium, k, in two different ways. First, we consider a lender who has no CDS on their books and is considering issuing new CDS in the amount C. The scenario we envision is that a client approaches the lender with a request for CDS in that amount. We then find the premium a lender requires to issue the CDS so that its total firm value remains unchanged. Specifically, we solve for k such that $V(X, 0,0) = V(X, C, k)$. The left hand side of this equation does not actually depend on k, as the lender CDS exposure is 0, as indicated by the second argument. For a fixed C, the right-hand side is a monotonically increasing function of k. For $k = \lambda g$, any issuance of CDS is value-decreasing, $V(X, 0,0) > V(X, C, k)$ because the price of the CDS just offsets the expected future losses and includes no compensation for putting the positive profits from normal operations at risk. Therefore, there is a unique k that preserves the firm value, $V(X, 0,0) = V(X, C, k)$.

Figure 2 depicts the required premium for different levels of current lender capital, X, and for a range of new CDS exposure, C. For all levels of capital, the required premium initially increases in CDS exposure, C, as one might expect. This reflects the additional risk a lender faces from issuing a larger CDS. However, if the lender is under-capitalized, $X<0$, after a certain CDS size the lender requires lower premiums to increase the size of the CDS to be issued. In other words, the lender charges a relatively lower premium to take on relatively more risk.

The flat line on the bottom of Figure 2 depicts the actuarially fair CDS price that just offsets expected future losses ($k = \lambda g$). As discussed above, the financial institution we are considering needs to charge a price above that minimum to not only offset future expected losses but also compensate for the risk CDS issuance poses to the normal profitable operations.

An alternative, and more general, way to compute the required CDS premium is to consider the cost of issuing additional CDS conditional on a certain level of CDS already on the books. This is the marginal cost of issuing more CDS, as opposed to the average cost depicted in Figure 2. Specifically, we solve for the required k such that $V(X, C, k) = V(X, C + \Delta C, k + \Delta k)$, where ΔC and Δk denote the increase in CDS exposure and the change in the CDS premium, respectively. More formally, we solve $\left.\frac{\partial k}{\partial C}\right|_{V=constant}$.

Figure 3 depicts the marginal CDS premium, k, required to induce the lender to issue more CDS, conditional to already having some exposure, C. Regardless of capitalization level, the required marginal CDS premium is increasing for low level of current exposure. However, once a certain level of exposure is achieved, the required marginal CDS premium declines. This is true for all levels of capitalization, but especially significant for institutions with low or negative capitalization levels. For instance, an institution with capitalization of $X = 0$, would require a declining CDS premium to increase their exposure once they have current exposure level of 1.5. The CDS premium in this case declines from .8 to .6 as exposure already on the balance sheet increases. For an under-capitalized lender, $X = - 10$, the decline in marginal required premium starts at exposure of .7. In this case, the required premium falls from above 1 to less than .6 as the current exposure increases.

Beyond the risk-transfer concerns, the above result offers the disturbing possibility that as the market receives negative signals about the value of the underlying asset, lenders are able and willing to issue CDS at lower rates. The negative signal certainly would get rational investors interested in acquiring more CDS. In a normal market, this would increase the CDS premium, which, in turn, would dampen the lending markets and ultimately cool down the underlying asset markets. However, since the CDS premiums decline rather than increase in the face of increased demand for CDS, we see a large increase in volume of CDS issuance, but the premium remains constant or declines. Therefore, the signal that is sent to the lending market is one of encouragement, making cheap financing easily available and relaxing lending standards.

Incidentally, this is perfectly consistent with the events that preceded the 2008 financial crisis. CDS premiums declined through 2008 across all markets, CDS issuance increased tremendously, and lending spreads declined in response.

In addition to the declining CDS premium noted above, both Figures 2 and 3 suggest that a well-capitalized lender/insurer requires smaller premiums relative to less capitalized industry players for low levels of CDS issuance. Therefore, the model predicts that at the early stages of a market when total CDS issuance is small relative to the capitalization of most financial institutions, well-capitalized firms gain market share and dominate the market. However, once the total CDS market increases, well-capitalized players need to charge higher premiums than their competitors and, therefore, lose market share. In other words, as the CDS market expands, and likely becomes riskier, less capitalized firms gain market share. Put together, our model suggests that risk-shifting occurs not only at the individual firm level but also likely at a market-wide level.

5. Conclusion

The apparent disconnect between the demand for CDS on mortgage-backed securities prior to the financial crisis and the pricing of those securities is often cited as one of the main contributing factors to the overall mispricing of mortgage-related investments. The explanations for this disconnect are often rooted in behavioral or agency conflict explanations. In this paper, we formalize these explanations in a simple model of a financial institution with profitable ordinary business and a CDS issuance business. Specifically, we model the following agency conflicts/market failures: the amount of CDS already issued does not affect the profitability of the ordinary business, nor does it affect the borrowing cost of the financial institution.

