Beyond Capital Regulation: An Underestimated Risk Source

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Abstract

Leverage constraints are an important pillar of bank regulation. Yet, this paper argues that in times of economic turmoil affecting a bank's borrower base at large, the traditional bank risk measures of leverage and capital ratios understate the total increase in bank risk. In a sequence of systematic shocks hitting the borrowers, the impact on a bank's asset value grows disproportionately with every bump due to the concavity of the loan value in the borrower's assets. Although this increase in credit exposure cannot be reflected by capital ratios, a structural default model can capture the added sensitivity. Using a sample of 334 non-financial firms and 27 banks, we demonstrate the nonlinear nature of the changes in banks' risk exposures after a series of shocks to their borrowers and show that the effect is more severe for firms with low ratings. We also simulate the impacts of the same series of shocks under different leverage scenarios and are thus able to assess the magnitude of asset risk relative to leverage risk. Further it appears that the benefit of ex-post deleveraging after a shock is limited despite its high cost. The results emphasize the importance of systematic risk among borrowers and of the ongoing monitoring of changes in economic climate so as to induce banks to provision adequately for risk changes.

Keywords: Capital structure, capital requirements, risk management, regulation

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I. Introduction

The Basel Accord of 1988 marked the first internationally coordinated effort to restrict banks' risk-taking by requiring them to hold a minimum share of their risk-weighted assets as regulatory capital ready to absorb losses, and, despite the additions to the framework made in its subsequent installments in areas such as operational risk, supervision, and liquidity, bank leverage in the wider sense has remained the cornerstone of regulation ever since. For example, at the time of writing, Basel III recommends that a Total Capital Ratio of 8% and a Leverage Ratio of 3% be maintained at all times, and the implementation of the Accord by U.S. agencies goes even further by requiring 6% leverage in the case of systemically relevant banks (and 5% for their holding companies).[1]

Inadequate capital reserves mean that a bank runs a high risk of being unable to meet its obligations under adverse circumstances and it is thus necessary to track the aforementioned ratios closely and enforce the adherence to the set limits. However, there is still the possibility of an increase in riskiness in the course of a successive degradation of a borrower's asset base. If a first shock hitting a borrower is severe enough to transmit to the lender's asset value, the latter can of course restore its capital to the level prevailing before the shock by raising more equity or selling assets. Yet, the unchanged, readjusted leverage ratio may divert the attention away from the hike in (total) bank risk stemming from the fact that the underlying loan is now much more sensitive towards the future financial situation of the borrower, implying that another shock of equal magnitude would materialize in an even steeper loss for the bank. Viewing debt as a contingent claim on the underlying assets, this varying sensitivity goes back to the concavity of the debt value curve and can best be expressed as "delta," a term we conveniently borrow from option terminology.[2] Therefore, the change in the bank's riskiness is larger by the combined

[1]The Total Capital Ratio is defined as the sum of Tier 1 and Tier 2 capital divided by risk-weighted assets, and the Leverage Ratio is Tier 1 capital divided by average total consolidated assets.

[2]The increased bank exposure is best illustrated by the following thought experiment: A bank has an outstanding loan of $100 million with a delta with respect to the borrower's assets of -0.10. If his assets fell by $20 million, then the loan value would in turn decrease by approximately $2 million, meaning that, if nothing else changed, the bank's equity capital would diminish by this amount. However, the bank risk would have risen by more than suggested by the leverage increase alone because the asset delta must have changed, say, from -0.10 to -0.15, implying a loan value impairment of $3 million in the event of another $20 million shock.

effects of reduced capital and higher exposure to its debtor's assets as measured by delta.

In this paper, we study how much of the overall change in bank risk following a systematic shock to the real economy stems from the change in bank capital, the traditional measure, and how much is rather related to the higher volatility of the bank's assets, more precisely the change in the deltas of the bank's approved loans. The hypothesis is that the current focus on bank leverage substantially understates the latter effect.

The analysis relies on a Merton-type (1974) structural model of default. In this kind of model, debt and equity are perceived as financial instruments whose value is determined by fundamentals such as leverage, volatility, debt maturity, and interest rates. Once calibrated to market data, this structural approach affords us the opportunity to analyze the value and sensitivities of borrower and bank debt in a controlled environment. While structural models are founded in sound economic arguments, accounts on their empirical performance at predicting credit spreads have been mixed so far, although they seem more accurate at explaining credit default swap (CDS)[3] than bond spreads.[4] More relevant for our study, Schaefer and Strebulaev (2008) conclude that the Merton (1974) model is well suited for the estimation of hedging ratios, in other words, the sensitivity of the debt value to changes in the asset value, the very essence of what we hope to deduce from the model. For the empirical evidence cited above, but also for the fact that they are more standardized instruments, CDS instead of bond spreads are relied upon to calibrate the model.[5]

The model enters our experiment outlined in the following at two levels: First we simulate two equally-sized systematic shocks striking a bank's borrower base, and the model enables us to evaluate their incremental impact on the value of the loans held by the

[3] A CDS protects the buyer against the losses from the default of a specified reference firm. The seller receives a periodic insurance premium in return, which amounts to the CDS spread in percentage points multiplied by the insured notional principal per year. The contract is unwound at maturity or upon a credit (i.e., default-related) event giving rise to (cash or physical) settlement, whichever occurs first.

[4] To cite only a few, Eom, Helwege, and Huang (2004) found in agreement with Jones, Mason, and Rosenfeld (1984) that bond spreads tend to be significantly understated, yet more recent findings like those of Ericsson, Reneby, and Wang (2007), Zhang, Zhou, and Zhu (2009), Schweikhard and Tsesmelidakis (2014) suggest that structural models explain CDS spreads better. This divergence is reconciled by the realization that bonds reflect a larger share of non-default factors like interest rate risk and illiquidity, while CDSs are considered to come closer to a pure market price for default risk (Leland (2004)).

[5] In further support of CDSs, several authors find that the CDS leads the bond market in price discovery, see, among others, Longstaff, Mithal, and Neis (2005), Blanco, Brennan, and Marsh (2005).

bank together with the debt sensitivities. In a second step, the losses in the market value of the loans translate into an asset shock for the bank. At this stage, the model permits to measure the bank's heightened exposure and to draw conclusions on its stability absent any government backing. The study is based on 27 of the largest U.S. banks. Because the banks' borrowers are not publicly identified, we assume that all banks in our sample hold a representative portfolio consisting of claims to non-financial corporations included in the S&P 500 index that have listed stock and a liquid CDS traded in their name (to provide the critical input factors to the model). This simplification should not matter for our study as we are interested in the impact of economy-wide shocks to corporate assets and their transmission to the banking sector through the lending channel in aggregate terms rather than in drawing comparisons between individual banks.

The main purpose of this paper is to evaluate the importance of a bank's asset risk (i.e., credit exposure) relative to its leverage risk. As will become clear in the course of the analysis, the ultimate answer to the posed problem cannot be given in theoretical terms alone but hinges on quantitative estimates that depend on actual circumstances, e.g., volatility, and the relevant leverage range. Therefore, the designed "stress test" involving the two borrower shocks is assumed to occur slightly before the onset of the 2007-2009 financial crisis, during a relatively calm period, so as not to exaggerate our conclusions with the excessive volatility levels witnessed during the crisis. Nevertheless we test the sensitivity of our results towards changes in volatility and other factors to give a sense of the outcome under alternative circumstances. It may seem tempting to use the unfolding of the crisis as natural experiment for the fall in asset values of the firms in our sample when analyzing the impact on banks. However, given the simultaneous changes in several debt value determinants in the course of the crisis, the effect of the asset shock alone cannot be isolated well enough to allow any sensible, unambiguous inference, which is why a simulation starting from calm, historical grounds, in which we can control for changes in variables unrelated to our inquiry is preferred.

The results support the hypothesis that leverage plays a relatively minor role compared to asset risk and thus that large shifts in leverage would be necessary to compensate even small- or medium-sized shocks to the borrower base. The first of two shocks is relatively unremarkable by itself at the borrower level, irrespective of its size, and even more so at the bank level. For example, a first shock of a 40% magnitude (as percentage of assets) impacts the borrower base moderately considering an average loss in market value of debt of 6.98%. This shock at the corporate level translates into a shock to the banks' loan assets of 3.28%, which reduces bank debt value by just 0.21%. On the other hand, a second equally-sized shock (in terms of pre-shock assets) materializes in a debt impairment of 42.43% at the borrower level which again transmits to banks and is responsible for a 23% and 64.29% fall in asset and debt values, respectively. Moreover, even if the banks exhibited a higher leverage ratio of 15% (up from 8.68%) they would still incur a severe debt loss of 25.07%. Obviously, the moderate change in leverage caused by the first shock conceals a dramatic underlying rise in banks' credit exposure. The mild repercussions of the first shock at the bank level may even remain unnoticed given broader market movements and create the impression that banks' risk can be contained by restoring pre-shock leverage levels. We indeed explore any possible improvement to the situation from deleveraging after the first shock and it appears that neither of the deleveraging strategies considered, be it capital injection, debt-equity conversion or contraction of the balance sheet, achieve to significantly reduce exposure with respect to subsequent shocks, and this despite the costly interventions they entail. For instance, for the 40% shock considered above, debt losses after the second impact do only decrease from 64.29% to 49.01% in case of a balance-sheet contraction, to 53.34% by a conversion of debt into equity, and to 58.78% by injecting new capital. To provide an additional perspective, we ask by how much leverage would need to be increased to make the debt insensitive to a shock of a given size and find that, e.g., additional 11.78 percentage points (pp) of leverage would be required to immunize the debt against a 25% bank-level shock. Such a vast increase in bank equity appears unlikely to become the new regulatory standard anytime soon given the comparatively low minimum requirements in effect nowadays. Instead the results argue in favor of a close monitoring of the systematic component of banks' exposures and adequate provisioning in the case of a significant deterioration of underlying assets.

Our results on the impact of asset shocks on banks can be seen as a lower bound to the actual magnitude for two reasons: First, in the event of an economy-wide shock, one can expect volatility to soar and increase the shock impact because of the increasing slope of the debt value function it induces far away from the default boundary.[6] As mentioned previously, we concentrate on the isolated effect of asset shocks and assume other determinants stay equal. Second, the items we select on the banks' assets side are gross loans and corporate debt securities as reported on *Bankscope*, the most detailed source at our disposal, and they stand for an average of 48.6% of the total assets of our sample banks. Mortgages or asset-backed securities are omitted because of the added complexity of accounting for their collateral, and government bonds are excluded as well.

This paper is most closely related to the literature on bank leverage and capital regulation. The 2008 banking crisis in conjunction with the introduction of a leverage constraint in Basel III have sparked a lively debate on the recommendable level of bank leverage. On one side, putting forward banks destructive risk taking and the cheapness of equity capital, Admati and Hellwig (2013) argue in favor of 25% minimum leverage. In response to this, DeAngelo and Stulz (2014) emphasize banks' irreconcilability with Modigliani-Miller theorems and the social value they create as producers of liquid claims. In their model, high leverage enables banks to successfully carry out this function while bank risk can be contained by concentrating on the risk management of the assets side. Arguing for a more rounded approach, Acharya and Schnabl (2008) point out that regulation should not just be limited to controlling banks' leverage but should also monitor balance sheet ratios such as loans to deposits as well as the aggregate risk to the economy, in line with our conclusion.

To our knowledge, this is the first paper to point out the hidden increased credit exposure and loss potential after a first systematic significant shock to borrowers and to demonstrate how this risk in large part eclipses the additional risk from increased bank leverage. It is also the first paper to analyze bank leverage in comparison to asset risk

[6]Rising volatility would have two effects increasing the debt losses after a shock: First, the described change in the slope; second, a downward shift of the curve, which in itself would add a great deal to debt losses. The most we would consider for the study at hand is the first effect.

within a Merton-type structural model. The results are of wide policy relevance as they question today's dominant focus of regulation on bank capital.

The outline of the paper is as follows. **Section II** describes the basic model and methodology used. **Section III** explains how the model is implemented to assess the losses on the debt of corporates, and how these shocks on the corporate level translate into loan losses and finally shocks to the banks. Results are presented along the way, starting by the shock impact on corporates (**III.A**), followed by the transmission of these shocks to the banks (**III.B**), the sensitivities of the banks' position (**III.C**), the consideration of deleveraging strategies (**III.D**), and finally an assessment of the relative impacts of asset and leverage risk (**III.E**). **Section IV** concludes.

II. The Structural Model

In this section, we start by giving an overview of the general model framework that allows us to estimate the impact of an asset shock to the debt value and calculate sensitivities towards various determinants. Then, we briefly discuss the calibration procedure and present our sample selection and data sources.

A. Model Setup

In his 1974 paper, Merton applies the Black Scholes (1973) formula to model debt and equity as contingent claims on the asset value. The framework relates the value of risky debt to fundamental factors like leverage, volatility, time to maturity, and interest rates, and it enables us to study the impact of shocks in the asset value to firm debt and default risk.

For this study, we apply the extension to the classical Merton setup proposed in Finger et al. (2002) and Stamicar and Finger (2006) that captures the possibility of default at any time through the existence of a default barrier (as first introduced by Black and Cox (1976)) and the uncertainty of the level of the barrier. This stochastic barrier has a similar effect to the incorporation of jumps in the asset value that helps to better explain short-term default risk, which traditionally tended to be understated by the original approach that only considers zero-coupon debt (Leland (2004)).

Firm assets V are assumed to evolve by the Geometric Brownian Motion

$$\frac{dV_t}{V_t} = \mu_V dt + \sigma_V dW_t, \tag{1}$$

where W_t is a Wiener Process, σ_V denotes the asset volatility, and μ_V the drift.

Default occurs the first time V passes the stochastic barrier B with $B = Ld$, where d is defined as face value of debt per share. Uncertainty in the barrier is captured by the lognormally distributed random variable L with mean $\overline{L}$ and standard deviation λ, and its true level is only revealed at default time.

The PDE for the random barrier down-and-out European put is

$$\frac{\partial P}{\partial t} + \frac{1}{2}\sigma_V^2 (V + Be^{rt})^2 \frac{\partial^2}{\partial V^2} + rV\frac{\partial P}{\partial V} - rP = 0, \qquad V > 0 \tag{2}$$

where X is the strike price, and $\sigma \equiv \sigma_V$ its volatility.
Applying the transformations shown in Stamicar and Finger (2006) and re-writing gives the put price:

$$P(V, t, B) = Xe^{-r(T-t)}\Phi(a_1, a_2) - V\Phi(a_5) + I(B, \sigma_V, V, X) \tag{3}$$

where T is the maturity of the option and the expressions for $\Phi(\cdot)$, a_1, a_2, a_5, and $I(B, \sigma_V, V, X)$ are provided in **Appendix A**.

Given the put value P, we combine the relation $V = E + D$ and the put-call parity to obtain the following values of debt D and equity E:

$$D(V, t, B) = -P(V, t, B) + Xe^{-r(T-t)} \tag{4}$$

$$E(V, t, B) = C(V, t, B) = P(V, t, B) + V - Xe^{-r(T-t)} \tag{5}$$

We set

$$X = Be^{r(T-t)} \tag{6}$$

as it can be shown that for this choice of a strike the equity value E comes closer the observed stock price S, and the more so the deeper in the money the call is.

The asset volatility is approximated by the linear relation

$$\sigma_V = \sigma_S \frac{S}{S + \overline{L}D}, \tag{7}$$

where σ_S denotes the equity volatility. Contrary to Finger et al. (2002), the stock volatility σ_S is obtained from option-implied rather than historical volatilities wherever available.

B. Estimating the Barrier Parameter $\overline{L}$

In Finger et al. (2002), L is defined as the global recovery rate, that is, default is designed to occur not just when the asset value goes below the face value of the debt, but rather at its recovery level. This means that it is assumed that the firm does not choose to default on its debt as long as continuation is more worthwhile than liquidation, akin to endogenous default models (Leland (1994), Leland and Toft (1996)).

