When Senior meets Junior: Information in Credit Default Swap Spreads of Large Banks

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Abstract

We investigate whether information in credit default swap spreads (CDS) is useful for assessing the default risk of large banks. Because of banks' special capital structure two liquid trading segments have emerged: one for CDS on senior bank debt, and one for CDS on subordinate bank debt. We find that both CDS spreads contribute significantly to price discovery but transactions costs (i.e., the relative bid-ask spread) are lower in subordinate CDS. After the onset of the financial crisis there is a lead-lag relation between senior and subordinate CDS, and subordinate CDS loose their transaction cost advantage. We further derive daily market-implied values for bank risk parameters. Comparing the pre- and post-crisis period, we show that the loss given default on senior bank debt increases from 57% to 62% and the probability of default increases from 0.32% to 1.23%. Our results indicate that the CDS market conveys differentiated information on banks' default risk that is suited to play an important role in enhancing market discipline in a new supervisory and regulatory framework.

JEL classification: G10, G20, G 21

Keywords: Credit derivatives; Banks; Subordinate debt; Loss given default

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1. Introduction

In the aftermath of the financial crisis of 2007-2009 and during the on-going sovereign debt crisis, governments, central banks, and bank supervisors have been struggling whether and how to rescue individual banks, how to restore financial stability, and how to shape the future global financial system (Bank for International Settlements 2009). In this paper, we investigate whether information from credit default swap (CDS) markets is useful for assessing the default risk of large banks. CDS spreads could help to enhance market discipline through market monitoring because since they represent a complementary source of real-time risk information, which, in turn, might influence banks' credit availability and funding costs.

Given the importance of large banks, the growth of credit risk transfer, and its role during the financial crisis (e.g., Brunnermeier 2009, Stulz 2010), it is surprising that there is little evidence on the informational content of CDS on banks (exceptions are Eichengreen, Mody, Nedeljkovic and Sarno 2009; King 2009).[1] Banks' credit spreads were relatively low for a long period of time and there was no additional demand for market-based credit risk assessment and market discipline mechanisms beyond traditional banking supervision, credit ratings, and accounting-based disclosure requirements. The situation has changed substantially after the beginning of the financial crisis in August 2007. Large credit losses, a substantial number of bank failures, the freeze up of interbank markets, and the adverse consequences on global economic activity are examples for the impact of realized default risk coming from the banking sector. Counterparty risk in interbank and OTC derivatives markets has become a key issue since credit spreads of banks have widened dramatically and also price volatility has increased substantially.

[1] The banking sector exhibits with 22% the largest industry share of frequently traded underlyings in CDS markets (CreditTrade Benchmarks database).

What do prices in the CDS market tell us about the default risk of large banks? To answer this question, we take advantage of a unique characteristic of this market: CDS traders frequently provide simultaneous quotations for contracts on senior and subordinate bank debt. The main reason for this simultaneous quotation is that, unlike industrial firms, banks make frequent and substantial use of subordinate notes and debentures (SND) since these securities are recognized as regulatory capital. Therefore, the subordinate CDS segment attracts an important share of the overall trading volume in CDS written on banks. Moreover, previous studies document that CDS markets in general are more sensitive to credit-related information and more liquid than other markets, in particular compared to bond markets and when credit conditions deteriorate. Furthermore, in contrast to stock markets, CDS markets exclusively involve institutional traders and there is little supervision and regulation.

Analyzing daily price information for an international sample of large banks, we obtain the following results. First, before the financial crisis, senior and subordinate CDS spreads contribute significantly to price discovery but transaction costs, measured by the relative bid-ask spread, are lower for subordinate CDS. Moreover, our time-series analysis and event study on credit rating announcements indicate that subordinate CDS are more risk-sensitive than senior CDS. These finding imply that subordinate CDS are useful to obtain early warning indications of changes in banks' default risk during normal times. Second, after the beginning of the financial crisis in August 2007, information is reflected earlier in senior CDS. We observe a significant lead-lag relationship between senior and subordinate CDS, indicating a deviation from the long-run equilibrium. Furthermore, the subordinate CDS segment looses its transaction cost advantage. We observe that "senior meets junior" in terms of the relative bid-ask spread. These findings indicate that during the financial crisis information processing and liquidity in CDS on banks has changed in favor of the senior segment. Third, using both CDS spreads for the same banks makes it possible for us to derive

daily market-implied values for two risk parameters jointly. We show that the loss given default on senior bank debt increases from 57% to 62% and the probability of default rises from 0.34% to 1.23%, when comparing the pre- and post-crisis period. Our study indicates that CDS markets convey differentiated information on banks' default risk that is suited to play an important role in a regulatory framework that aims at enhancing market discipline.

Our paper makes contributes to the literature on banking and finance, especially market-based risk indicators, in several ways (e.g., Brunnermeier 2009; De Jonghe 2010; Knaup and Wagner 2011). To the best of our knowledge, our study is the first comprehensive analysis of CDS spreads on banks. We note that trading in CDS on banks was rather resilient during the financial crisis, while inter-bank lending and trading in bank bonds and debentures broke down very quickly. We provide new evidence on changes in information processing and liquidity in both CDS market segments before and during the financial crisis, indicating that market participants adjust their trading behavior strategically. Moreover, the simultaneous quotation of CDS spreads on senior and subordinate bank debt makes it possible for us to derive daily market-implied values for two risk parameters jointly in a simple and parsimonious framework. By doing so, we circumvent the estimation of firm-value models that are often based on restrictive assumptions and not suited for banks, and, propose an elegant way to derive loss given default values for bank debt without having data on defaulted debt securities. This is an important issue for bank supervisors because, unlike non-financial firms, the financial sector displays a significantly lower number of actual default events in the long-run, making it difficult to derive risk parameters from historical data. Our results may be useful for improving prudential bank supervision and to enhance market discipline, as suggested by Hart and Zingales (2009).