This approach demonstrates that after a certain level of CDS has been issued, all financial institutions would require lower and lower CDS premiums for issuing more CDS. In other words, as the demand for CDS increases its price drops. While this is a typical conclusion of any production function with fixed costs, it is highly unusual for financial contracts which have no fixed cost but have increasing variable costs (risk) to behave this way.

Even more strikingly, as the total CDS issuance in the market place increases, less capitalized issuers gain market share, replacing well-capitalized firms. Thus, there is risk-shifting not only within individual firms, but also between competing CDS issuers.

The above findings have significant policy implications. First, when the CDS market is small relative to the overall capitalization of CDS issuers, the pricing functions behave as expected. Increases in demand for credit protection through CDS generates increasing CDS premiums. This, in turn, would appropriately affect the MBS pricing and send a correct signal to the underlying real estate markets.

Once the CDS market becomes significant relative to the overall capitalization of the issuers, then the above mechanism breaks down and CDS pricing declines with increase in CDS demand. When this occurs, the underlying MBS and real estate markets receive a signal that appears to indicate low (and falling) overall risk, while the actual risk is increasing. This suggests that, first and foremost, the CDS issuance needs to be kept small relative to the capitalization of each firm. Second, the market share of firms needs to be monitored to ensure that if under-capitalized firms start gaining market share, their activity is curtailed either through direct regulation or through making the capital shortfalls public. Finally, the total volume of CDS issued, and the pricing of CDS contracts, needs to be reported publically so that CDS purchasers can assess the potential counter-party risk on their own.

References

Amato, J. D. and Gyntelberg, J. (2005). CDS index tranches and the pricing of credit risk correlations.

Arentsen, E., Mauer, D. C., Rosenlund, B., Zhang, H. H., and Zhao, F. (2015). Subprime mortgage defaults and credit default swaps. The Journal of Finance, 70(2):689–731.

Ashcraft, A. B. and Santos, J. A. (2009). Has the CDS market lowered the cost of corporate debt? Journal of Monetary Economics, 56(4):514–523.

Augustin, P., Subrahmanyam, M. G., Tang, D. Y., Wang, S. Q., et al. (2014). Credit default swaps: A survey. Foundations and Trends® in Finance, 9(1–2):1–196.

Bolton, P. and Oehmke, M. (2011). Credit default swaps and the empty creditor problem. The Review of Financial Studies, 24(8):2617–2655.

Bongaerts, D., De Jong, F., and Driessen, J. (2011). Derivative pricing with liquidity risk: Theory and evidence from the credit default swap market. The Journal of Finance, 66(1):203–240.

Brigo, D., Capponi, A., and Pallavicini, A. (2014). Arbitrage-free bilateral counterparty risk valuation under collateralization and application to credit default swaps. Mathematical Finance, 24(1):125–146.

Crépey, S., Jeanblanc, M., and Zargari, B. (2009). Counterparty risk on a CDS in a Markov chain copula model with joint defaults. Recent Advances in Financial Engineering, pages 91–126.

Criado, S. and Rixtel, A. v. (2008). Structured finance and the financial turmoil of 2007-2008: An introductory overview.

Duffie, D. and Singleton, K. J. (2012). Credit risk: pricing, measurement, and management. Prince- ton University Press.

Fender, I. and Scheicher, M. (2009). The pricing of subprime mortgage risk in good times and bad: evidence from the ABX.he indices. Applied Financial Economics, 19(24):1925–1945.

Fligstein, N. and Goldstein, A. (2010). The anatomy of the mortgage securitization crisis. In Markets on Trial: The Economic Sociology of the US Financial Crisis: Part A, pages 29–70. Emerald Group Publishing Limited.

Fostel, A. and Geanakoplos, J. (2011). Tranching, CDS and asset prices: How financial innovation can cause bubbles and crashes.

Hull, J. C. and White, A. D. (2000). Valuing credit default swaps i: No counterparty default risk. The Journal of Derivatives, 8(1):29–40.

Jarrow, R. A. (2011). The role of abs, CDS and CDOs in the credit crisis and the economy. Rethinking the Financial Crisis, pages 210–234.

Levitin, A. J. and Wachter, S. M. (2010). Information failure and the us mortgage crisis.
Longstaff, F. A., Mithal, S., and Neis, E. (2005). Corporate yield spreads: Default risk or liquidity? New evidence from the credit default swap market. The Journal of Finance, 60(5):2213–2253.

Levitin, A. J., Lin, Desen, and Wachter, S. M. (2017). Risk Premia in the Subprime Crisis. W. P.