To apply the model, for each firm, we determine $\bar{L}$ using a number of observations over an estimation window from January 2003 through July 2007 by minimizing the sum of squared errors between observed CDS spreads and the CDS spreads produced by the above model.[7] In this sense, $\bar{L}$ does not just reflect the average recovery rate as in the model definition, but is also an adjustment to the book value of debt d that imprecisely measures the default-relevant level of debt. Adjustments to the book value can be in order because for example a large fraction of the debt may be secured, insured or off the balance sheet.

[7] We refer the reader to **Appendix B** for the model's CDS pricing formula as well as further calibration specifics. For a more complete description of the overall calibration procedure, see Schweikhard and Tsesmelidakis (2014).

C. Sample Selection and Data Sources

Our experiment requires a representative sample of corporate debt held by banks. As the exact composition of a bank's loan book and security investments is proprietary, we assume that the value of a portfolio of such claims experiences the same evolution as the value of a representative sample of borrowers that we select as follows: We consider all firms that have been part of the S&P 500 index between 2007 and 2009 for inclusion in our representative sample. Besides stock prices, our approach requires firms to have a liquidly traded CDS in their name, survive until at least June 2007. The combined effect of these restrictions is that we end up with a merged data set of 334 non-financial companies. Our bank sample comprises 27 U.S. institutions, which are all available banks satisfying the mentioned criteria with the exception of government-sponsored enterprises.

Our primary sources for daily market data are *CRSP* for stocks, *Markit* for CDSs, *Bloomberg* for zero-coupon swap rate curves, and *IvyDB OptionMetrics* for implied volatility surfaces. When dealing with stock data, we apply the usual adjustments for stock splits, dividends, and other capital measures. Moreover, stale observations in the CDS data are discarded. Concerning the option data, we focus on one-year implied volatility of at-the-money put options for the calculation of the asset volatility in equation (7), in line with Finger and Stamicar (2006). On the rare occasions where no option data is available we resort to realized volatilities estimated as the stock return standard deviation over a 90-day rolling window. Finally, our database is cleaned from any empty or invalid observations.

In terms of accounting data, *Compustat*'s quarterly reports provide us with the bulk of necessary balance sheet information that we further enhance by capital structure information from *Capital IQ* and bank-specific items from *Bankscope*. Our rating and sector classifications are based on monthly S&P's issuer ratings and Global Industry Classification Standard (GICS) codes, respectively.

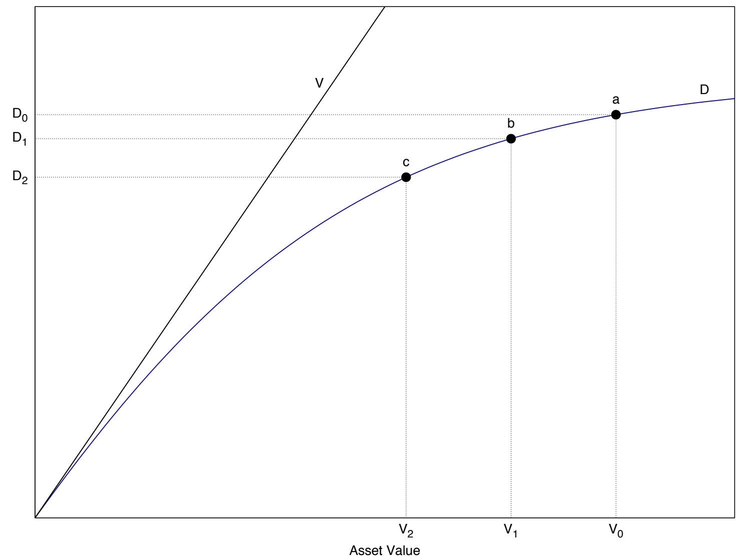
III. The Experiment

Our experiment takes place in two time steps: First, using the structural model outlined above, we simulate a shock of a given percentage size affecting the assets of each borrower in our sample of corporates and record the repercussion on the banks. Second, we assume that a shock of the same absolute size as before occurs again and compare its effect to the first shock. At each step, we thoroughly analyze changes in debt values, debt deltas, and CDS spreads at both the corporate and the bank level.

A. The Effect of Shocks to the Asset Value on Debt

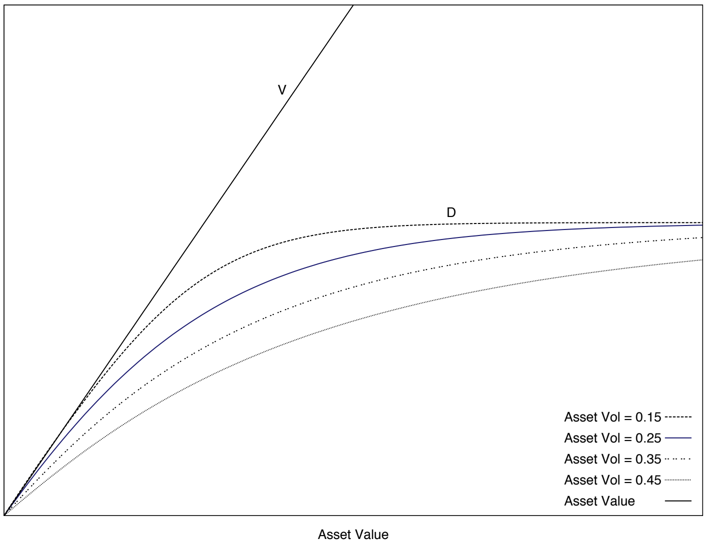
Theory The nonlinear nature of credit risk is a well-known fact. In the Merton model, this manifests in the concavity of debt value as a function of firm value. Additionally, the riskiness of the debt, which reflects in both the standard deviation of the debt and its slope delta, increases as the firm value approaches the default boundary. **Graph I** illustrates this basic relationship and shows how, ceteris paribus, two consecutive asset value shocks of equal size translate into losses in the debt value of increasing magnitude, i.e., $D_0 - D_1 < D_1 - D_2$ although $V_0 - V_1 = V_1 - V_2$ for $V_0 < V_1 < V_2$. This disproportionality is more pronounced the smaller the initial leverage.

Graph I: The Effect of Asset Shocks on Debt



While in our analysis we control for the asset volatility and time to maturity of a firm by keeping them constant between shocks, cross-sectional differences in these parameters at the outset influence the severity of the losses. **Graph II** exemplifies that the curvature of the debt function is negatively related to the asset volatility. In general, the more angular the curve, the lower the relative impact of small shocks, but the higher the relative impact of large shocks, and vice-versa for a lower, higher-volatility curve.

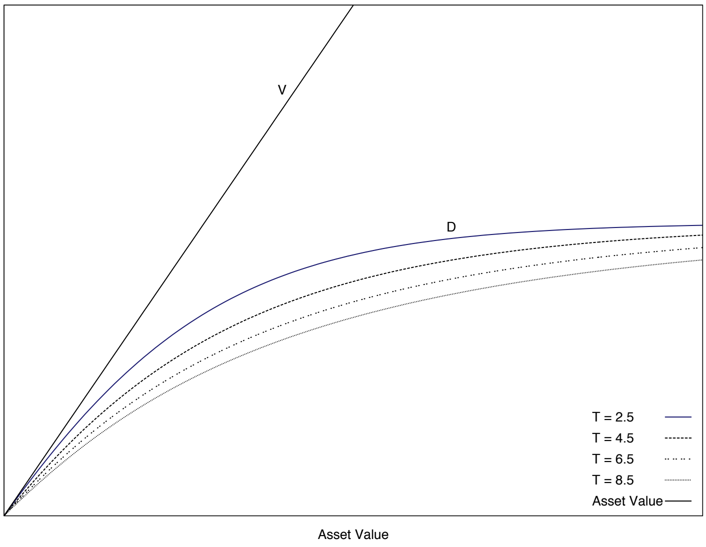
Graph II: Asset Volatility



Graph III makes a similar point with respect to the time to maturity T of the debt: The shorter T, the more pronounced the concavity of the function and the lower the sensitivity of the debt towards small-scale asset depreciation. **Figure VIII** in **Appendix C** illustrates the shapes of the delta, vega, theta, and rho "greeks" as a function of the asset value and provides us with additional insights about the sensitivities of the debt towards the asset value, the asset volatility, the time to maturity, and the interest rate.

Implementation Next we describe how we estimate the average percentage debt loss of our firm sample for a series of shock sizes. We choose June 15, 2007 as the starting point of our analysis, shortly before the outbreak of the financial crisis and well before the beginning of the bear market in October 2007 that hit rock bottom in March 2009 with a cumulative loss of 56% in the S&P 500 level. The month of June 2007 was still a calm period characterized by relatively low volatilities. Moreover, implicit bank subsidies are likely to have been less pervasive before than after the onset of the crisis. We believe

Graph III: Time to Maturity



that both these aspects contribute to make this reference date a neutral testing ground for our experiment.

Initially, we investigated the possibility to carry out the experiment by comparing the pre-crisis debt values and deltas at the firm level to those at two milestone days in terms of asset declines within the crisis, September 29, 2008 and March 9, 2009. However, this revealed to be impracticable because of the drastic change in the shape of the debt curves which first of all resulted from the jump in volatility.

To avoid capturing confounding effects, our analysis is instead conducted on a ceteris-paribus basis, that is, we simulate shocks to the borrowers' assets and keep all other firm-specific determinants of credit risk constant. We consider varying shock sizes in the range of 10% to 45% of a borrower's initial total asset value. The parameters of the put option implied in the debt value are set as follows: The asset volatility is estimated from the option-implied equity volatility using equation (7); the time to maturity T is estimated as the Macaulay Duration of the firm's unsecured senior debt;[8] the strike price is set according to equation (6).

After recording a shock and the ensuing percentage debt loss, this percentage is multiplied by the total unsecured senior debt of a bank as per the capital structure summary provided by *Capital IQ*.

[8]For the estimation of the Macaulay Duration we resort to maturity information on a firm's outstanding debt from *Capital IQ*.

Results In **Table 1** we present changes in CDS and debt deltas after two consecutive 10%, 20%, 30%, and 40% shocks, respectively, and differentiate the firms in our sample first according to their GICS sector classification and second with respect to their rating. For all sector and rating buckets the steepness in both CDS and debt deltas increases disproportionately after the second shock. This effect becomes more and more visible the larger the shocks. Further, the degree with which a firm's delta increases in absolute terms after a shock varies with the rating: the lower the rating, the steeper delta gets after a shock. The sectors most exposed to delta risk are "Consumer Discretionary," "Telecommunications," and "IT," while the least affected ones are "Energy" and "Consumer Staples". The results on the change of debt deltas are also depicted as a histogram in **Figure 5**. It appears that the ordering of firm groups according to the debt delta changes both across shock sizes, within the same shock period, and across periods, within the same shock size. This outcome can be explained by the fact that the shape of the debt value curves varies with the asset volatility and maturity, as illustrated in **Graphs II, III**, and therefore the elasticity for a given shock size differs across firms.

In **Figures 1, 2, 3,** and **4** we plot the historical evolution of CDS and debt delta averages over the period 2006 to 2010. Obviously, all firms, even the AAA-ranked ones, were affected by the financial crisis as reflected by their higher credit risk. The steeper slope may be either due to a rise in asset volatility or a reduction of leverage. Sectors like Energy, Utilities, Consumer Staples remained relatively stable, while Consumer Discretionary, Telecommunications, and Materials were more exposed. With respect to the classification of firms by ratings, it appears that AAA- to A-rated firms survived the crisis similarly well, whereas there is a clear monotonous degradation of credit quality among the BBB to B groups. The debt value deltas roughly mirror the CDS deltas, and one has to bear in mind that their scale differences stem from the fact that the CDS deltas range from $-\infty$ to 0 whereas debt deltas only vary between 0 and 1.

Tables 2 and **3** present summary statistics on the CDS spread reactions in bps and debt impairments in percent after two shocks. The most important result is again that the increase in CDS spreads and debt losses is disproportional between the first and the second shock. Although both shocks are of equal size the second one hits the firms much more severely. The effect is accentuated by larger shock sizes, so, for example, while the average CDS spreads in the Energy sector increase by 17 bps after a 10% shock, a second shock results in an average 30 bps increase, which is almost twice as much, but with the 30% shock size we see an 18-fold spread increase across periods. The effect is similar in the case of debt losses. Here, a 10% shock in the asset values of companies in the Energy sector translates into an average 1.03% debt loss after the first hit and a 1.46% debt loss after the second, whereas a shock size of 30% translates into average losses of 4.51% and 14.57%, respectively. When we decompose results by ratings we notice that the average CDS spread and debt loss are inversely related with the rating, the only exception being the A category. These results are also reflected in **Figures 6** and **7**.

Further, we group firms according to their debt ratio and their asset volatility, respectively. The resulting average debt loss for the debt ratio and volatility buckets after the shocks are depicted in **Figure 8** which shows that the debt impairment increases in the debt ratio and decreases in the asset volatility. The negative relation between debt loss and asset volatility is due to the fact that for higher volatility the debt loss curve flattens which decreases the height of fall after a shock tremendously and manifests in smaller percentage losses.

B. The Effect of Corporate Shocks on Banks

The next step in our experiment consists in analyzing how the overall estimated debt losses of the representative portfolio of non-financial firms affect banks and contribute to increase their default risk.

Theory We model the debt of banks analogously to the case of corporates, hence, the same general observations made in the previous subsection still apply. A major difference lies in the shocks which are significantly attenuated when they reach the banks. This is because (1) most of the shock at the borrower level is absorbed by its equity, which is also reflected by a debt delta that usually remains far below one, (2) loans and trading securities account only for a share of a bank's credit exposure, and (3) whatever fraction of the original shock reaches the bank is partly absorbed by its equity reserves. In consequence, the two shocks have very different magnitudes at the bank level both with respect to their impact on asset and debt.

Note that in our analysis of the repercussions of shocks on a bank we deliberately focus on the consideration of an institution's credit exposure and disregard other transmission channels, although it is probable that in a crisis scenario and absent government guarantees a bank's debt would become riskier for reasons beyond the mere fall in borrowers' assets.

In reality, large banks may benefit from implicit government backing and thus be "too big to fail." In this case, the debt value may effectively not be threatened by worsening asset conditions and the impairments would be borne by the taxpayer. Hence, our analysis remains meaningful whether one assumes guarantees to prevail at a given point in time or not, only the interpretation changes.

In the following, whenever we refer to a bank's leverage ratio, we mean the total book value of its equity divided by the total book value of its assets. This constitutes a simplification of the leverage ratio formula in Basel III which however should be of minor importance for the interpretation of our results.

Implementation When recalculating the leverage ratio after a shock, the pre-shock book value leverage is used and its equity and liability components are reduced proportionally to the equity and debt loss captured by our model.

The percentage debt losses at the corporate level are weighted by each borrower's total unsecured debt. The sum of debt losses over all borrowers is then multiplied by a bank's gross loans and corporate debt securities to obtain the bank-level asset shock. The inclusion of the latter is motivated by the fact that most firms in our sample are large corporations which tend to have access to financing via the capital market.

The principles for the debt valuation outlined in the last subsection are equally applied to banks.

Results **Table 4** summarizes the average effects of two consecutive borrower-level shocks in t_1, t_2 on the banks of our sample under different scenarios. The average asset volatility and time to maturity remain at 0.14 and 2.55, respectively, throughout. The upper panel reports the baseline case with an average bank leverage of 8.68%. First we notice that, as explained above, the first and second shocks affect the banks very differently and also in a very moderated way. For example, the 30% shocks at the corporate level affect the banks' assets (debt) to an extent of only 1.86% (0.08%) at the first impact and 7.88% (5.08%) at the second. The larger the corporate shock, the larger the share of the borrower asset loss that transmits to the banks, as can be seen from the total debt loss to the banks of 75.86% in the case of two successive 45% shocks. The hike in debt losses in t_2 reveals the potential for further losses after a first shock has occurred. Interestingly, this potential is not immediately apparent by merely looking at the bank's situation in t_1, which suggest a stable environment and hide that in actuality the bank's borrower base is heavily stricken. Besides the debt losses, the increases in debt deltas and CDS spreads are informative:[9] The deltas reflect the steeper impact of further asset deterioration while the CDS spreads reveal the increased default risk.