The rest of the paper proceeds as follows. In Section 2 we review the related literature on credit default swap markets, indicators of bank fragility, and proposals on how to use

subordinate bank debt to enhance market discipline. In Section 3 we outline the conceptual framework and describe the data. In Section 4 we report our main empirical results on CDS information processing, market liquidity, and market-implied risk parameters. Section 5 concludes.

2. Related literature

Our study relates to the growing research on credit default swap markets, studies on market-based indicators of bank fragility, and proposals to use market information on subordinate bank debt in prudential bank supervision.

First, empirical research on credit derivatives provides evidence that CDS markets are highly efficient in processing credit-related information (e.g., Acharya and Johnson 2007; Jorion and Zhang 2007). These studies show that CDS markets lead bond markets in a time-series and event-specific framework, and CDS spreads contribute more to price discovery than bond spreads (e.g., Blanco, Brennan and Marsh 2005; Zhu 2006; Norden and Weber 2009). Moreover, CDS markets react significantly prior to downgrades or negative watchlistings announced by the major rating agencies (e.g., Hull, Predescu, and White 2004; Norden and Weber 2004; Norden 2011). Furthermore, there is evidence that CDS markets have affected the pricing of bank loans to large firms (e.g., Norden and Wagner 2008; Hirtle 2009; Ashcraft and Santos 2009). In the aftermath of the financial crisis, King (2009) analyzes the impact of government rescue measures from October 2008 to January 2009 on banks' stock prices and CDS spreads in ten countries. He finds that government interventions were perceived as good news for creditors and bad news for stockholders, except in the US where banks' stock prices substantially increased again.

Second, various studies examine indicators of bank fragility based on price information from various markets. These studies investigate whether market-based risk indicators provide

additional and more timely information than traditional risk measures, such as financial ratios and credit ratings, and bank supervisors' assessments (e.g., Berger, Davies, and Flannery 2000; Swidler and Wilcox 2002; Bongini, Laeven and Majnoni 2002; Gropp, Vesala, and Vulpes 2004; Düllmann and Sosinska 2007; Adrian and Brunnermeier 2008; De Jonghe 2010; Knaup and Wagner 2011). Two of these papers are more closely related to our work. On the one hand, Düllmann and Sosinska (2007) provide a case study on the determinants of CDS spreads on senior banks debt issued by three large German banks. On the other hand, Knaup and Wagner (2011) propose a credit risk indicator for US banks, linking their stock prices to aggregate default risk. The credit risk indicator is defined as the ratio of banks' stock price sensitivities to aggregate CDS spreads on investment and non-investment grade borrowers and can be interpreted as an indicator for banks' asset quality. The study shows that the credit risk indicator significantly predicts banks' performance in the aftermath of the financial crisis and its informational content goes beyond traditional measures of asset quality and bank risk. By contrast, we analyze *bank-specific* CDS spreads on senior and subordinate debt, and we derive daily market-implied values for banks' loss-given default on senior debt and probability of default.

Third, starting in the mid-nineteen nineties, researchers and policymakers have been thinking about how to incorporate market discipline in prudential bank supervision and regulation. Most of these proposals investigate whether and how subordinate notes and debentures (SND) can be used to set incentives for banks through market monitoring and market influence (e.g., Flannery 1998; DeYoung, Flannery, Lang and Sorescu 2001; Bliss 2001; Evanoff and Wall 2002; Lang and Robertson 2002; Basel Committee on Banking Supervision 2003; Sironi 2003; Krishnan, Ritchken, and Thomson 2005; Bank for International Settlements 2009; Chen and Hasan 2011). The reasons for considering subordinate bank debt are that this type of debt is more risk-sensitive than senior debt, and

every bank is able to issue subordinate debt, including the large number of non-listed institutions. Such a regulation aims at implementing market monitoring based on credit spreads of subordinate bank debt and might also require banks to issue or repurchase subordinate debt under certain conditions. Moreover, capital requirements could be tied to banks' credit spreads. A major problem with these proposals is that, although credit spreads of newly issued SND could be an informative snapshot of bank fragility but there is little secondary trading in these instruments and, thus, no continuous market monitoring (Basel Committee of Bank Supervision, 2003). There is no such problem with CDS markets, where trading has been rather resilient even after the beginning of the financial crisis in August 2007 (Fitch Ratings, 2009). Thus, we examine the informational content of large banks' CDS spreads on senior and subordinate debt to find out whether this information is useful for market monitoring.

3. Conceptual framework and data

3.1. Conceptual framework

Our study makes use of CDS on senior and subordinate bank debt, which have not been considered in earlier studies so far. Therefore, several conceptual remarks are in order.