Markose, S., Giansante, S., and Shaghaghi, A. R. (2012). "too interconnected to fail" financial network of us cds market: Topological fragility and systemic risk. Journal of Economic Behavior & Organization, 83(3):627–646.

Nashikkar, A., Subrahmanyam, M. G., and Mahanti, S. (2011). Liquidity and arbitrage in the market for credit risk. Journal of Financial and Quantitative Analysis, 46(3):627–656.

Schönbucher, P. J. (2003). Credit derivatives pricing models: models, pricing and implementation. John Wiley & Sons.

Stanton, R. and Wallace, N. (2011). The bear's lair: Index credit default swaps and the subprime mortgage crisis. The Review of Financial Studies, 24(10):3250–3280.

Stroebel, J. C. and Taylor, J. B. (2009). Estimated impact of the fed's mortgage-backed securities purchase program. Technical report, National Bureau of Economic Research.

Stulz, R. M. (2010). Credit default swaps and the credit crisis. The Journal of Economic Perspectives, 24(1):73–92.

Zingales, L. (2008). Causes and effects of the Lehman Brothers bankruptcy. Committee on Oversight and Government Reform US House of Representatives.

Table 1: Parameters used for the numerical solutions

Parameter	Typical Value
Risk-free rate	5%
Size of jump, g	10
Probability of a jump, λ	2%
Positive drift in capital due to operating business, μ	1
Volatility of capital due to operating business, σ	1
CDS issuance, C	Varied between 0 and 10
CDS premium, k	Endogenous

Table 1 reports the base parameter values used to generate the numerical solutions reported in the paper.

Figure 1: Value Function

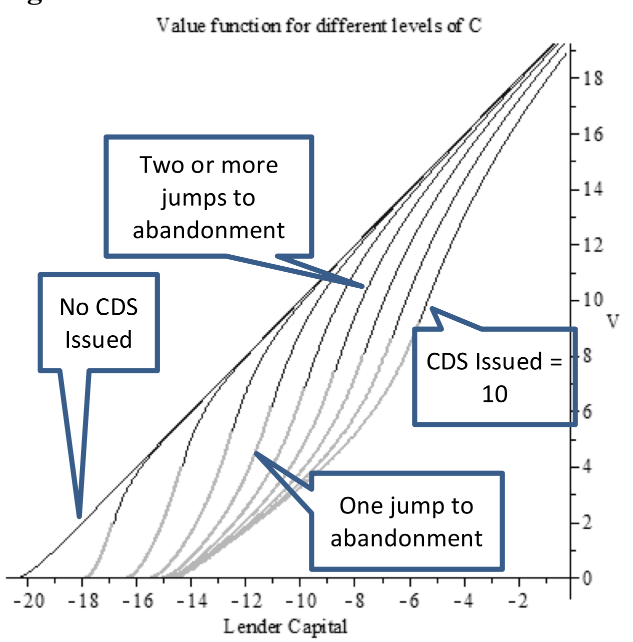

Figure 1 depicts the value function for the lender/insurer as determined by the numerical solution of Equation (6). The horizontal-axis depicts the current lender capital. Only negative values are shown, although the function extends over all positive values as well. As capital increases, the value function approaches a 45-degree line and the abandonment option becomes infinitely small. Each curve on the graph represents one single value function computed for a specific level of CDS issued. The highest value function depicts the solution with no CDS issued. The lowest value function depicts the solution with 10 units of CDS issued. The lower portion of each value function is based on the upper branch of Equation (6) (low capital) and the upper portion of the value function is based on the lower branch of Equation (6) (high current capital). The two functions are matched with value-matching and smooth pasting at the level of capital that is exactly one jump away from abandonment.