After the baseline case, we now consider different initial capital structures for the banks, that is we adjust the leverage ratio to 2%, 4%, 6%, etc. by adding or subtracting an appropriate amount of equity from each bank's initial capital stock while keeping all else equal. The adjustment is thus achieved by keeping the face value of the debt constant. This allows us to assess how different minimum leverage requirements would aggravate or relax the credit risk of the bank's debt. The general picture of debt losses decreasing as equity capital increases confirms the basic economic intuition that default becomes less likely with a larger equity cushion. However, the increase in leverage required to significantly alleviate the impact is considerable: For example, taking the baseline case as the reference point, the total loss at the 35% (45%) shock size of 31.52% (75.86%) would only insignificantly be reduced if the leverage ratio was increased to 10% (as total losses would still amount to 28.55% and 72.38%, respectively). A requirement of 15% leverage would be a somewhat more convincing proposition (decreasing losses to 4.74%

[9] Note that banks that default in t_2 (and whose percentage is reported in the "Def." column), as resulting from non-positive equity, are excluded from the delta and CDS averages.

and 62.35%), especially in the case of shocks below 40%. However, under the most severe scenarios, even a leverage of 20% would not shield the bank against significant losses and default risk. One should bear in mind that leverage ratios of 15% and 20% would be extreme departures from the status quo vastly curtailing banks' profitability and entail a complete overhaul of the industry.

Therefore, we conclude that small percentage point changes in the capital requirements are unlikely to lead to a significantly more resilient and stable financial sector.

C. The Sensitivities towards the Banks' Asset Volatility and Debt Maturity

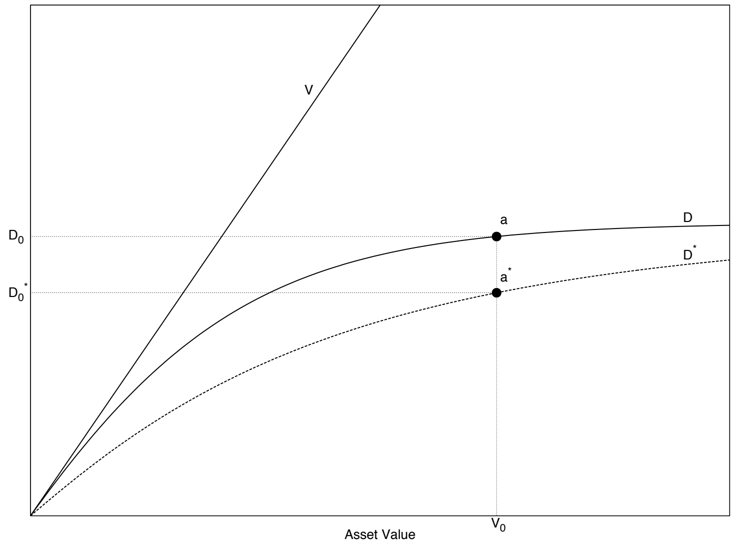
For our baseline case we chose a relatively calm period before the outbreak of the financial crisis, and the average asset volatility of banks is only at 14%. To give a sense of how our results would differ in a higher-volatility environment, we repeat the baseline analysis by bumping up the volatility by 10%, 20%, ..., 50%, respectively.

Table 5 shows that a higher asset volatility goes hand in hand with a mild rise in total losses, which are however mainly driven by the t_1 period as t_2 losses are decreasing in volatility. This is due to the different shape of the debt curve: The slope of a higher-volatility curve increases towards the far right end, which explains higher t_1 losses, and is less steep around the strike compared to the low-volatility baseline case. We also note that the CDS spread well captures the overall increased default risk that comes along with high volatility.

The reader may notice that the t_0 leverage ratios turn out higher for higher asset volatilities. The reason for this is not that a higher volatility causes a higher leverage, but rather that a higher volatility entails a lower market value of debt D_{0^*}, as depicted in **Graph IV**, and hence requires a higher percentage of equity, $V_0 - D_{0^*}$, in order to keep the asset value V_0 and all other determinants constant. The bank can now only afford a lower percentage of debt in market value terms, which is reflected by the relation $Lev_0 < Lev_0^*$.

Next, we ask how results would be affected if banks held longer-maturity liabilities. In our sample, we take the average debt maturity to be the Macaulay Duration of 2.55. We

Graph IV: Effect of Higher Asset Volatility or Maturity



relax this assumption by adding 1, 2, 3, and 4 years, respectively. Generally speaking we note that longer-term debt has a lower market value as it entails more uncertainty than short-term debt about whether the debt will remain "in the money," an effect that is not dissimilar to higher volatility, and **Graph IV** can therefore be interpreted as depicting a short (D) and a long maturity (D^*) curve of the bank's debt.

Similar to the volatility case, in **Table 6**, we notice a mildly increasing total loss in the maturity. It may seem intriguing why the CDS increases exhibit a downward sloping term structure, except for the smallest 10% and 20% shock sizes in t_1. Yet, it is a known result of structural models that the default probability is particularly high for short maturities when the firm value gets close to the default boundary. The empirical credit spread literature confirms this to be a stylized fact as reported by Sarig and Warga (1989), among others.

D. The Effect of Ex-Post Deleveraging

After having analyzed the influence of the initial leverage ratio on the final outcome, we next investigate any benefits that may arise from a deleveraging after the first shock has occurred. A deleveraging may be induced by regulation like the Basel Accords that require banks to maintain a certain level of capital (or leverage) at all times, or by market pressure. Merrill, Nadauld, Stulz, and Sherlund (2013) argue that risk-sensitive capital requirements may force a bank to sell illiquid assets, while Shleifer and Vishny (2011) emphasize that the pervasiveness of short-term and collateralized funding of financial institutions is likely to have led to the precipitated forced sale of assets during the recent financial crisis.

We are less concerned about the concrete motives for leverage reductions and rather focus on three ways of achieving them by different equity and debt manipulations.

Fire Sales Taking the baseline case as the starting point, we assume deleveraging takes place between the first and second shock and resets a bank's leverage ratio to its original level. We denote the adjustment period as t_{1^*}. The first way of deleveraging considered consists of a sale of assets with the aim to repay debt. We will refer to it as the "Fire Sales" case, although we do not take into account any feedback effects on asset values that may aggravate the seller's situation even further. For our purposes it amounts to a balance sheet contraction where debt and equity are reduced proportionally according to the shock size s:

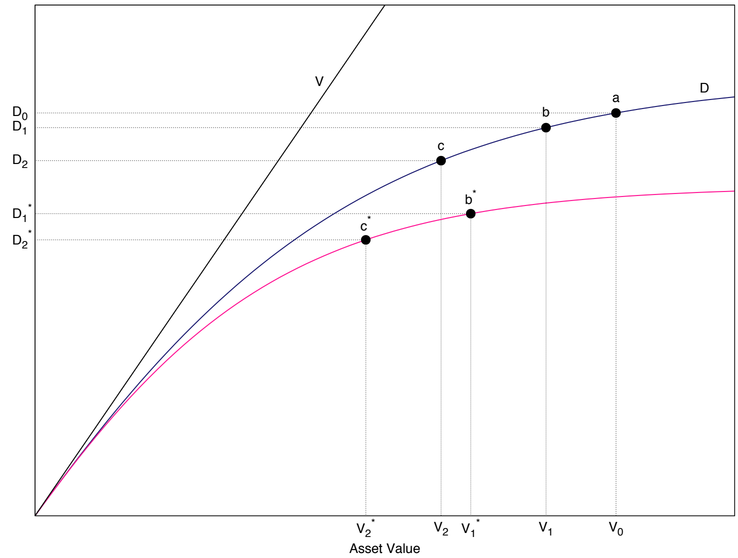
$$d_{1^*} = (1 - \frac{s}{V_0})d_0 \tag{8}$$

$$E_{1^*} = (1 - \frac{s}{V_0})E_0 \tag{9}$$

In **Graph V** the first shock is illustrated by the move from point a to b. Afterwards, with the above deleveraging strategy, the bank moves to b^* on a lower debt curve because of the reduction of the face value of debt d that determines the put option's strike. There are two opposed effects with respect to the second shock: On the one hand, upcoming shocks will be less devastating on the debt because of the reduced elasticity of the flatter curve; on the other hand, if the second shock's size is assumed to still remain at the absolute level of the baseline case, then it hits a now smaller, downscaled firm with lighter equity reserves. In the graphical example, $D_2^* - D_1^* < D_2 - D_1$, which also implies a lower total loss given the equal impact of the first shock.

The first panel of **Table 7** presents results that can be directly compared to the baseline case. The newly introduced period t_{1^*} reflects the debt reduction because of the

Graph V: Fire Sales



deleveraging. The total loss, the sum of debt losses in t_1 and t_2, is now smaller for any shock size (e.g., from 75.86% down to 52.64% for a shock size of 45%), in line with the graphical example. The better outcome compared to the baseline case is not meant to suggest that fire sales are a good strategy, which they are certainly not given the asset sales at unfavorable, dislocated prices they entail and the repercussions on other banks they have — all these effects are ignored here as the aim is to focus on the mere impact of deleveraging through reduction of debt and assets proportional to the size of the shock.

Conversion For the second case of deleveraging, the asset value is held constant, that is, at the same level as after the shock, and the debt ratio is required to be the same as before the first shock, i.e.,

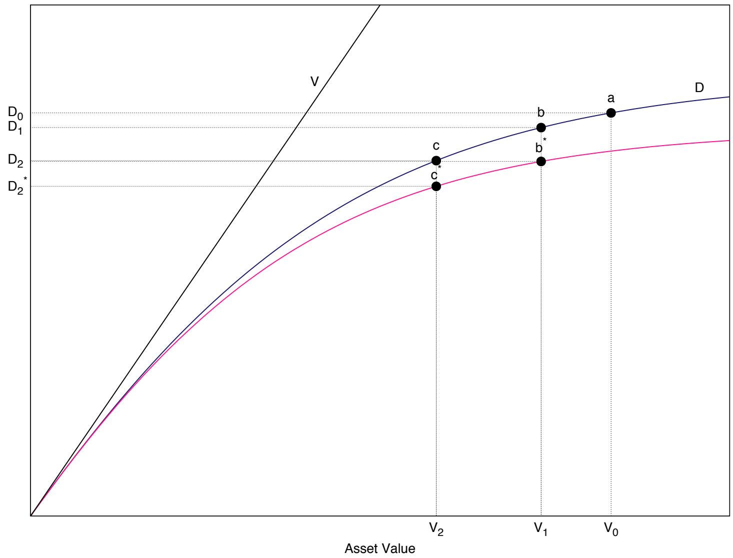
$$d_{1^*} = \frac{d_0}{V_0}(V_0 - s) \tag{10}$$

$$E_{1^*} = V_0 - s - d_{1^*} \tag{11}$$

From these equations, it can be seen that this case entails a shift of debt to equity capital, which is why we label this the "Conversion" strategy. Such a debt-equity conversion may be triggered in the course of a distressed bank with bail-in debt.

Graph VI differs in the following aspects: d decreases, but to a smaller extent, translating into a smaller downward shift of the debt curve; the points b and b^* as well as c and c^*, respectively, stay vertically aligned as the asset values V_1 and V_2 remain unchanged.

Graph VI: Conversion



As per the middle panel of **Table 7**, for shocks of 40% and 45%, there is still a sizable albeit smaller benefit of this strategy with total losses ranging between the baseline and fire sales cases. Below 40%, total losses turn out even more favorable than under the fire sales case. This can be explained by two effects: First, by the less pronounced relocation of the debt curve that remains quite flat far in the money, resulting in a lower height of fall for small shocks; and second, although the leverage is reset to the same level in t_1^*, the asset value is not reduced in the conversion strategy, implying that an equally-sized shock strikes a larger firm with more equity reserves in absolute terms.

Recapitalization Finally, the last panel in **Table 7** presents a scenario that we label "Recapitalization" as it entails an equity injection large enough to offset the first shock. Such an intervention might be conceivable if the bank was heavily distressed and received support from either the government or a parent company. As the first shock is effectively undone, the results amount to the impact of just the larger second shock. Total losses are generally mildly smaller than under the baseline case, e.g. 19.43% vs. 31.52% for the 35% shocks, and 73.06% vs. 75.86% for the 45% shocks.

Summary The total losses of any of the deleveraging strategies considered above are always inferior to those incurred under the baseline case, which we expected. Comparing those three cases with one another, we find that for small shocks (up to 35%) recapitalized banks are the least affected by the second shock, followed by convertible debt. This is due to the flatter curves at the far end compared to the Fire Sales case. For large shock sizes, the opposite is true, fire sales are at an advantage because of the shorter height of fall. Hence, no strategy strictly dominates the others in terms of containing t_2 losses as the circumstances are decisive.

To conclude, each strategy represents a costly intervention in a bank, and yet its risk reduction benefit is limited. The leverage correction after the first shock conceals the deterioration of the bank loans' underlying assets and can do only little to mitigate the bank's risk exposure.

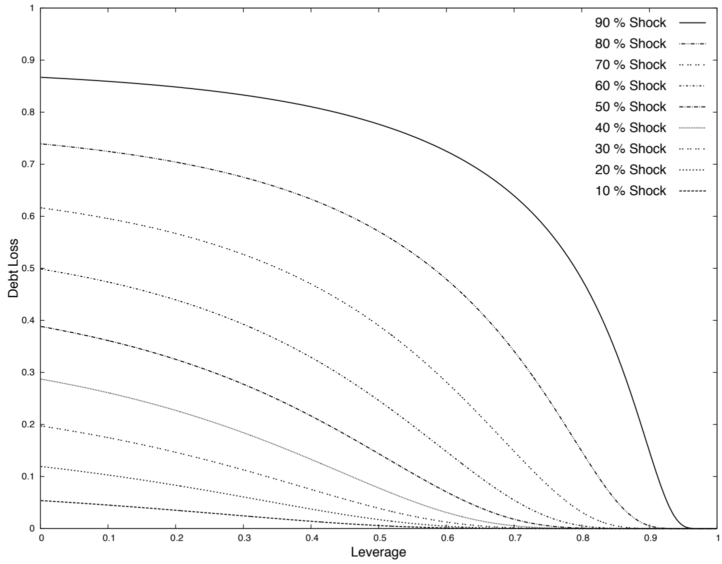
E. The Relation between Debt Loss, Shock Size, and Leverage

The previous results suggest that the impact of leverage on debt loss in the case of large asset shocks is very limited. **Graph VII** plots the relationship between the percentage debt loss and leverage ratio depending on the size of one single shock.[10] If we focus on the leverage ratio in the range from 0 to 0.2 which represents the practically relevant one, we notice that the flat shape of the curves supports our prior conclusion that the debt loss is rather insensitive with respect to the leverage ratio. This holds even more towards either end of the shock spectrum. To achieve a more sizable effect leverage would have to rise by far more reaching values above 30%.

Table 8 provides a complementary, empirical perspective: Using our cross-section of 27 banks, we calculate the additional percentage points in the leverage ratio required to keep the debt value immune against one single shock. Results are decomposed by rating classes and leverage ratio buckets. Starting with the aggregate column ("Agg."), we notice that even a 5% shock would require a 9 percentage point increase in leverage,

[10]The plot is for illustrative purposes and does not give an accurate depiction of the average results for the bank sample. The plot rather reflects one representative bank with debt loss determinants such as asset volatility and maturity set equal to the sample means.

Graph VII: Debt Loss vs. Leverage Ratio and Shock Size



which would roughly equal a doubling of the status quo. As one would expect, banks in the highest AA category are relatively well capitalized and would require less additional leverage, both in absolute and relative terms. Banks in the most prevalent leverage 8-10% range would also require additional capital worth at least 8.10 percentage points in order to compensate any shock to their debt. With respect to leverage buckets, no clear picture emerges when comparing different groups with one another as the banks lumped together are quite diverse and much of the variation is driven by other determinants like asset volatility and debt maturity.