First, theoretically, subordinate CDS spreads must be equal to or greater than same-maturity and same-currency senior CDS spreads. The reason for this relation is that subordinate debt is more risk-sensitive than senior debt, which results from the absolute priority rule in debt service. In that respect, subordinate debt is similar to equity although it is a debt claim. The loss-given-default (LGD) of subordinate debt is always greater than the one of senior debt, except for the extreme case in which both values are at 100% (which is equivalent to zero recovery rates on both types of claims). In contrast, the probability of default (PD) is the same of both types of debt since it is measured at the issuer level and not at

the level of single securities. Technically, leaving aside minimum thresholds, the CDS contracts stipulate that credit events are triggered jointly by obligation acceleration and cross-default clauses. Figure 1 illustrates this relation between overall losses (horizontal axis) and the debt-specific LGDs (as a percentage of its notional value) for subordinate debt and senior debt. If losses exceed a bank's total equity (E), then the LGD of subordinate debt begins to rise. When losses equal total equity plus the notional value of subordinate debt, the LGD on subordinate debt reaches 100%. For higher losses, the latter remains constant, while the LGD of senior debt starts to increase until it reaches the theoretical maximum of 100% at $E + D^{SUB} + D^{SEN}$.

(Insert Figure 1 here)

Second, in the subsequent empirical analysis, we consider the difference and the ratio of subordinate and senior CDS spreads. The main reason for this approach is that these measures have different theoretical properties and, thus, are likely to exhibit different empirical patterns over time and across banks. On the one hand, the ratio of CDS spreads measures the ratio of the market-implied LGDs for subordinate and senior debt. The ratio is increasing in losses until the latter reach the notional value of subordinate debt and, then, decreasing again (see Figure 1). On the other hand, the difference of CDS spreads measures the product of the PD times the difference in LGDs. For this measure, PD and LGD may work into the same or into opposite directions, making the interpretation more difficult. For example, the difference can still vary even if the LGD of subordinate debt has reached 100% because of changes in the PD and changes in the LGD of senior debt. We control for the fact that both measures relate to a bank's capital structure by taking into account the notional values of subordinate and senior debt.

Third, our measures based on subordinate and senior CDS spreads make it possible to isolate the relative effects for individual banks over time. It that sense, our "seniority spread" (the difference or ratio of subordinate and senior CDS spreads) is analogous to the "default spread", which is defined as the difference in credit spreads of differently-rated debt issues, for example, credit spreads of BBB-rated bonds minus AAA-rated bonds (e.g., Fama and French, 1993). In other words, although similar by construction, our measure is based on CDS that relate to debt instruments with different ranks but identical probabilities of default.

Fourth, we argue that the combined information from senior and subordinate CDS spreads might be superior to the information reflected by one type of spread because of different market microstructures in both segments. These differences might be due to information processing, market liquidity, and trading costs.

3.2. The data

To examine the informational content of CDS on banks, we base our study on an international sample of large banks spanning the period from 2001 to 2008. Our sample includes 20 large banks from seven European countries for which we have simultaneous daily time series of senior and subordinate CDS spreads (United Kingdom: 4, Germany: 4, Italy: 4, France: 3, Netherlands: 2, Spain: 2, and Switzerland: 1). Appendix A describes the sample composition. These banks can be seen as systemically relevant since there has been liquid CDS trading in these underlyings over many years. CDS spreads refer to daily closing prices (London time), a maturity of five years, and are all denominated in Euro. Table 1 provides summary statistics for our data.

(Insert Table 1 here)

The median of senior CDS spreads across banks and over time is 18 bps, while the corresponding median of subordinate CDS spreads is 30 bps. The rightmost column indicates that both CDS spreads widened dramatically to medians of 67 bps (senior) and 117 bps (subordinate) since the beginning of the financial crisis in August 2007. The median of the bank-specific difference between the subordinate and senior CDS spread ($DIF^{SUB,\ SEN}$) is 12 bps for the full sample period and 44 bps during the financial crisis. The median ratio ($RATIO^{SUB,\ SEN}$) is 1.73 for the full sample period but only 1.62 during the financial crisis. We also have daily information on bid-ask spreads for senior and subordinate CDS quotes, which makes it possible for us to calculate the absolute bid-ask spread, defined as the difference between the ask and bid quote, and the relative bid-ask spread (also called percentage bid-ask spread), defined as the absolute bid-ask spread over the mid spread. The median of the relative bid-ask spread during the full sample period is 23.34% for the senior CDS and 16.91% for subordinate CDS.[2] Furthermore, we report the banks' share price performance (SHARE) using an index that is normalized to 100 (Jan 2, 2001). The peak in the cross-sectional median of SHARE was reached in mid-June 2007, which was shortly before the beginning of the financial crisis. Median total assets (TA) are 505 billion Euros in the full sample period and 636 during the financial crisis. Banks' share price performance and the size of banks' balance sheets indicate that the crisis was preceded by a period of strong growth. The median of the ratio of subordinate bank debt to total assets (SUBTA) is 2.47% in the full sample period and 2.03% during the financial crisis. For comparison, we also show statistics on deposit taking (DEPTA), interbank liabilities (IBTA), and capital ratios (CAPTA). Mean credit ratings of the banks range between 3 (AA) and 7 (A-), with a median of 4 (A+).