Figure 2: Required average CDS premium

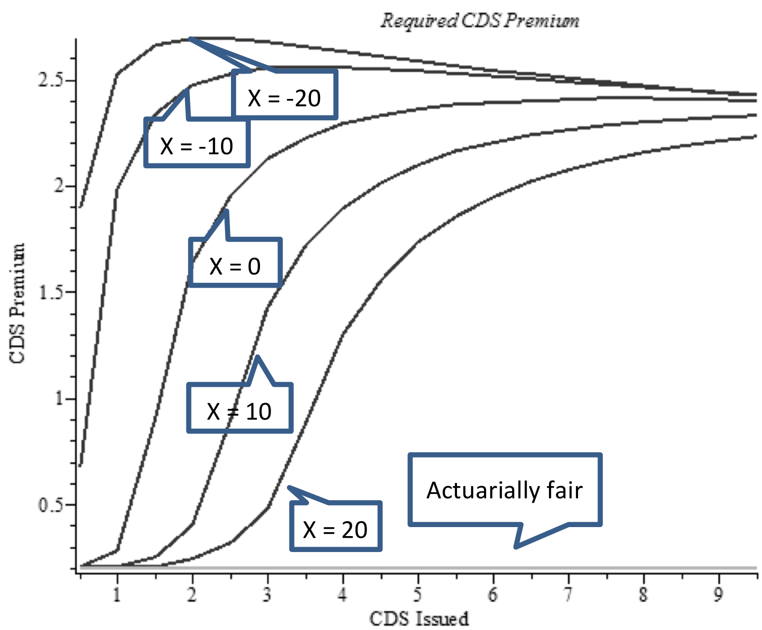

Figure 2 depicts the CDS premium, *k*, that a lender/insurer requires to issue a certain level of CDS, depicted on the horizontal-axis. This is the required premium to move from no CDS issued to CDS issued as depicted on the horizontal-axis. Each line depicts the CDS premium required for different levels of current capital. The required CDS premium increases with the size of the CDS to be issued in all cases when the size of the CDS is small relative to the current capital level. However, when the size of the CDS to be issued increases relative to the current level of capital, the required premium starts to decline. This occurs early if current level of capital is low (X = - 20). Even for relatively higher levels of capital, say X = -10, the required premium declines past a certain CDS size.

Figure 3: Required Marginal CDS premium

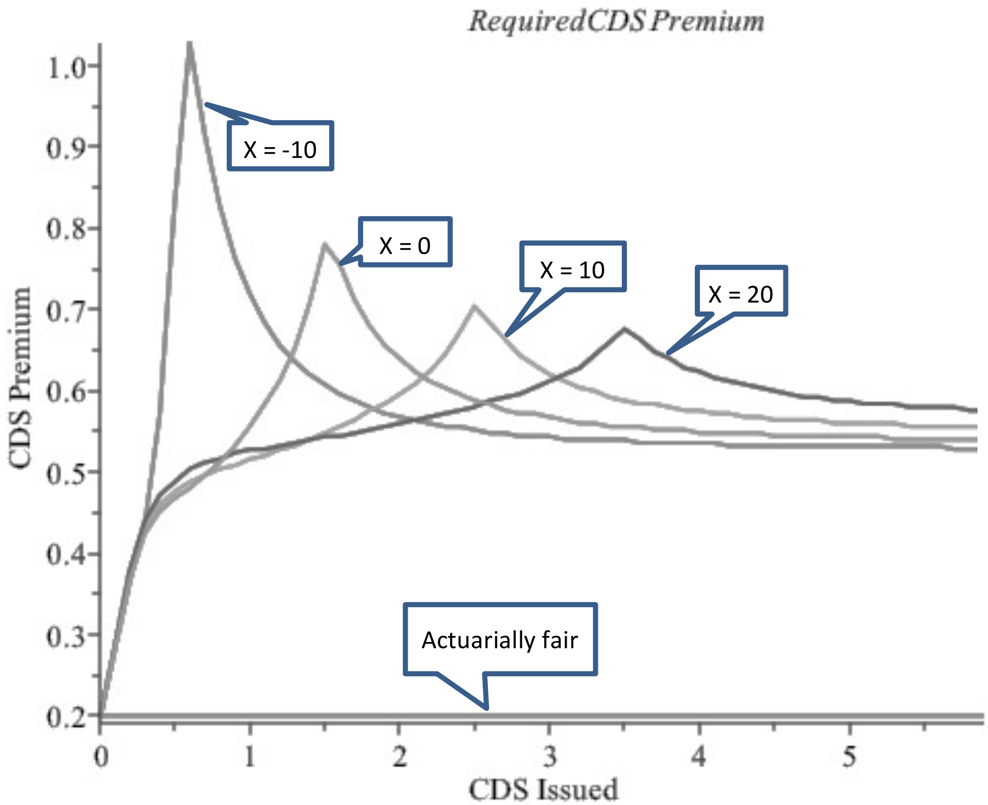

Figure 3 depicts the marginal CDS premium required to issue more CDS when a lender/insurer has already issued a particular level of CDS depicted on the horizontal-axis. The required marginal premium increases in the level of CDS already issued in all cases when the CDS issued is low relative to the capital of the firm. However, once the CDS already issued becomes significant relative to the capital of the firm, the marginal rate required to issue further CDS declines in all cases. This decline occurs early in the case of under-capitalized firms (X = - 10). However, even very highly capitalized firms (X=20), eventually start charging lower and lower marginal premiums to further increase CDS exposure. Comparing the solutions across capitalization levels is also insightful. For low levels of CDS issued, well-capitalized firms are most competitive and likely issue the most CDS. However, if overall CDS exceeds a certain level, the least capitalized firms become most competitive and likely capture the largest market share.