IV. Conclusion

This study analyzes the impact of two consecutive systematic shocks on the asset value of the corporate sector and how they transmit to the bank level. The aim is to assess the importance of asset risk relative to leverage risk. The results indicate that leverage plays a minor role compared to the possibility of large shocks implied by an increase in asset risk. Even different deleveraging strategies in between shocks are, despite their cost, not suitable to contain the potential of disproportional future losses. We suggest that these results should motivate a reconsideration of the current regulatory focus on bank capital and leverage ratios. The scope of the study at hand is limited to gross loans and corporate bonds but the concept shall apply to other claims as well. Further research needs to be undertaken to evaluate the banks' credit exposure to their mortgages. Although they are collateralized, the unfolding of the financial crisis in 2007 highlights the relevance of the real estate market.

APPENDIX

A. Derivation of Debt Value

The debt value is calculated as the value of a European short Put option on the asset value plus B. The European put problem is

$$\frac{\partial P}{\partial t} + \frac{1}{2}\sigma^2 (V + Be^{rt})^2 \frac{\partial^2}{\partial V^2} + rV \frac{\partial P}{\partial V} - rP = 0, \qquad V > 0$$

where X is the strike price, T is the maturity of the option, V the asset value, and $\sigma \equiv \sigma_V$ its volatility.

Applying the transformations shown in Finger et al. (2006) and re-writing gives us:

$$P(V, t, B) = Xe^{-r(T-t)}\Phi(a_1, a_2) - V\Phi(a_5) + I(B, \sigma, V, X)$$

where

$$\begin{aligned} I(B, \sigma, V, X) = &-Xe^{-r(T-t)}[\Phi(a_3, a_4)] + V[1 - \Phi(a_4)] \\ &+ Be^{rt}[\Phi(a_2) - \Phi(a_4) - \Phi(a_5) + \Phi(a_6)] - \frac{V}{B}Xe^{-rT}[\Phi(a_3, a_4)] \\ &+ 2Xe^{z/2 - r(T-t)} \int_{z/\sqrt{2\tau}}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-s^2/2} e^{-z^2/8s^2} ds \end{aligned}$$

with

$$\begin{aligned} z &= \log\left(\frac{V}{Be^{rt}} + 1\right) \\ \tau &= \frac{1}{2}\sigma^2 (T - t) \end{aligned}$$

and standard normal cumulative distributions

$$\Phi(x,y) = \frac{1}{\sqrt{2\pi}} \int_x^y e^{-s^2/2} ds$$

$$\Phi(y) = \Phi(-\infty, y)$$

The limits for integration are

$$\begin{aligned}
a_1 &= \frac{-\sigma\eta + \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}} \\
a_2 &= -\frac{\sigma(\eta - \eta_\chi) - \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}} \\
a_3 &= \frac{\sigma\eta + \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}} \\
a_4 &= \frac{\sigma(\eta_\chi + \eta) + \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}} \\
a_5 &= -\frac{\sigma(\eta - \eta_\chi) + \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}} \\
a_6 &= \frac{\sigma(\eta_\chi + \eta) - \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}}
\end{aligned}$$

The distance to default parameters are

$$\begin{aligned}
\eta &= \frac{1}{\sigma} \log\left(1 + \frac{V}{Be^{rt}}\right) \\
\eta_\chi &= \frac{1}{\sigma} \log\left(1 + \frac{X}{Be^{rt}}\right)
\end{aligned}$$

The integral in $I(B,\sigma,V,X)$ can be solved analytically as follows:

$$\begin{aligned}
\frac{1}{\sqrt{2\pi}}\int_{z/\sqrt{2\tau}}^{\infty} e^{-s^2/2}e^{-z^2/8s^2}ds &= \frac{1}{2}\left[e^{-z/2}\Phi\left(\frac{s^2-z/2}{s}\right)-e^{z/2}\Phi\left(-\frac{s^2+z/2}{s}\right)\right]_{z/\sqrt{2\tau}}^{\infty} \\
&= \frac{1}{2}e^{-z/2}-\frac{1}{2}\left[e^{-z/2}\Phi\left(\frac{(z/\sqrt{2\tau})^2-z/2}{z/\sqrt{2\tau}}\right)-e^{z/2}\Phi\left(-\frac{(z/\sqrt{2\tau})^2+z/2}{z/\sqrt{2\tau}}\right)\right] \\
&= \frac{1}{2}e^{-z/2}-\frac{1}{2}\left[e^{-z/2}\Phi\left(\frac{z}{\sqrt{2\tau}}-\frac{z/2}{z/\sqrt{2\tau}}\right)-e^{z/2}\Phi\left(-(\frac{z}{\sqrt{2\tau}}+\frac{z/2}{z/\sqrt{2\tau}})\right)\right] \\
&= \frac{1}{2}e^{-z/2}-\frac{1}{2}\left[e^{-z/2}\Phi\left(\frac{z-\tau}{\sqrt{2\tau}}\right)-e^{z/2}\Phi\left(-\frac{z+\tau}{\sqrt{2\tau}}\right)\right] \\
&= \frac{1}{2}e^{-z/2}-\frac{1}{2}e^{-z/2}\Phi\left(\frac{z-\tau}{\sqrt{2\tau}}\right)+\frac{1}{2}e^{z/2}\Phi\left(-\frac{z+\tau}{\sqrt{2\tau}}\right) \\
&= \frac{1}{2}e^{-z/2}\left[1-\Phi\left(\frac{z-\tau}{\sqrt{2\tau}}\right)+e^{z}\Phi\left(-\frac{z+\tau}{\sqrt{2\tau}}\right)\right]
\end{aligned}$$

B. Derivation of CDS Spread

1. Model

Finger et al. (2002) show that the risk-neutral survival probability $F(t)$ that the firm does not default before time t can be approximated by the closed-form expression

$$F(t)=\Phi\left(-\frac{A_t}{2}+\frac{log(h)}{A_t}\right)-h\cdot\Phi\left(-\frac{A_t}{2}-\frac{log(h)}{A_t}\right), \tag{12}$$

with

$$h=\frac{S_0+\overline{L}d}{\overline{L}d}\exp\lambda^2, \tag{13}$$

$$A_t^2=\sigma_V^2t+\lambda^2, \tag{14}$$

where $\Phi(\cdot)$ is the cumulative normal distribution function and σ_V denotes the asset volatility.

The premium leg and the protection leg are valued independently and then set equal so as to ensure that the contract is fairly priced at the time of agreement. Rearranging terms, one can arrive at the following non-arbitrage CDS fee c for a contract maturing in T :

$$c=r(1-R)\frac{1-F(0)+e^{r\xi}(G(t+\xi)-G(\xi))}{F(0)-F(t)e^{-rt}-e^{r\xi}(G(t+\xi)-G(\xi))}, \tag{15}$$

with

$$G(u) = h^{z+\frac{1}{2}}\Phi\left(-\frac{log(h)}{\sigma_V\sqrt{u}} - z\sigma_V\sqrt{u}\right) + h^{-z+\frac{1}{2}}\Phi\left(-\frac{log(h)}{\sigma_V\sqrt{u}} + z\sigma_V\sqrt{u}\right), \qquad (16)$$

where $z = \sqrt{\frac{1}{4} + \frac{2r}{\sigma_V^2}}$, $\xi = \frac{\lambda^2}{\sigma_V^2}$, r is the deterministic risk-free interest rate, and R is the expected recovery rate to a specific debt class.

2. Calibration

The standard deviation of the barrier, λ, is set to 0.3, the debt class specific recovery rate R is set to 0.5, the risk-free interest rate r is assumed to be the five-year constant maturity zero-coupon swap rate, the equity volatility σ_S is the one-year at-the-money implied volatility from put options, the book value of debt d is set equal to the total liabilities per share as reported in the latest quarterly report.

C. Additional Graphs

Graph VIII: Greeks of the Debt Value

These plots depict the shapes of the debt value's "greeks" delta, vega, theta, and rho as functions of the asset value. X is the exercise price of the put option implied in the debt.

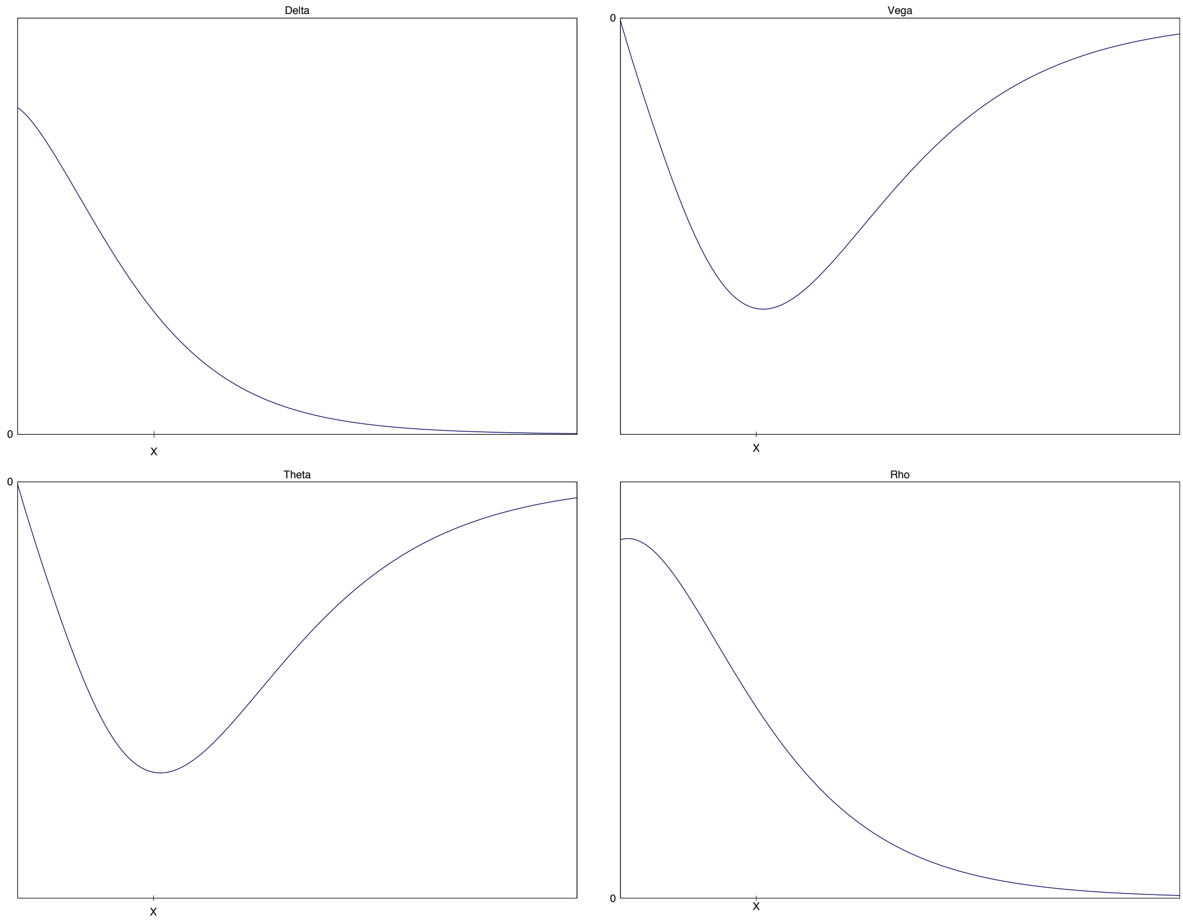


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Table 1: CDS and Debt Deltas after Shocks

This table presents changes in CDS and debt deltas in percent after two consecutive 10%, 20%, 30%, and 40% shocks, respectively. In the upper panels the firms are allocated according to their sector classification whereas the lower panels focus on ratings. The second column presents the number of firms in a sector or rating bucket. For the sector names we use the abbreviations in brackets listed in the following: Consumer Discretionary (CD), Consumer Staples (CS), Energy (E), Health (H), Industrials (I), Information Technology (IT), Materials (M), Telecommunications (T), and Utilities (U).

		#	Shock size 10%			Shock size 20%		Shock size 30%		Shock size 40%	
			t_0	t_1	t_2	t_1	t_2	t_1	t_2	t_1	t_2
Panel A: CDS Deltas											
SECTOR	CD	68	-6	-13	-32	-32	-111	-42	-218	-111	-27
	CS	34	-3	-5	-12	-12	-48	-35	-411	-48	-62
	E	32	-2	-3	-6	-6	-36	-12	-244	-36	-174
	H	44	-4	-7	-15	-15	-39	-49	-265	-39	-99
	I	50	-2	-3	-5	-5	-32	-12	-182	-32	-181
	IT	38	-8	-16	-32	-32	-339	-88	-399	-339	-235
	M	29	-2	-4	-7	-7	-36	-18	-323	-36	-262
	T	8	-5	-9	-17	-17	-147	-39	-472	-147	0
	U	31	-3	-5	-11	-11	-70	-25	-212	-70	0
	Total	334	-4	-8	-17	-17	-93	-36	-276	-93	-118
RATING	AAA	6	0	-1	-2	-2	-15	-5	-166	-15	0
	AA	14	-1	-2	-4	-4	-28	-11	-386	-28	0
	A	100	-1	-2	-4	-4	-23	-9	-274	-23	-120
	BBB	143	-3	-5	-10	-10	-65	-22	-322	-65	-118
	BB	52	-8	-14	-30	-30	-202	-83	-222	-202	-71
	B	13	-25	-50	-141	-141	-214	-205	-66	-214	-516
	Unrated	6	-16	-29	-59	-59	-930	-154	-1	-930	-19
	Total	334	-4	-8	-17	-17	-93	-36	-276	-93	-118
Panel B: Debt Deltas											
SECTOR	CD	68	3.57	5.32	8.01	8.01	18.20	12.11	37.77	18.20	66.28
	CS	34	1.62	2.76	4.70	4.70	13.48	7.98	36.14	13.48	73.81
	E	32	2.75	3.76	5.21	5.21	10.33	7.29	21.60	10.33	46.62
	H	44	2.59	3.90	5.92	5.92	13.67	9.01	30.54	13.67	59.37
	I	50	1.61	2.49	3.90	3.90	9.96	6.18	26.40	9.96	59.43
	IT	38	3.40	5.02	7.49	7.49	16.39	11.15	33.06	16.39	58.76
	M	29	1.86	2.84	4.41	4.41	11.04	6.94	27.74	11.04	59.09
	T	8	3.53	5.32	8.03	8.03	17.91	12.07	36.87	17.91	68.94
	U	31	2.23	3.74	6.34	6.34	18.21	10.79	45.47	18.21	77.24
	Total	334	2.57	3.90	5.99	5.99	14.30	9.25	32.69	14.30	62.83
RATING	AAA	6	0.44	0.83	1.60	1.60	6.19	3.10	25.55	6.19	70.11
	AA	14	0.51	1.02	2.08	2.08	8.84	4.31	32.04	8.84	73.66
	A	100	0.86	1.44	2.49	2.49	7.88	4.40	23.91	7.88	55.48
	BBB	143	2.28	3.58	5.67	5.67	14.25	9.01	33.17	14.25	63.45
	BB	52	4.97	7.36	10.88	10.88	22.90	15.95	42.69	22.90	68.18
	B	13	11.43	15.44	20.73	20.73	35.35	27.39	53.63	35.35	73.00
	Unrated	6	5.17	7.54	11.02	11.02	23.16	16.07	44.14	23.16	69.46
	Total	334	2.57	3.90	5.99	5.99	14.30	9.25	32.69	14.30	62.83

Table 2: CDS Spread Reactions to Shocks

This table shows summary statistics for CDS spread reactions in bps after two consecutive 10%, 20%, 30%, and 40% shocks, respectively. In the upper panels the firms are allocated according to their sector classification whereas the lower panels focus on their ratings. The second column presents the number of firms in a sector or rating bucket. For the sector names we use the abbreviations in brackets listed in the following: Consumer Discretionary (CD), Consumer Staples (CS), Energy (E), Health (H), Industrials (I), Information Technology (IT), Materials (M), Telecommunications (T), and Utilities (U).