(Insert Figure 2 here)

[2] The relative bid-ask spread of 23% for senior CDS is similar to the 24% relative bid-ask spread for a sample of

Figure 2 plots the time-series of the cross-sectional median of the CDS difference (Panel A), the CDS ratio (Panel B), and banks' share price performance and negative rating events (Panel C). Panel A shows that the CDS difference increased during the market turmoil 2002-2003 and rose sharply after August 2007. Moreover, we note several sharp spikes since the beginning of the financial crisis, marking a period of high uncertainty. Panel B displays the CDS ratio, which ranges most of the time between 2.5 and 1.5 during the period from 2001 to 2007. Then, the CDS ratio sharply dropped at the beginning of the financial crisis and quickly increased from September 2007 to late March 2008 (after the Bear Stearns failure) and reached a second high in September 2008 (after the Lehman failure). Panel C shows that banks' stock prices increased from mid-2002 to mid-2007 and that there is a clustering of negative rating events in the second half of 2002 and during 2007-2008. After the peak in mid-2007 (SHARE = 172), stock prices fell strongly and very quickly (SHARE = 57). A comparison of our CDS measures with banks' stock price performance shows that there are important differences in the direction of the market response and volatility, especially during the financial crisis. For instance, the strong reversal in CDS spreads on European banks in September 2008, reflected by the sharp decreases in the difference and ratio of subordinate and senior CDS spreads are due to the announcement of bank rescue plans by several governments, while banks' stock prices continued to fall in most of the countries.

4. Credit default swaps on banks before and during the financial crisis

4.1. Information processing in a time-series framework

To investigate the information reflected in the CDS market we regress banks' senior and subordinate CDS spread changes on stock returns to test whether our data is consistent with

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US industrial firms reported by Acharya and Johnson (2007).

the theoretical prediction that subordinate CDS spreads are more risk-sensitive than senior CDS spreads. Table 2 reports the results.

(Insert Table 2 here)

We obtain two key findings. First, changes in subordinate CDS spreads are more strongly related to stock returns than to changes in senior CDS spreads. Second, the changes in both CDS spreads become substantially more sensitive to stock returns during the financial crisis but subordinate CDS spreads still exhibit a higher sensitivity to stock returns.

In a next step, we extend and complete the previous analysis by analyzing lead-lag relations between the two CDS segments and their contributions to price discovery. We follow related studies (e.g., Blanco, Brennan and Marsh (2005), Zhu (2006) and Norden and Weber (2009)) and estimate a two-stage vector error correction model (VECM). In the first stage, we estimate the long-run empirical relation between subordinate and senior CDS spread levels. In the second stage, we include the lagged residuals from the first stage (which can be interpreted as an error correction term) to study the dynamic short-run relation between changes in subordinate and senior CDS spread changes. The main underlying idea is that senior and subordinate CDS spreads of the same bank should be strongly related in the long-run but might temporarily be out of this equilibrium. Thus, the question is which spreads help closing the gap between actual and theoretical spreads. Table 3 reports results from the second stage of the VECM estimation.

(Insert Table 3 here)

Panel A of Table 3 shows that, before the financial crisis, there are two-way linkages and a long-run equilibrium between senior and subordinate CDS spreads before the financial crisis. In particular, there are no significant lead-lag relationships, i.e., we cannot predict changes in subordinate CDS spreads with changes in senior CDS spreads. Moreover, the coefficients of the error correction terms E_{t-1} are both highly significant and correctly signed. This result implies that, on average, no CDS market segment dominates in terms of information processing over time.

Panel B of Table 3 reports the corresponding results for the period since the beginning of the financial crisis. Now, the long-run equilibrium breaks down. We observe a significant lead-lag relationship, going from the senior to the subordinate CDS spread. Furthermore, in the regression with ΔCDS^{SEN} as dependent variable, the error correction term E_{t-1} exhibits a significantly negative coefficient, which is not in line with theory and the findings from Panel A. These results imply that in the aftermath of the financial crisis information on banks' default risk is earlier reflected in senior CDS spreads than in subordinate CDS spreads.

4.2. Information processing around credit rating events

The previous time-series analysis indicates that prior to the financial crisis neither senior nor subordinate CDS on banks were dominant in terms of information processing. Subsequently, we analyze information processing in an event study framework. Specifically, we compare the abnormal price reaction in both CDS market segments around negative credit ratings events. We focus on negative events only since downside information on bank risk is critical for investors and bank supervisors. To provide robust evidence, we consider "reviews for downgrade" (negative watchlisting) from the three major credit rating agencies (Standard & Poor's, Moody's Investor Services, and Fitch Ratings). Earlier research documents that rating reviews are less anticipated than actual rating downgrades (e.g., Hull, Predescu, and White

2004, Norden and Weber 2004). Raw CDS spread changes are adjusted by changes in a CDS index for the same rating category and seniority. We note that the subsequent results are not sensitive to the way in which we calculate abnormal CDS spread changes since our conclusions remain unchanged if we consider raw CDS spread changes. Figure 3 displays the event study results for reviews for downgrade.

(Insert Figure 3 here)

The event study yields two results. First, Panel A of Figure 3 shows that cumulative abnormal spread changes for the subordinate CDS (broken line) are most of the time above the senior CDS (solid line). Consistent with theory, we observe a stronger reaction of the subordinate CDS. We further note that both abnormal spread changes become statistically significant shortly after the announcement day. The cumulative abnormal change amounts to 14 basis points for the subordinate CDS and to six basis points for the senior CDS at etime = 2. Second, Panel B of Figure 3 indicates that the CDS market reaction is much weaker and very similar across segments during the financial crisis. In opposite to theory, we observe negative cumulative abnormal spread changes in both segments during event time [-10, -2].[3] Although there are significant increases during the event time interval [-2, -1], the overall reaction is very small and does not significantly differ between segments. One explanation for these weaker results during the crisis are that reviews for downgrade were announced particularly late, i.e., they were already fully anticipated by the CDS market (see Figure 2, Panel C). Moreover, markets were much more volatile in this period, including large jumps in CDS spreads at the failure of Lehman Brothers and sharp decreases in CDS spreads after the government rescue measures, creating a lot of contamination in the pre-event period.