		#	Shock size 10%								Shock size 20%								Shock size 30%								Shock size 40%							
			t_1				t_2				t_1				t_2				t_1				t_2				t_1				t_2			
			Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max
SECTOR	CD	68	45	92	0	686	98	254	0	1982	144	345	0	2668	684	1395	1	8578	401	1191	0	9264	4541	4212	0	9792	828	1694	1	9665	8575	2629	0	9999
	CS	34	25	47	0	213	53	104	0	467	78	152	0	680	769	2153	5	9160	216	461	2	2001	4061	3932	62	9864	847	2302	5	9773	8887	2655	0	9963
	E	32	17	24	1	115	30	43	2	206	47	67	3	321	192	368	11	1919	103	157	7	768	1854	3111	60	9754	239	433	14	2240	7645	3628	519	9953
	H	44	27	47	0	243	56	105	0	581	83	152	0	824	845	2309	0	9450	238	552	0	3345	2925	3577	7	9757	929	2447	0	9833	7026	4079	0	9969
	I	50	13	17	0	64	26	31	0	123	39	47	0	186	190	256	1	1188	93	111	0	464	2514	3505	13	9884	229	301	1	1375	8683	2670	404	9975
	IT	38	46	64	0	220	91	133	0	458	137	197	0	678	1187	2322	0	9369	362	558	0	2038	3903	3980	0	9887	1324	2501	0	9850	6532	3941	0	9952
	M	29	18	32	0	160	35	63	1	326	53	95	1	487	494	1708	7	9270	133	261	3	1363	2297	3149	36	9807	547	1797	10	9757	8087	3448	0	9939
	T	8	25	21	0	68	47	42	0	137	72	63	0	205	386	507	4	1585	171	165	1	535	4328	4432	87	9774	458	568	5	1790	9506	591	8123	9995
	U	31	25	14	6	75	51	27	11	144	76	41	18	219	390	260	63	1332	185	104	39	541	6679	4017	358	9864	466	299	81	1551	9502	313	8346	9909
	Total	334	29	55	0	686	59	138	0	1982	87	192	0	2668	599	1586	0	9450	233	636	0	9264	3644	3963	0	9887	687	1734	0	9850	8163	3177	0	9999
RATING	AAA	6	5	5	1	15	12	10	3	30	17	15	4	45	103	72	28	213	46	36	11	108	2464	3706	229	9876	121	86	32	257	9875	91	9727	9967
	AA	14	10	8	2	33	23	17	5	72	33	25	7	105	188	142	47	592	86	65	20	270	2828	3104	361	9836	221	167	56	698	9770	174	9272	9942
	A	100	8	9	0	50	17	18	0	107	26	27	0	157	128	153	0	936	63	68	0	403	1828	2914	0	9884	154	179	0	1094	7815	3683	0	9975
	BBB	143	22	23	0	165	42	45	0	323	63	68	0	489	313	459	0	3501	151	172	0	1232	3888	4029	7	9864	377	524	0	3921	8762	2423	208	9993
	BB	52	59	67	0	324	119	150	0	763	179	216	0	1088	1683	2912	0	9450	483	686	0	3674	5719	4126	15	9887	1861	3104	0	9850	7348	3659	0	9999
	B	13	155	173	18	686	355	515	26	1982	510	687	43	2668	3452	3591	98	9325	1590	2473	81	9264	6131	3909	0	9370	3961	4005	141	9822	5536	3956	0	9658
	Unrated	6	60	60	0	145	113	113	0	290	173	172	1	435	1152	1522	4	4061	426	440	2	1156	7820	3844	35	9808	1325	1684	5	4496	6996	3584	481	9581
	Total	334	29	55	0	686	59	138	0	1982	87	192	0	2668	599	1586	0	9450	233	636	0	9264	3644	3963	0	9887	687	1734	0	9850	8163	3177	0	9999

Table 3: Debt Value Reactions to Shocks

This table shows summary statistics for debt value reactions in percent after two consecutive 10%, 20%, 30%, and 40% shocks, respectively. In the upper panels the firms are allocated according to their sector classification whereas the lower panels focus on their ratings. The second column presents the number of firms in a sector or rating bucket. For the sector names we use the abbreviations in brackets listed in the following: Consumer Discretionary (CD), Consumer Staples (CS), Energy (E), Health (H), Industrials (I), Information Technology (IT), Materials (M), Telecommunications (T), and Utilities (U).

		#	Shock size 10%								Shock size 20%								Shock size 30%								Shock size 40%							
			t_1				t_2				t_1				t_2				t_1				t_2				t_1				t_2			
			Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max
SECTOR	CD	68	1.08	0.86	0.00	3.45	1.64	1.16	0.00	4.53	2.70	1.98	0.00	7.65	6.32	3.52	0.00	16.00	5.12	3.42	0.00	13.60	18.39	7.50	0.06	36.17	8.78	5.19	0.00	22.10	45.32	10.98	11.49	63.89
	CS	34	0.50	0.58	0.00	2.13	0.86	0.91	0.00	3.45	1.35	1.47	0.00	5.50	4.09	3.29	0.03	13.01	2.81	2.78	0.00	10.58	14.91	7.24	2.05	32.05	5.34	4.57	0.03	17.80	44.41	8.52	19.07	61.56
	E	32	1.03	0.88	0.02	3.52	1.46	1.13	0.07	4.51	2.47	1.98	0.09	7.87	5.17	3.21	0.76	12.96	4.51	3.33	0.29	13.23	14.57	6.22	4.83	28.04	7.45	4.94	0.86	19.81	38.91	8.09	22.25	54.31
	H	44	0.76	0.85	0.00	3.89	1.18	1.17	0.00	5.10	1.92	1.99	0.00	8.79	4.75	3.75	0.00	14.74	3.72	3.50	0.00	14.86	14.67	8.44	0.00	30.98	6.51	5.46	0.00	22.23	39.87	13.99	4.00	60.46
	I	50	0.57	0.64	0.00	2.49	0.90	0.91	0.00	3.34	1.46	1.53	0.00	5.75	3.83	2.99	0.04	11.08	2.88	2.75	0.01	10.02	13.04	6.58	0.62	26.91	5.19	4.35	0.04	15.82	39.52	9.74	9.98	55.17
	IT	38	0.97	1.05	0.00	3.85	1.45	1.42	0.00	4.97	2.39	2.42	0.00	8.63	5.52	4.47	0.00	14.24	4.51	4.21	0.00	14.51	15.93	10.03	0.00	34.10	7.68	6.52	0.00	21.64	40.22	16.98	0.00	62.82
	M	29	0.65	0.72	0.00	3.09	1.02	0.98	0.01	4.25	1.66	1.67	0.02	7.21	4.25	3.02	0.19	13.27	3.24	2.91	0.06	12.61	14.07	6.28	2.05	29.75	5.79	4.47	0.21	19.53	40.61	9.29	17.29	56.60
	T	8	1.09	0.82	0.00	1.93	1.66	1.12	0.00	2.98	2.72	1.91	0.00	4.83	6.33	3.57	0.03	11.05	5.17	3.36	0.00	9.16	18.06	8.07	1.37	27.95	8.82	5.23	0.03	15.35	45.28	9.73	24.19	55.65
	U	31	0.76	0.62	0.01	2.99	1.27	0.81	0.04	3.72	2.02	1.41	0.05	6.59	5.75	2.34	0.81	10.63	4.12	2.39	0.22	10.98	19.29	4.02	8.65	26.90	7.63	3.54	0.86	16.39	49.54	4.79	38.34	55.58
	Total	334	0.82	0.82	0.00	3.89	1.26	1.12	0.00	5.10	2.06	1.90	0.00	8.79	5.08	3.50	0.00	16.00	3.98	3.32	0.00	14.86	15.80	7.58	0.00	36.17	6.98	5.13	0.00	22.23	42.43	11.46	0.00	63.89
RATING	AAA	6	0.18	0.24	0.00	0.63	0.34	0.44	0.01	1.15	0.52	0.68	0.01	1.77	2.02	2.01	0.41	5.63	1.19	1.43	0.08	3.80	9.97	5.12	5.55	19.01	2.52	2.64	0.42	7.30	39.45	6.54	30.94	48.49
	AA	14	0.21	0.24	0.01	0.91	0.42	0.39	0.06	1.49	0.63	0.62	0.07	2.38	2.69	1.58	0.76	6.28	1.50	1.22	0.29	4.75	12.60	4.09	5.98	19.83	3.29	2.14	0.86	8.51	43.00	5.90	32.73	53.19
	A	100	0.37	0.39	0.00	1.82	0.62	0.57	0.00	2.53	0.99	0.95	0.00	4.30	3.00	2.13	0.00	8.37	2.06	1.78	0.00	7.70	11.44	5.95	0.00	23.11	3.94	2.98	0.00	12.31	36.67	12.18	0.00	55.99
	BBB	143	0.80	0.60	0.00	2.73	1.27	0.83	0.00	3.62	2.05	1.40	0.00	6.25	5.25	2.65	0.00	11.08	4.03	2.47	0.00	10.77	16.46	6.01	0.33	27.92	7.16	3.86	0.00	16.54	43.63	8.96	7.47	61.34
	BB	52	1.43	0.92	0.00	3.09	2.11	1.26	0.00	4.25	3.49	2.14	0.00	7.21	7.64	4.08	0.00	13.27	6.49	3.76	0.00	12.61	20.49	8.94	0.03	34.43	10.79	5.87	0.00	19.53	47.00	13.04	7.17	63.89
	B	13	2.78	0.78	1.27	3.89	3.80	0.88	2.26	5.10	6.46	1.60	3.60	8.79	11.97	2.25	7.12	16.00	11.32	2.44	6.86	14.86	27.50	4.41	17.76	36.17	17.63	3.32	10.77	22.23	54.20	5.36	42.13	63.52
	Unrated	6	1.30	1.22	0.02	3.20	1.96	1.58	0.03	4.19	3.22	2.75	0.05	7.26	7.31	4.56	0.25	12.45	6.05	4.61	0.13	12.38	20.07	9.85	1.64	29.23	10.19	6.87	0.30	18.80	46.12	16.73	12.41	57.22
	Total	334	0.82	0.82	0.00	3.89	1.26	1.12	0.00	5.10	2.06	1.90	0.00	8.79	5.08	3.50	0.00	16.00	3.98	3.32	0.00	14.86	15.80	7.58	0.00	36.17	6.98	5.13	0.00	22.23	42.43	11.46	0.00	63.89

Table 4: Impact of Corporate Shocks on Banks – Varying Initial Leverage

This table summarizes the average effects of two consecutive shocks in t_1, t_2 on the U.S. banks of our sample under different scenarios. The upper panel comprises the baseline case in which each bank starts with its real leverage ratio "Lev" defined as total equity over total assets. In the scenarios below every bank's capital structure has been adjusted to reflect the given leverage ratio. The adjustment is achieved by keeping the face value of the debt constant and altering the equity. "Def." denotes the fraction of defaulted banks in t_2 as defined by a negative equity value. Defaulted banks are not considered for the CDS Change and Delta averages. All numbers are given in percentage terms except for the CDS Change which is absolute and given in basis points. The Asset Shock and Debt Loss are calculated in percentage terms relative to their t_0 values and can thus be interpreted incrementally. Total Loss is the cumulative debt loss across the two shock periods. The average maturity and asset volatility are 2.55 and 0.14, respectively.

		t_0		t_1					t_2						
	Shock Size	Lev	Debt Delta	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Def.	Total Loss
BASELINE	10%	8.68	0.32	0.37	0.01	0.36	8.50	2.05	0.59	0.02	0.44	8.21	3.90	0.00	0.03
	20%			0.95	0.03	0.44	8.21	5.88	2.42	0.19	1.08	6.99	30.90	0.00	0.22
	30%			1.86	0.08	0.60	7.76	13.93	7.88	5.08	14.15	3.88	698.10	11.11	5.16
	35%			2.49	0.13	0.76	7.44	21.64	13.74	31.39	37.21	2.22	959.12	55.56	31.52
	40%			3.28	0.21	1.04	7.04	34.94	23.00	64.29	30.19	2.48	391.11	70.37	64.50
	45%			4.29	0.37	1.58	6.53	60.64	36.11	75.48	33.40	2.66	1367.13	81.48	75.86
	10%	2.00	15.34	0.37	0.72	17.40	1.87	240.27	0.59	1.38	21.19	1.67	591.64	0.00	2.10
	20%			0.95	2.07	21.12	1.67	818.48	2.42	9.88	42.57	1.01	1424.20	55.56	11.95
	30%			1.86	4.86	28.18	1.39	2340.80	7.88	52.54	41.60	0.64	476.11	74.07	57.40
	35%			2.49	7.41	33.90	1.22	2390.70	13.74	65.43	31.27	0.81	1997.41	77.78	72.84
	40%			3.28	11.44	41.67	1.03	1390.56	23.00	68.82	44.87	0.72	91.63	88.89	80.25
	45%			4.29	17.95	51.36	0.84	1575.36	36.11	70.74	10.20	0.90	205.58	88.89	88.69
	10%	4.00	5.63	0.37	0.25	6.43	3.82	54.69	0.59	0.48	7.97	3.55	113.19	0.00	0.73
	20%			0.95	0.72	7.94	3.55	165.60	2.42	3.74	18.99	2.52	1529.75	3.70	4.47
	30%			1.86	1.72	11.07	3.15	443.61	7.88	40.19	46.21	1.18	399.71	70.37	41.92
	35%			2.49	2.67	13.92	2.87	789.44	13.74	63.33	26.06	1.83	85.13	74.07	66.01
	40%			3.28	4.25	18.41	2.55	1513.41	23.00	69.69	8.87	2.09	608.77	74.07	73.94
	45%			4.29	7.04	25.52	2.18	2277.33	36.11	71.13	29.60	1.75	584.05	81.48	78.17
	10%	6.00	2.19	0.37	0.09	2.50	5.81	17.68	0.59	0.18	3.08	5.52	34.80	0.00	0.27
	20%			0.95	0.27	3.07	5.52	51.80	2.42	1.38	7.52	4.33	329.34	0.00	1.65
	30%			1.86	0.63	4.27	5.07	128.04	7.88	21.10	43.94	2.06	413.11	55.56	21.73
	35%			2.49	0.98	5.40	4.76	206.86	13.74	56.95	28.14	2.42	709.64	70.37	57.93
	40%			3.28	1.57	7.27	4.37	358.45	23.00	69.68	20.83	3.07	31.59	74.07	71.25
	45%			4.29	2.64	10.59	3.90	732.33	36.11	71.95	5.84	3.49	351.83	74.07	74.60
	10%	8.00	0.89	0.37	0.04	1.01	7.81	6.51	0.59	0.07	1.24	7.51	12.51	0.00	0.10
	20%			0.95	0.10	1.23	7.52	18.79	2.42	0.52	2.95	6.29	102.47	0.00	0.62
	30%			1.86	0.24	1.70	7.06	44.96	7.88	9.69	26.53	3.45	1484.00	25.93	9.93
	35%			2.49	0.37	2.13	6.74	70.37	13.74	44.76	33.10	2.57	838.53	59.26	45.14
	40%			3.28	0.59	2.86	6.34	115.02	23.00	66.05	23.38	4.22	2.58	74.07	66.64
	45%			4.29	0.99	4.16	5.84	204.68	36.11	72.83	0.46	4.84	19.39	74.07	73.83
	10%	10.00	0.37	0.37	0.01	0.42	9.82	2.59	0.59	0.03	0.52	9.53	4.89	0.00	0.04
	20%			0.95	0.04	0.51	9.53	7.39	2.42	0.20	1.20	8.32	37.16	0.00	0.25
	30%			1.86	0.10	0.70	9.08	17.33	7.88	3.96	12.27	5.21	530.37	11.11	4.06
	35%			2.49	0.15	0.88	8.77	26.67	13.74	28.40	37.39	3.47	461.95	51.85	28.55
	40%			3.28	0.23	1.16	8.37	42.41	23.00	61.54	20.11	4.92	222.34	70.37	61.77
	45%			4.29	0.39	1.68	7.86	71.82	36.11	71.99	0.04	5.93	1.48	74.07	72.38
	10%	15.00	0.05	0.37	0.00	0.05	14.83	0.32	0.59	0.00	0.06	14.57	0.59	0.00	0.01
	20%			0.95	0.01	0.06	14.58	0.90	2.42	0.02	0.14	13.48	4.04	0.00	0.03
	30%			1.86	0.01	0.09	14.17	2.05	7.88	0.38	1.37	10.42	67.79	0.00	0.39
	35%			2.49	0.02	0.11	13.88	3.08	13.74	4.72	12.20	7.34	440.21	11.11	4.74
	40%			3.28	0.03	0.14	13.52	4.73	23.00	37.70	25.07	5.92	509.27	51.85	37.73
	45%			4.29	0.04	0.20	13.05	7.57	36.11	62.30	18.38	8.71	1557.56	62.96	62.35
	10%	20.00	0.01	0.37	0.00	0.01	19.85	0.05	0.59	0.00	0.01	19.62	0.08	0.00	0.00
	20%			0.95	0.00	0.01	19.62	0.13	2.42	0.00	0.02	18.65	0.54	0.00	0.00
	30%			1.86	0.00	0.01	19.26	0.28	7.88	0.04	0.15	15.91	6.84	0.00	0.04
	35%			2.49	0.00	0.01	19.01	0.42	13.74	0.44	1.50	12.90	78.44	0.00	0.44
	40%			3.28	0.00	0.02	18.68	0.64	23.00	12.25	14.19	8.55	294.99	22.22	12.25
	45%			4.29	0.01	0.02	18.27	1.00	36.11	50.03	12.85	9.76	57.29	55.56	50.04

Table 5: Impact of Corporate Shocks on Banks – Sensitivity towards Volatility

This table summarizes the average effects of two consecutive shocks in t_1, t_2 on the U.S. banks of our sample under different asset volatility scenarios. The baseline case in Table 4 with $\sigma_V = 0.14$ provides an additional benchmark. "Def." denotes the fraction of defaulted banks in t_2 as defined by a negative equity value. Defaulted banks are not considered for the CDS Change and Delta averages. All numbers are given in percentage terms except for the CDS Change which is absolute and given in basis points. The Asset Shock and Debt Loss are calculated in percentage terms relative to their t_0 values and can thus be interpreted incrementally. Total Loss is the cumulative debt loss across the two shock periods. The average maturity is 2.55.

		t_0		t_1					t_2						
Shock Size	Vol	Lev	Debt Delta	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Def.	Total Loss
10%				0.37	0.13	3.45	8.80	6.46	0.59	0.22	3.80	8.53	11.63	0.00	0.35
20%				0.95	0.35	3.79	8.54	17.88	2.42	1.26	5.72	7.44	74.87	0.00	1.61
30%	0.24	8.97	3.25	1.86	0.75	4.40	8.13	39.79	7.88	9.71	18.65	4.70	1004.62	11.11	10.46
35%				2.49	1.07	4.90	7.84	58.86	13.74	35.30	38.48	3.06	1306.91	55.56	36.38
40%				3.28	1.55	5.63	7.48	88.83	23.00	64.81	33.15	3.08	628.52	70.37	66.35
45%				4.29	2.27	6.74	7.03	140.20	36.11	74.95	29.51	3.05	1759.62	81.48	77.22
10%				0.37	0.29	7.14	9.70	12.82	0.59	0.49	7.57	9.45	22.37	0.00	0.78
20%				0.95	0.77	7.56	9.46	34.79	2.42	2.43	9.74	8.47	129.63	0.00	3.21
30%	0.34	9.85	6.88	1.86	1.60	8.29	9.09	74.94	7.88	13.45	20.61	5.98	1359.98	11.11	15.05
35%				2.49	2.23	8.86	8.83	108.21	13.74	38.35	35.02	4.37	1705.46	55.56	40.58
40%				3.28	3.10	9.65	8.51	158.09	23.00	65.05	30.46	4.27	884.52	70.37	68.15
45%				4.29	4.34	10.78	8.10	238.71	36.11	74.18	27.06	3.77	2219.69	81.48	78.52
10%				0.37	0.44	9.62	11.17	19.32	0.59	0.73	10.04	10.94	33.21	0.00	1.17
20%				0.95	1.16	10.03	10.95	51.93	2.42	3.44	12.05	10.04	183.45	0.00	4.60
30%	0.44	11.31	9.37	1.86	2.36	10.73	10.61	110.22	7.88	16.37	20.77	7.74	1728.20	11.11	18.73
35%				2.49	3.25	11.25	10.37	157.42	13.74	40.72	31.41	6.18	2125.66	55.56	43.98
40%				3.28	4.46	11.96	10.08	226.70	23.00	65.20	27.34	5.96	1135.31	70.37	69.65
45%				4.29	6.12	12.96	9.70	335.82	36.11	73.45	24.47	4.80	2711.88	81.48	79.57
10%				0.37	0.57	10.83	13.19	25.46	0.59	0.94	11.19	12.98	43.45	0.00	1.51
20%				0.95	1.49	11.19	12.99	68.13	2.42	4.27	12.90	12.15	234.76	0.00	5.76
30%	0.54	13.32	10.61	1.86	3.00	11.79	12.67	143.59	7.88	18.63	19.70	9.99	2108.92	11.11	21.63
35%				2.49	4.11	12.23	12.45	204.04	13.74	42.51	27.57	8.46	2571.96	55.56	46.62
40%				3.28	5.59	12.83	12.18	291.94	23.00	65.23	23.93	8.10	1385.04	70.37	70.82
45%				4.29	7.58	13.65	11.83	428.82	36.11	72.80	21.67	6.17	3230.62	81.48	80.38
10%				0.37	0.68	11.02	15.73	31.34	0.59	1.10	11.33	15.54	53.31	0.00	1.78
20%				0.95	1.76	11.32	15.54	83.69	2.42	4.94	12.71	14.76	285.20	0.00	6.70
30%	0.64	15.85	10.84	1.86	3.53	11.81	15.25	175.82	7.88	20.35	17.94	12.71	2510.00	11.11	23.88
35%				2.49	4.82	12.18	15.05	249.28	13.74	43.80	23.77	11.20	3052.90	55.56	48.62
40%				3.28	6.51	12.66	14.79	355.67	23.00	65.20	20.57	10.67	1643.19	70.37	71.70
45%				4.29	8.76	13.31	14.46	520.57	36.11	72.23	18.83	7.89	3782.25	81.48	80.99

Table 6: Impact of Corporate Shocks on Banks – Sensitivity towards T

This table summarizes the average effects of two consecutive shocks in t_1, t_2 on the U.S. banks of our sample under different time to maturity T scenarios. The baseline case in Table 4 with $T = 2.55$ provides an additional benchmark. "Def." denotes the fraction of defaulted banks in t_2 as defined by a negative equity value. Defaulted banks are not considered for the CDS Change and Delta averages. All numbers are given in percentage terms except for the CDS Change which is absolute and given in basis points. The Asset Shock and Debt Loss are calculated in percentage terms relative to their t_0 values and can thus be interpreted incrementally. Total Loss is the cumulative debt loss across the two shock periods. The average asset volatility is 0.14.

		t_0		t_1					t_2						
Shock Size	T	Lev	Debt Delta	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Def.	Total Loss
10%				0.37	0.03	0.82	8.52	2.00	0.59	0.05	0.96	8.23	3.76	0.00	0.08
20%				0.95	0.08	0.95	8.24	5.69	2.42	0.37	1.97	7.04	28.11	0.00	0.45
30%	3.55	8.70	0.74	1.86	0.18	1.23	7.79	13.25	7.88	6.24	15.60	4.02	530.31	11.11	6.42
35%				2.49	0.27	1.49	7.48	20.31	13.74	32.43	38.77	2.38	747.10	55.56	32.70
40%				3.28	0.43	1.91	7.09	32.18	23.00	64.55	30.14	2.56	320.08	70.37	64.98
45%				4.29	0.71	2.66	6.59	54.37	36.11	75.57	31.78	2.73	1019.00	81.48	76.28
10%				0.37	0.05	1.40	8.56	2.02	0.59	0.09	1.60	8.28	3.75	0.00	0.14
20%				0.95	0.13	1.60	8.28	5.70	2.42	0.58	2.94	7.11	26.81	0.00	0.71
30%	4.55	8.74	1.29	1.86	0.30	1.98	7.84	13.10	7.88	7.26	16.69	4.17	448.46	11.11	7.56
35%				2.49	0.45	2.33	7.54	19.87	13.74	33.27	37.79	2.52	630.46	55.56	33.72
40%				3.28	0.68	2.87	7.15	31.01	23.00	64.72	29.87	2.65	282.16	70.37	65.40
45%				4.29	1.08	3.77	6.66	51.31	36.11	75.55	30.66	2.80	845.03	81.48	76.63
10%				0.37	0.07	2.04	8.62	2.05	0.59	0.13	2.29	8.34	3.76	0.00	0.20
20%				0.95	0.20	2.29	8.34	5.74	2.42	0.79	3.89	7.19	25.95	0.00	0.99
30%	5.55	8.79	1.90	1.86	0.44	2.77	7.91	13.06	7.88	8.13	17.51	4.32	397.88	11.11	8.57
35%				2.49	0.64	3.18	7.61	19.63	13.74	33.96	36.92	2.66	556.04	55.56	34.60
40%				3.28	0.95	3.81	7.23	30.28	23.00	64.81	29.48	2.73	257.50	70.37	65.76
45%				4.29	1.46	4.82	6.75	49.30	36.11	75.45	29.82	2.87	739.74	81.48	76.91
10%				0.37	0.10	2.69	8.68	2.07	0.59	0.17	2.98	8.41	3.77	0.00	0.26
20%				0.95	0.26	2.98	8.41	5.78	2.42	1.00	4.76	7.28	25.28	0.00	1.26
30%	6.55	8.86	2.52	1.86	0.57	3.53	7.99	13.01	7.88	8.88	18.11	4.46	362.89	11.11	9.45
35%				2.49	0.83	3.99	7.69	19.43	13.74	34.50	36.10	2.79	504.15	55.56	35.32
40%				3.28	1.21	4.68	7.32	29.70	23.00	64.84	34.21	2.82	239.68	70.37	66.05
45%				4.29	1.82	5.76	6.85	47.75	36.11	75.32	29.16	2.94	668.77	81.48	77.13

Table 7: Impact of Corporate Shocks on Banks – Deleveraging

This table summarizes the average effects of two consecutive shocks in t_1, t_2 on the U.S. banks of our sample under different deleveraging scenarios. Deleveraging is supposed to occur in a subperiod after the first shock. In all scenarios the leverage ratio prevailing in t_0 is restored. "fire sale" implies the proportional reduction of (face value of) outstanding debt and asset value. "Guarantee" means that the asset value remains constant after the first shock but that pre-shock leverage is restored. "Recap" entails a full equity recapitalization that exactly offsets the shock. "Lev" is defined as total equity over total assets. "Def." denotes the fraction of defaulted banks in t_2 as defined by a negative equity value. Defaulted banks are not considered for the CDS Change and Delta averages. All numbers are given in percentage terms except for the CDS Change which is absolute and given in basis points. The Asset Shock and Debt Loss are calculated in percentage terms relative to their t_0 values and can thus be interpreted incrementally. Total Loss is the cumulative debt loss across the two shock periods. The average maturity and asset volatility are 2.55 and 0.14, respectively.

		t_0		t_1					t_1^*				t_2						
	Shock Size	Lev	Debt Delta	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Debt Red.	Debt Delta	Lev	CDS Change	Asset Shock	Debt Loss	Debt Delta	Lev	CDS Change	Def.	Total Loss
FIRE SALES	10%			0.37	0.01	0.36	8.50	2.05	2.20			-2.05	0.59	0.02	0.39	8.38	3.50	0.00	0.03
	20%			0.95	0.03	0.44	8.21	5.88	5.63			-5.88	2.42	0.13	0.81	7.38	23.85	0.00	0.17
	30%	8.68	0.32	1.86	0.08	0.60	7.76	13.93	10.95	0.32	8.68	-13.93	7.88	4.19	13.45	4.15	575.60	11.11	4.27
	35%			2.49	0.13	0.76	7.44	21.64	14.65			-21.64	13.74	26.17	38.51	2.37	847.12	55.56	26.29
	40%			3.28	0.21	1.04	7.04	34.94	19.29			-34.94	23.00	49.01	23.77	2.52	332.81	70.37	49.22
	45%			4.29	0.37	1.58	6.53	60.64	25.10			-60.64	36.11	52.27	34.67	2.69	1284.02	81.48	52.64
CONVERSION	10%			0.37	0.01	0.36	8.50	2.05	1.36			-2.05	0.59	0.02	0.39	8.38	3.45	0.00	0.03
	20%			0.95	0.03	0.44	8.21	5.88	3.48			-5.88	2.42	0.13	0.78	7.42	22.44	0.00	0.16
	30%	8.68	0.32	1.86	0.08	0.60	7.76	13.93	6.76	0.32	8.68	-13.93	7.88	3.23	10.47	4.39	482.09	7.41	3.31
	35%			2.49	0.13	0.76	7.44	21.64	9.04			-21.64	13.74	24.59	34.51	2.47	1519.27	48.15	24.72
	40%			3.28	0.21	1.04	7.04	34.94	11.88			-34.94	23.00	53.34	28.09	2.60	274.64	70.37	53.55
	45%			4.29	0.37	1.58	6.53	60.64	15.43			-60.64	36.11	60.55	31.04	2.75	781.14	81.48	60.92
RECAP.	10%			0.37	0.01	0.36	8.50	2.05				-2.05	0.59	0.02	0.39	8.39	3.38	0.00	0.02
	20%			0.95	0.03	0.44	8.21	5.88				-5.88	2.42	0.12	0.74	7.48	20.69	0.00	0.12
	30%	8.68	0.32	1.86	0.08	0.60	7.76	13.93	0.00	0.32	8.68	-13.93	7.88	2.29	7.26	4.73	559.83	0.00	2.29
	35%			2.49	0.13	0.76	7.44	21.64				-21.64	13.74	19.43	31.23	2.53	1311.34	37.04	19.43
	40%			3.28	0.21	1.04	7.04	34.94				-34.94	23.00	58.78	28.95	2.10	202.92	70.37	58.78
	45%			4.29	0.37	1.58	6.53	60.64				-60.64	36.11	73.06	24.08	2.59	2346.61	77.78	73.06

Table 8: Bank Shocks and Leverage

This table reports, in cross-sectional average terms, the leverage increase (both absolute and relative, in percent) in the pre-shock that would be required to make the bank debt insensitive towards a single shock of a given size. Results are decomposed by rating group and leverage ratio buckets. The “Agg.” column refers to the aggregate results across all rating classes and leverage buckets, respectively.