We conclude that before the financial crisis subordinate CDS spreads move more strongly before negative rating events than senior CDS spreads. After the beginning of the financial crisis, the reaction in both CDS segments does not different significantly.

4.3. Market liquidity across segments

Another important characteristic that potentially differs across CDS segments is market liquidity. The latter is an important determinant of the bid-ask spread, which itself is a frequently used proxy for trading costs. In the following, we examine the aggregate market liquidity in both CDS segments. For this purpose, we calculate the daily cross-sectional median of the relative bid-ask spread for CDS on senior and subordinate bank debt. Figure 4 displays the results.

(Insert Figure 4 here)

Panel A of Figure 4 shows that before the beginning of the financial crisis the median of the relative bid-ask spread for subordinate CDS is most of the time lower than the one for senior CDS. In other words, relative trading costs are more attractive for subordinate CDS on banks. If we examine the bank-specific data, this observation is confirmed: In 84% of the bank-day observations during the period from January 2001 to July 2007 the relative bid-ask spread for subordinate CDS is lower than the one for senior CDS. The median difference between both bid-ask spreads over time is approximately five percentage points (senior: 23% vs. subordinate: 17%). This finding is statistically significant at the 0.01-level using a non-parametric Wilcoxon sign test and a standard t-test. However, if we examine the period after the beginning of the crisis, the relative bid-ask spreads in both segments become very similar.

[3] This result is confirmed by further analyses. For actual rating downgrades, we observe even more pronounced

The mean difference shrinks to only 0.08 percentage points (senior: 7.49% vs. subordinate: 7.41). For comparison, Panel B of Figure 4 displays the cross-sectional median of the absolute bid-ask spread. It is noteworthy that for a relatively long period (2003-2007) the absolute bid-ask spread is both segments is almost identical although mid levels of subordinate CDS spreads are approximately one and a half-times higher than senior CDS spreads (see Table 1). As expected, after the beginning of the crisis, the absolute bid-ask spreads in both segments start to rise, indicating an increase in absolute trading costs. We also note that the absolute bid-ask spread during the crisis is still lower than during the market turmoil in early 2003.

Combining the evidence from both panels, we find that before the crisis trading banks' credit risk was more attractive in the subordinate CDS market segment. After the beginning of the crisis, the subordinate CDS segment lost its relative advantage over the senior CDS segment. Although absolute (relative) bid-ask spreads of senior and subordinate CDS both increase (decrease) after the beginning of the crisis, the magnitude of the changes is in favor of trading in the senior CDS segment. The statistical significance of these findings is confirmed by conventional statistical tests.

The CDS market structure has shifted towards the senior segment, indicating a "flight-to-quality" in the sense that more CDS trading happens in the less risky contracts. This change in market liquidity is supported by our previous analyses on information processing.

4.4. Market-implied loss given default and probability of default

The spread on a CDS represents the periodic premium the buyer has to pay to the seller for receiving protection against pre-defined credit events of the underlying. Thus, the CDS spread is mainly a compensation for the expected loss that is associated with one unit of default-risky exposure to the underlying. At this stage, we leave aside consideirng risk premia for

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negative cumulative abnormal spread changes for the period after the beginning of the financial crisis.

deviations from risk neutrality and illiquidity premia in CDS spreads (e.g., Amato 2005). The expected loss is defined as the product of the borrower's probability of default, the LGD, and exposure at default (normalized to one). To simplify the analysis, we make the assumption that the LGD on subordinate bank debt is constant at 100% for all banks and over time. Note that our approach is flexible enough to use lower values as well, including bank- and period-specific values. A value of 100% is not unrealistic for the period since the beginning of the global financial crisis in August 2007, in which the magnitude of most banks' losses substantially exceeded their total equity and subordinate debt volume. Our assumption might be overcautious during normal times and for healthy banks.[4] In prudential bank supervision and regulation there has been a long tradition for "built-in" worst-case assumptions since overestimating losses is less costly than underestimating losses.

Using the above relation for the expected loss, the assumption for the subordinate LGD, and our market data on senior and subordinate CDS spreads, we can derive market-implied upper bounds for banks' LGD on senior debt and probability of default. This approach makes it possible to derive upper bounds but no "true" values since our assumption on the subordinate LGD is rather strict. However, we argue that upper bounds of LGDs (equivalent to minimum values for recovery rates) are particularly useful for bank supervisors. Specifically, we can solve the following system of two equations to obtain daily time series of bank-specific values for LGD_{it}^{SEN} and PD_{it} for the sample period from 2001 to 2008.

(1) $LGD_{it}^{SUB} / LGD_{it}^{SEN} = CDS_{it}^{SUB} / CDS_{it}^{SEN}$ with $LGD_{it}^{SUB} = 100\%$

(2) $PD_{it} \times (LGD_{it}^{SUB} - LGD_{it}^{SEN}) = CDS_{it}^{SUB} - CDS_{it}^{SEN}$

Figure 5 displays the time series of the cross-sectional mean, minimum and maximum of LGD_{it}^{SEN} and PD_{it}.

[4] For instance, Moody's reports average recovery rates on subordinate corporate bonds for the period from 1982 to 2006 that range between 29% and 31%, implying LGDs of approximately 70% (Moody's Investors Service, 2007). However, it is easy to replace the 100% assumption by lower bank- or period-specific values.

(Insert Figure 5 here)

Panel A of Figure 5 shows that the mean values for upper bounds on LGD_{it}^{SEN} vary between 40% and 80% over time, resulting in a mean of 58%. The median (minimum) of all values from the pre-crisis period is 56% (10.9%) and 61% (37.8%) for the crisis period. Interestingly, there is little variation in LGD_{it}^{SEN} between countries: German banks exhibit a pooled median of 56% and Switzerland (here: UBS) a median of 61%, while banks from the other countries are between these values. We note that these market-implied loss given default values are consistent with empirical estimates of recovery rates on defaulted securities (e.g., Moody's Investors Service, 2006). Panel B of Figure 5 displays the corresponding time series of PD_{it}. The mean PD over the full sample period is 0.5180%. Its value amounts to 0.34% but almost quadruples during the financial crisis to 1.23% (1.51% in 2008). Table 4 shows the bank-specific values for LGD_{it}^{SEN} and PD_{it} for pre- and post-crisis period.

(Insert Table 4 here)

On average, the CDS market-implied loss given default on senior bank debt increases from 57% to 62% and the market-implied probability of default rises from 0.34% to 1.23%. We observed the largest absolute and relative increases in the PD for UBS (by factor 7) and Barclays (by factor 6).

5. Conclusion

Measuring and monitoring the default risk of banks is more important than ever. In this paper, we take advantage of the fact that there are two liquid trading segments in CDS on banks as

underlyings: one for contracts on senior bank debt, and one for contracts on subordinate bank debt. We investigate whether the combined information from these two CDS market segments is useful for assessing the default risk of an international sample of large banks from the period 2001-2008.

We find that both CDS spreads contribute significantly to price discovery before the onset of the financial crisis. Interestingly, trading was less expensive in subordinate CDS in the pre-crisis period. After the beginning of the crisis, information is reflected earlier in senior CDS spreads than in subordinate CDS spreads. Moreover, the subordinate CDS segment looses its trading cost advantage, reaching approximately similar relative bid-ask spreads as the senior CDS segment. Comparing the pre- and post-crisis period, we document substantial increases in the market-implied loss given default and probability of default parameters. Our results indicate that CDS markets convey differentiated information on bank risk that is suited to play an important role in enhancing market discipline. For instance, the combined information from CDS spreads on senior and subordinate bank debt could serve as a trigger or early warning indication for further supervisory action and/or tighter regulatory requirements for systemically relevant banks. Therefore, our study can be useful for improving prudential bank supervision and counterparty risk management in the banking industry.

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Figure 1: The theoretical relation between banks' losses and debt-specific LGDs

This figure displays the relation between banks' overall losses (horizontal axis) and the debt-specific LGDs expressed as a percentage of the notional values (vertical axis). The LGD of subordinate debt is plotted by the broken line and the LGD of senior debt is plotted by the solid line. The notional values of subordinate and senior debt are D^{SUB} and D^{SEN}, and E indicates total equity.

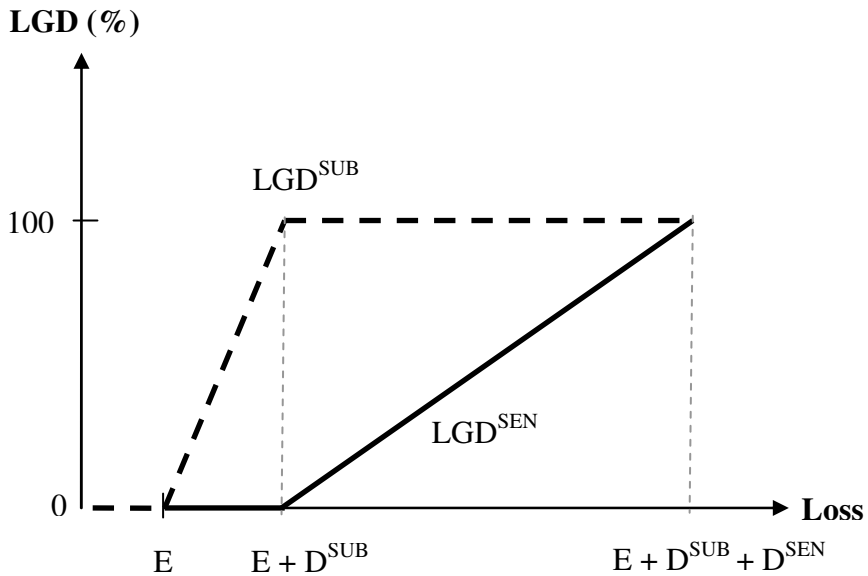
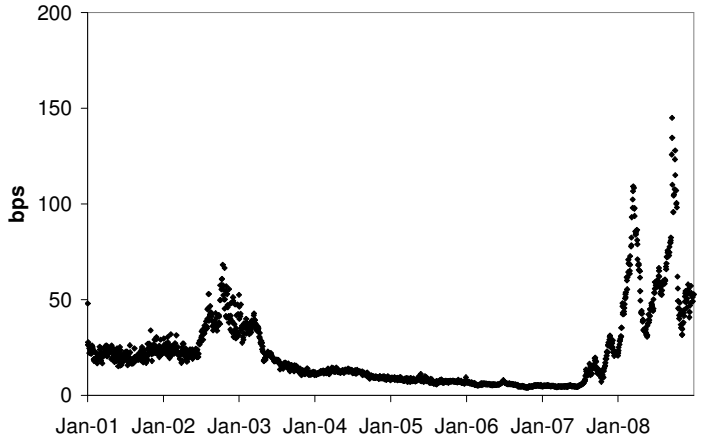