RATING

	AA		A		BBB		BB		Agg.	
Shock	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase
5%	5.46	82.17	9.74	115.48	20.72	118.39	13.98	193.23	9.04	108.60
10%	6.16	91.84	10.65	126.17	22.05	126.02	19.41	268.31	10.06	121.26
15%	6.72	99.55	11.31	133.96	22.97	131.28	20.12	278.03	10.71	129.00
20%	7.23	106.48	11.88	140.62	23.73	135.61	20.70	286.10	11.27	135.71
25%	7.72	113.00	12.40	146.74	24.41	139.48	21.22	293.31	11.78	141.90
30%	8.19	119.30	12.89	152.50	25.04	143.07	21.71	300.03	12.27	147.78
35%	8.65	125.47	13.36	158.05	25.63	146.45	22.17	306.41	12.74	153.46
40%	9.10	131.51	13.82	163.45	26.20	149.71	22.62	312.58	13.20	159.00
45%	9.54	137.46	14.26	168.71	26.75	152.85	23.05	318.59	13.65	164.41
50%	9.98	143.33	14.70	173.88	27.28	155.92	23.48	324.45	14.09	169.74
55%	10.42	149.13	15.13	178.95	27.81	158.90	23.89	330.22	14.53	174.97
60%	10.85	154.88	15.55	183.95	28.32	161.83	24.30	335.91	14.95	180.14

LEV BUCKETS

	[0,0.04]		]0.04,0.06]		]0.06,0.08]		]0.08,0.1]		]0.1,0.14]		]0.14,		Agg.	
Shock	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase	Abs. Lev Increase	Rel. Lev Increase
5%	4.10	124.27	6.19	148.04	10.12	140.92	8.10	88.15	12.29	110.75	16.26	99.34	9.04	108.60
10%	4.51	136.65	6.74	161.07	12.06	168.00	8.95	97.42	13.51	121.66	17.52	107.12	10.06	121.26
15%	4.81	145.67	7.13	170.40	12.66	176.50	9.61	104.61	14.41	129.59	18.42	112.77	10.71	129.00
20%	5.06	153.44	7.46	178.31	13.17	183.75	10.20	111.00	15.15	136.23	19.20	117.63	11.27	135.71
25%	5.30	160.62	7.76	185.52	13.63	190.36	10.75	116.97	15.84	142.29	19.91	122.10	11.78	141.90
30%	5.52	167.41	8.05	192.32	14.07	196.62	11.28	122.73	16.47	147.83	20.58	126.33	12.27	147.78
35%	5.74	174.06	8.32	198.89	14.49	202.64	11.80	128.31	17.07	153.12	21.22	130.38	12.74	153.46
40%	5.96	180.55	8.59	205.29	14.90	208.48	12.30	133.79	17.64	158.17	21.84	134.30	13.20	159.00
45%	6.17	186.96	8.86	211.59	15.30	214.23	12.79	139.15	18.20	163.04	22.45	138.14	13.65	164.41
50%	6.38	193.29	9.12	217.80	15.69	219.86	13.28	144.45	18.73	167.74	23.05	141.87	14.09	169.74
55%	6.59	199.60	9.37	223.91	16.08	225.43	13.76	149.65	19.25	172.28	23.63	145.54	14.53	174.97
60%	6.79	205.85	9.63	230.01	16.46	230.91	14.23	154.79	19.76	176.75	24.19	149.12	14.95	180.14

Figure 1: Evolution of CDS Deltas across Sectors

This chart depicts the evolution of the average CDS delta with respect to asset value in percent across sectors from 2006 to 2010.

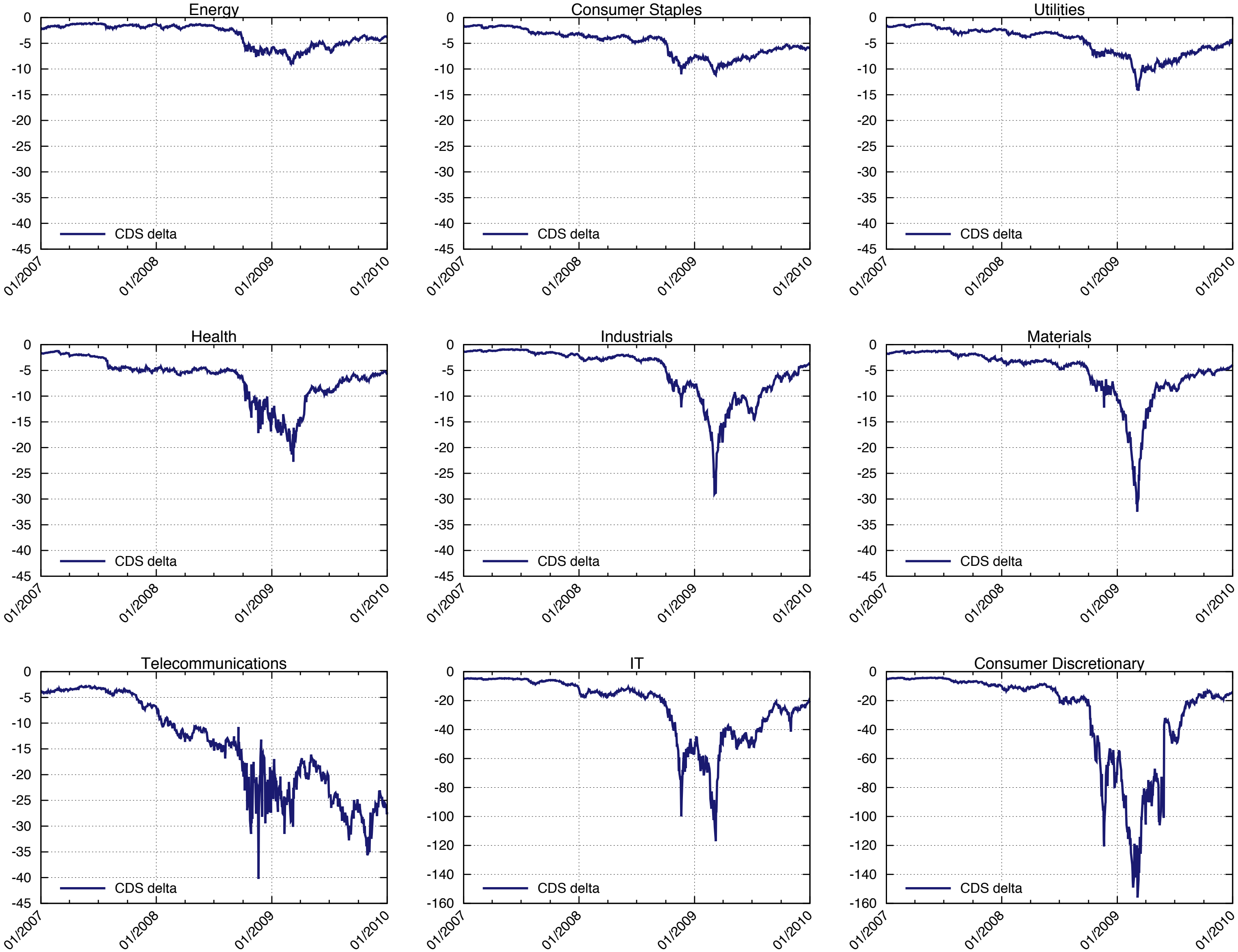


Figure 2: Evolution of CDS Deltas across Rating Classes

This chart depicts the evolution of the average CDS delta with respect to asset value in percent across rating classes from 2006 to 2010.

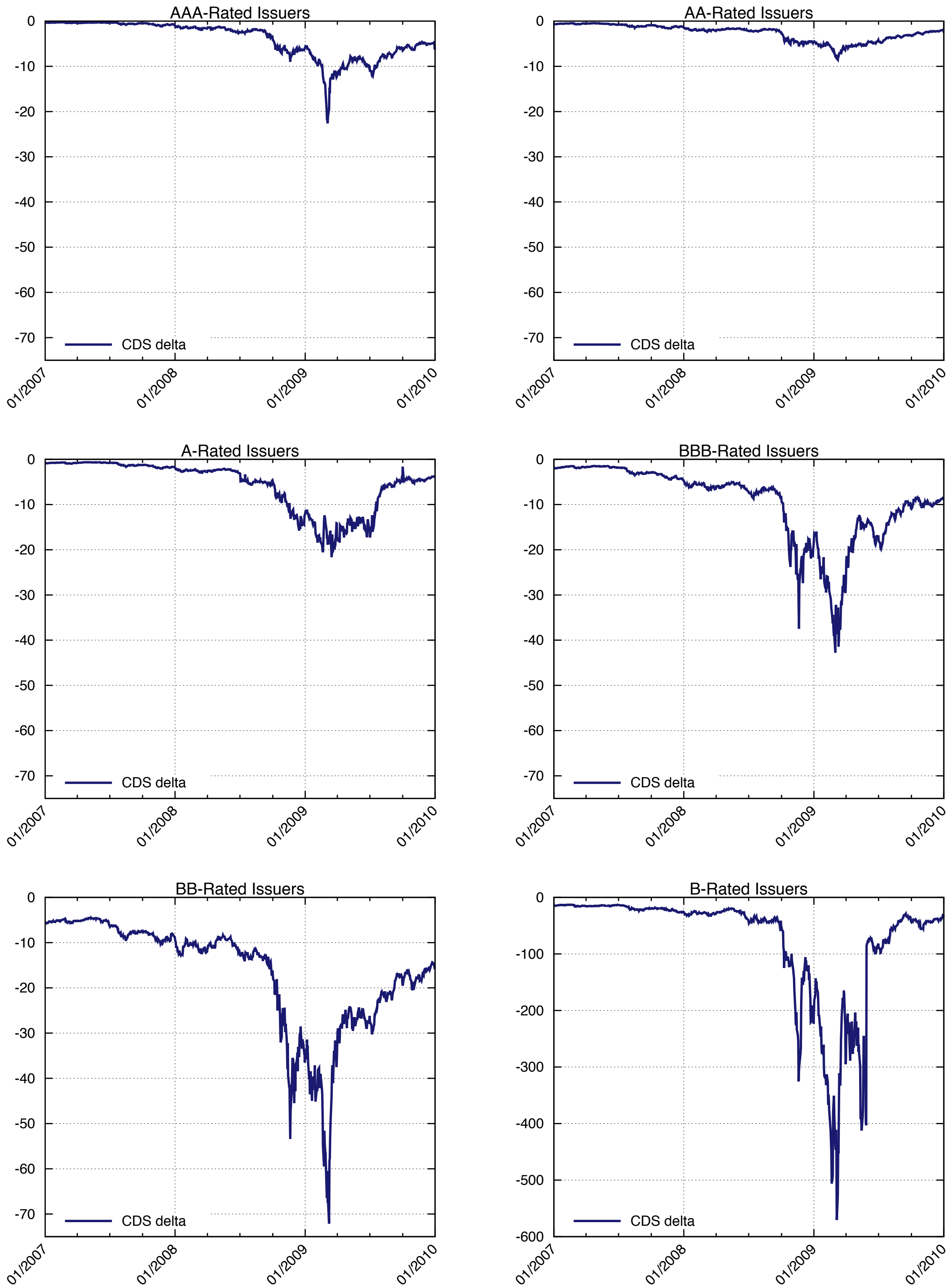


Figure 3: Evolution of Debt Deltas across Sectors

This chart depicts the evolution of the average debt delta with respect to asset value in percent across sectors from 2006 to 2010.

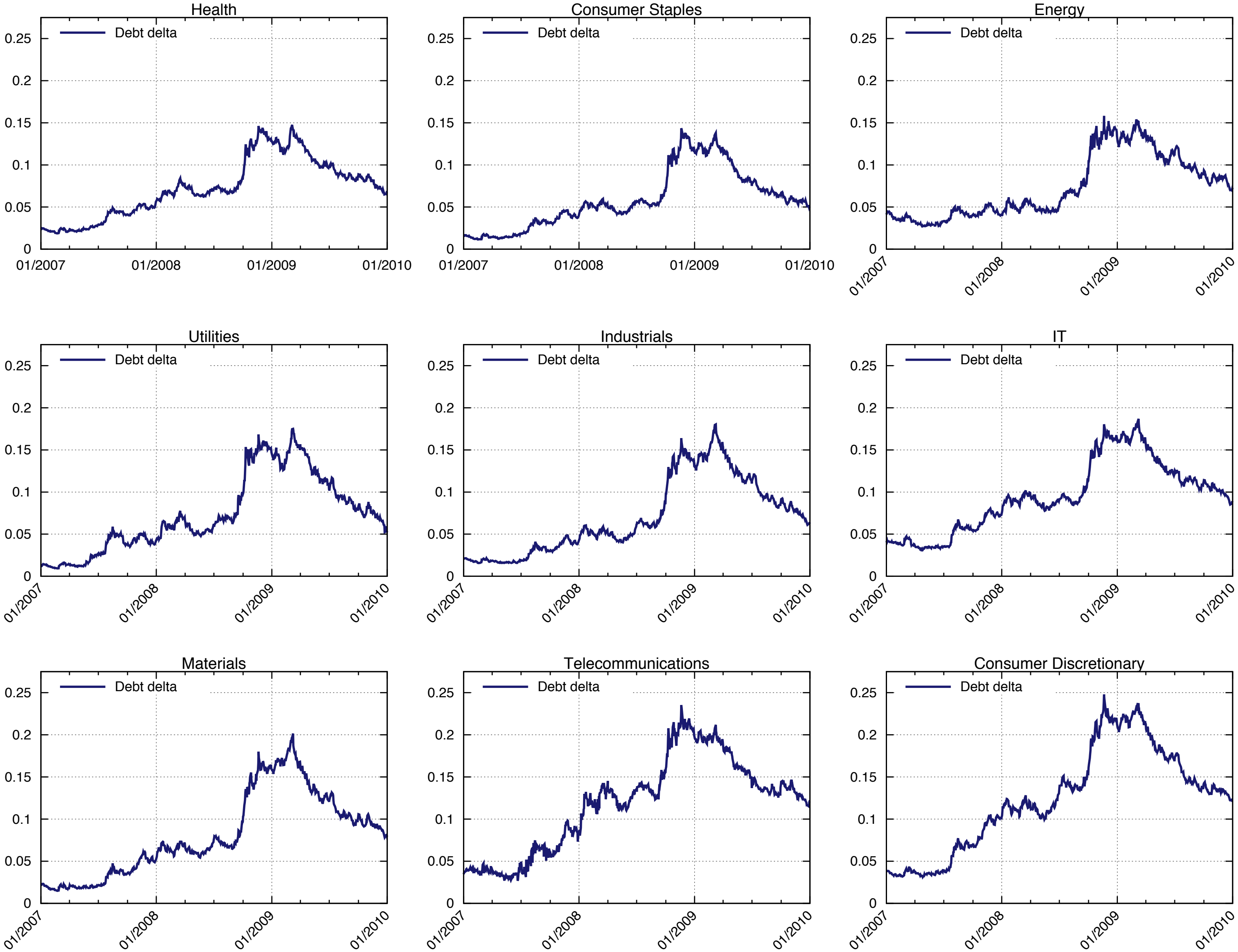


Figure 4: Evolution of Debt Deltas across Rating Classes

This chart depicts the evolution of the average debt delta with respect to asset value in percent across rating classes from 2006 to 2010.

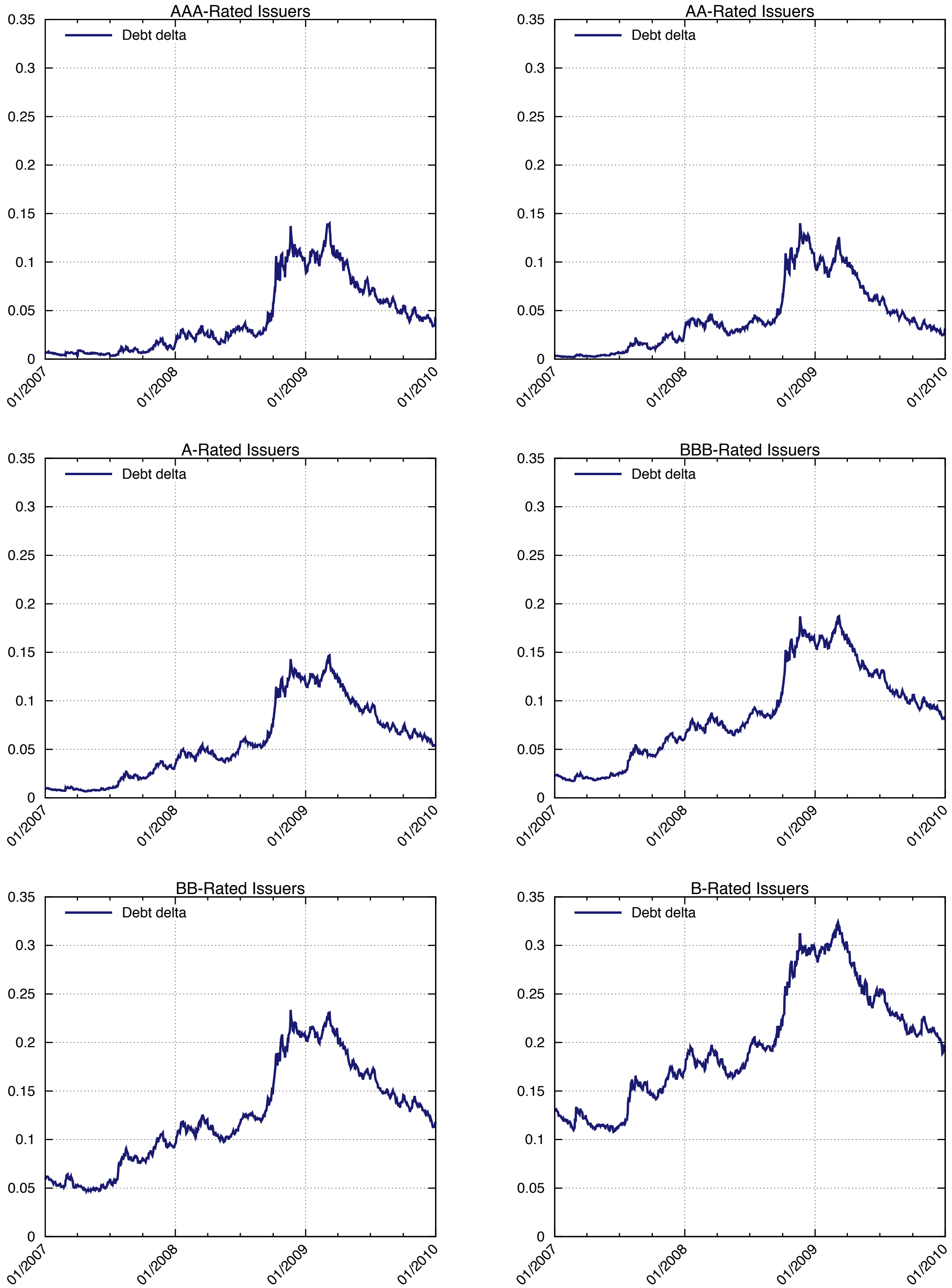
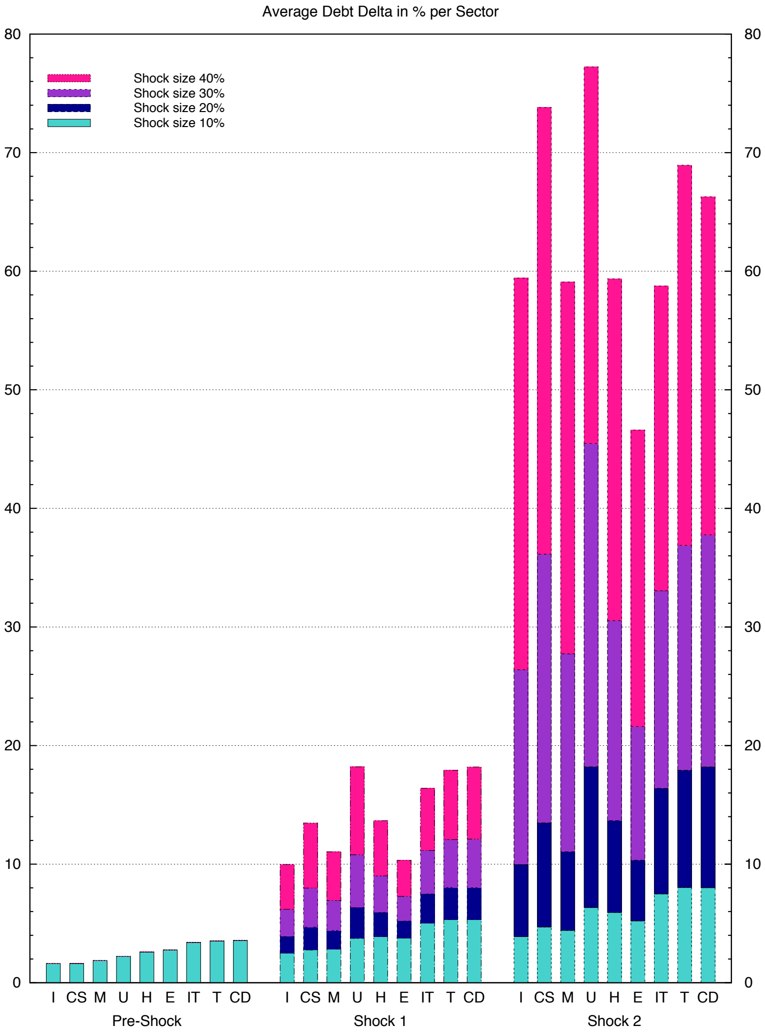


Figure 5: Debt Deltas after Shocks across Sectors and Rating Classes

These charts depict average debt deltas in percent prior and after two consecutive shocks of 10%, 20%, 30%, and 40% according to sectors and rating classes, respectively. The bars for the individual shock sizes are overlapping, not stacked. For the sector names we use the abbreviations in brackets listed in the following: Consumer Discretionary (CD), Consumer Staples (CS), Energy (E), Health (H), Industrials (I), Information Technology (IT), Materials (M), Telecommunications (T), and Utilities (U).



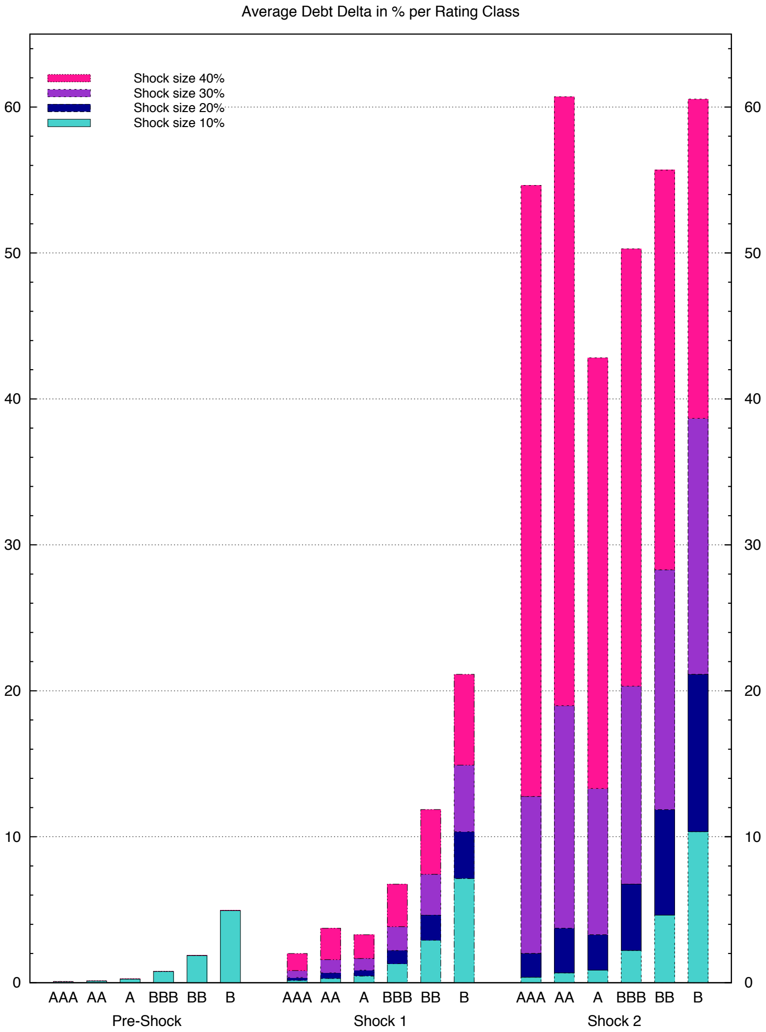


Figure 6: CDS Spread Reaction to Shocks across Sectors and Rating Classes

These charts depict average CDS spread changes in bps after two consecutive shocks of 10%, 20%, 30%, and 40% according to sectors and rating classes, respectively. The bars for the individual shock sizes are overlapping, not stacked. For the sector names we use the abbreviations in brackets listed in the following: Consumer Discretionary (CD), Consumer Staples (CS), Energy (E), Health (H), Industrials (I), Information Technology (IT), Materials (M), Telecommunications (T), and Utilities (U).

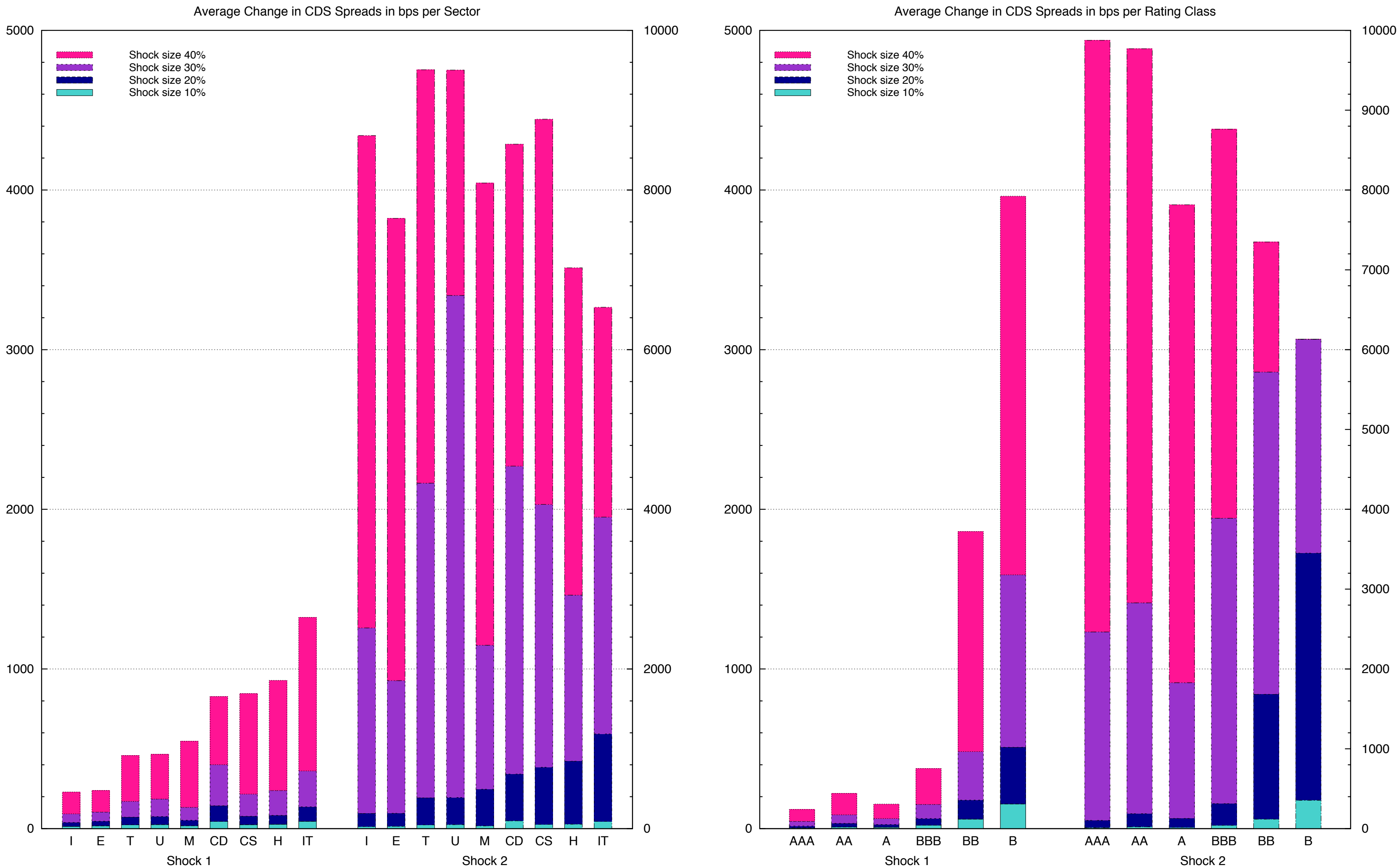


Figure 7: Debt Value Reactions to Shocks across Sectors and Rating Classes

These charts depict average debt value reactions in percent after two consecutive shocks of 10%, 20%, 30%, and 40% according to sectors and rating classes, respectively. The bars for the individual shock sizes are overlapping, not stacked. For the sector names we use the abbreviations in brackets listed in the following: Consumer Discretionary (CD), Consumer Staples (CS), Energy (E), Health (H), Industrials (I), Information Technology (IT), Materials (M), Telecommunications (T), and Utilities (U).

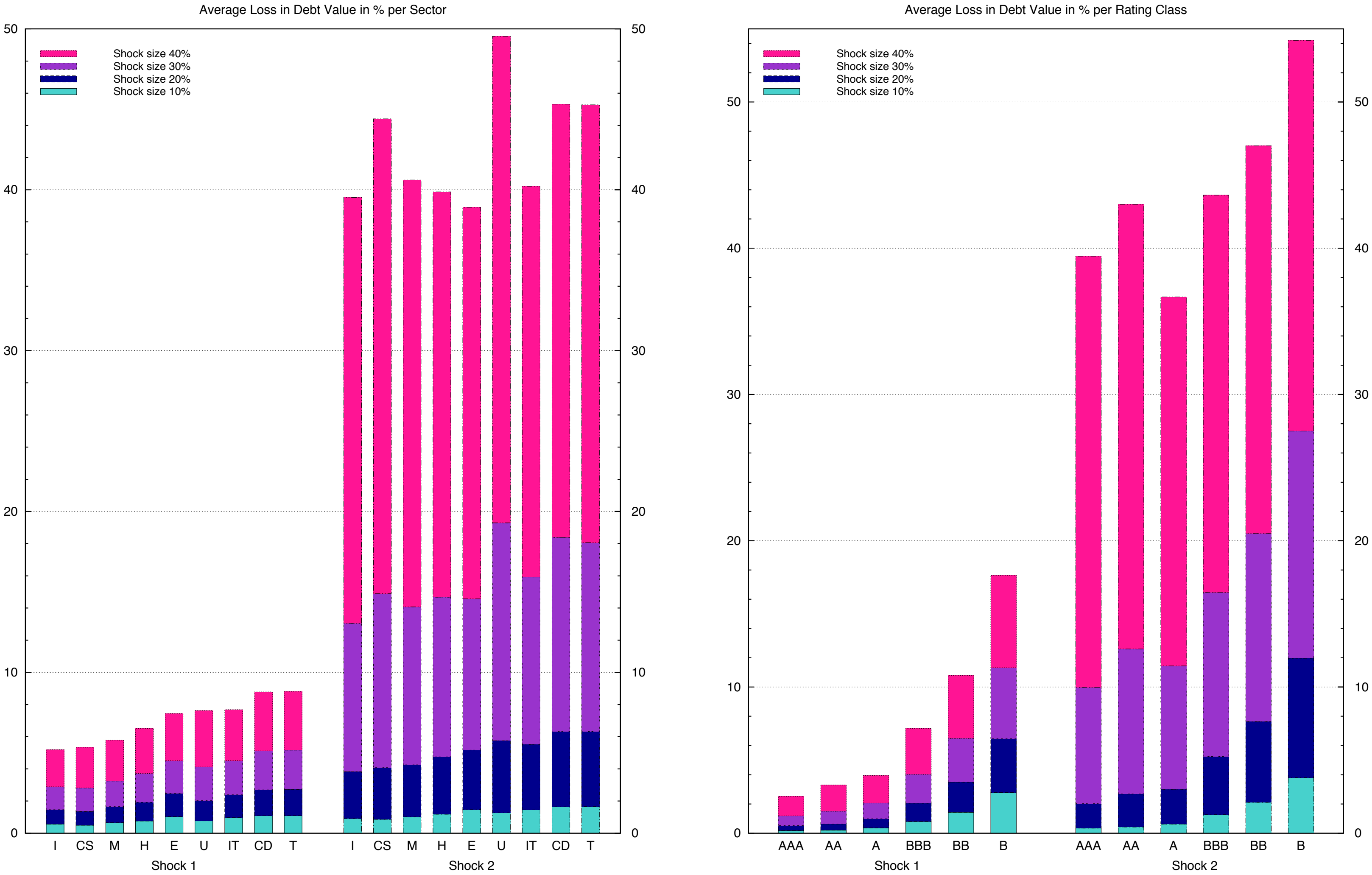


Figure 8: Debt Value Reactions to Shocks across Leverage and Asset Volatility Buckets

These charts depict average debt value reactions in percent after two consecutive shocks of 10%, 20%, 30%, and 40% according to leverage and volatility buckets, respectively. The bars for the individual shock sizes are overlapping, not stacked. For the sector names we use the abbreviations in brackets listed in the following: Consumer Discretionary (CD), Consumer Staples (CS), Energy (E), Health (H), Industrials (I), Information Technology (IT), Materials (M), Telecommunications (T), and Utilities (U).