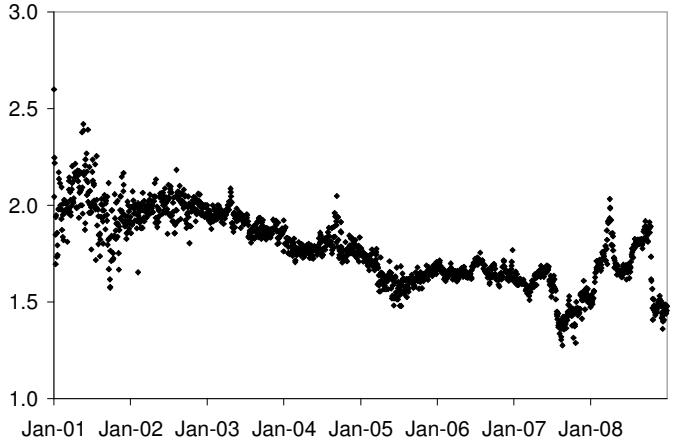
Figure 2: Banks' CDS spreads and share prices during 2001-2008

This figure shows the difference and ratio of subordinate and senior CDS spreads as well as banks' share price performance and the number of negative rating announcements (rating downgrades and reviews for downgrade). Data comes from 20 large European banks and covers the period from 2001 to 2008.

Panel A: Median difference of 5-year unsecured subordinate and senior CDS spreads



Panel B: Median ratio of 5-year unsecured subordinate and senior CDS spreads



Panel C: Banks' share prices (index) and negative rating events per month

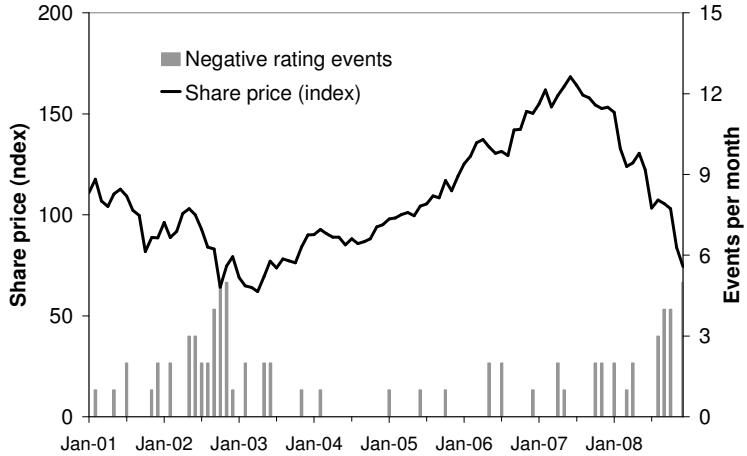
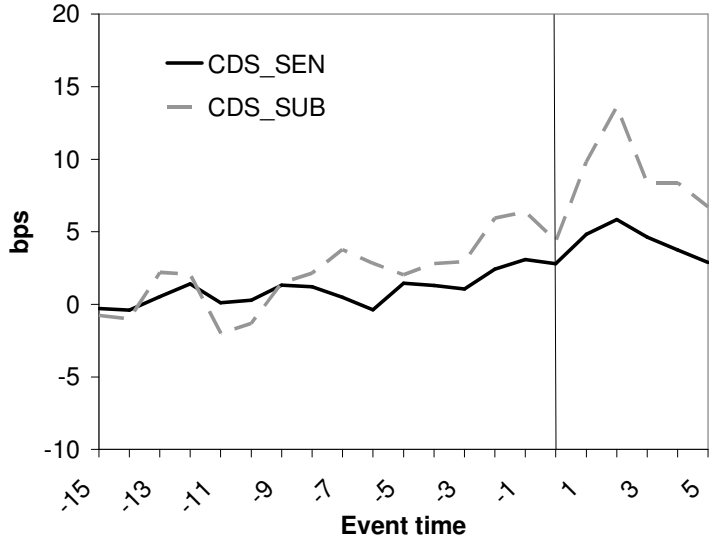


Figure 3: CDS market reaction around negative rating events

This figure displays cumulative abnormal CDS spread changes over the event time interval [-15, 5]. The event occurs at event time zero. Abnormal CDS spreads changes are calculated as the difference between individual banks' daily raw CDS spread changes minus changes of a CDS index for the same debt seniority and for same-rated banks. Ratings from vary from 3 (AA) to 7 (A-). Data comes from 20 large European banks and covers the period from 2001 to 2008.

Panel A: Reviews for downgrade before the crisis



Panel B: Reviews for downgrade during the crisis

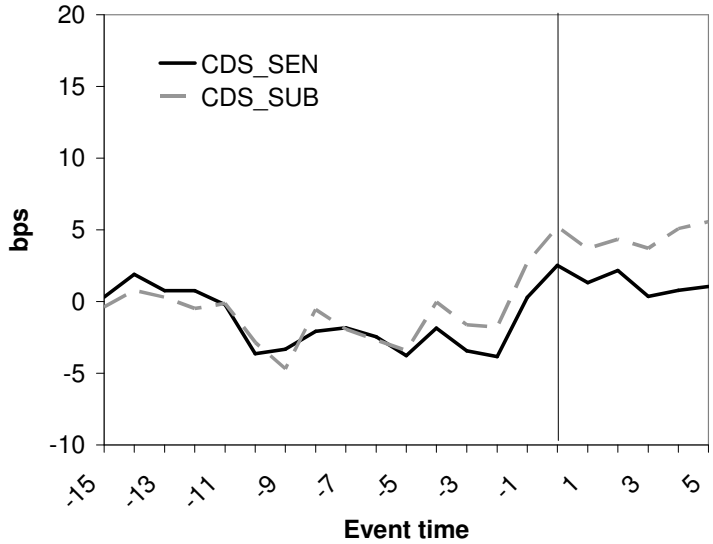
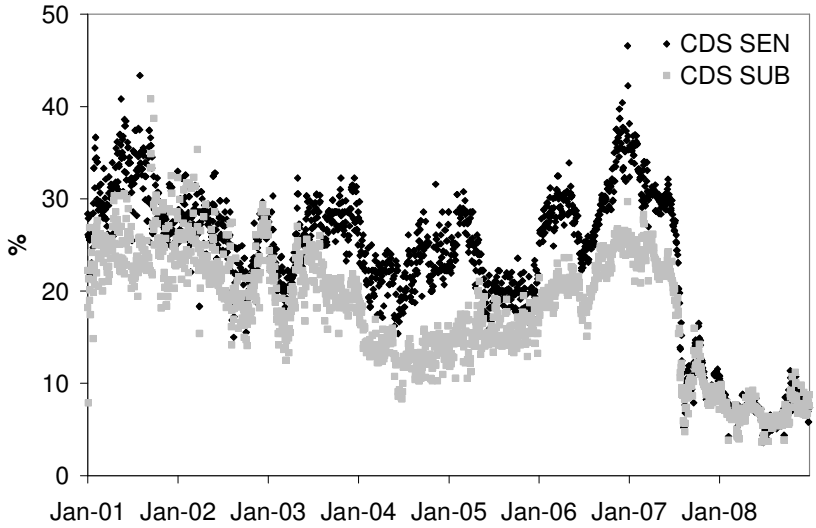


Figure 4: Liquidity of banks' senior and subordinate CDS spreads during 2001-2008

This figure displays the cross-sectional median of the banks' relative bid-ask spreads for senior and subordinate CDS (Panel A) and corresponding median for the absolute bid-ask spreads (Panel B). Data comes from 20 large European banks and covers the period from 2001 to 2008.

Panel A: Relative bid-ask spreads of CDS on banks



Panel B: Absolute bid-ask spreads of CDS on banks

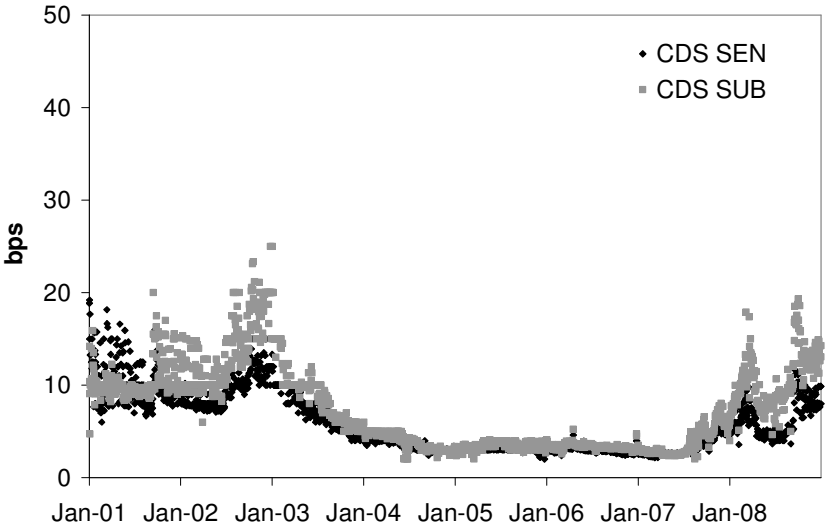
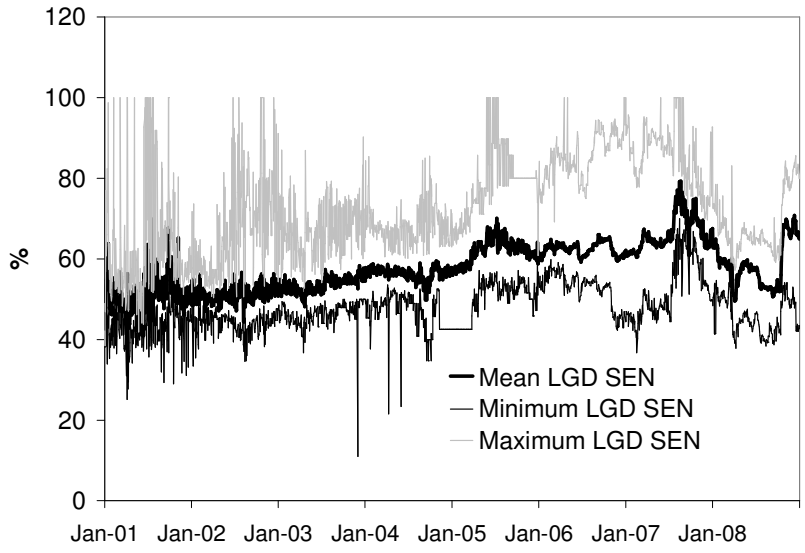


Figure 5: CDS market-implied risk parameters

This figure displays the mean, minimum and maximum of bank-specific time series of loss given default on senior debt (Panel A) and the probability of default. Data comes from 20 large European banks and covers the period from 2001 to 2008.

Panel A: Banks' loss given default on senior debt



Panel B: Banks' probability of default

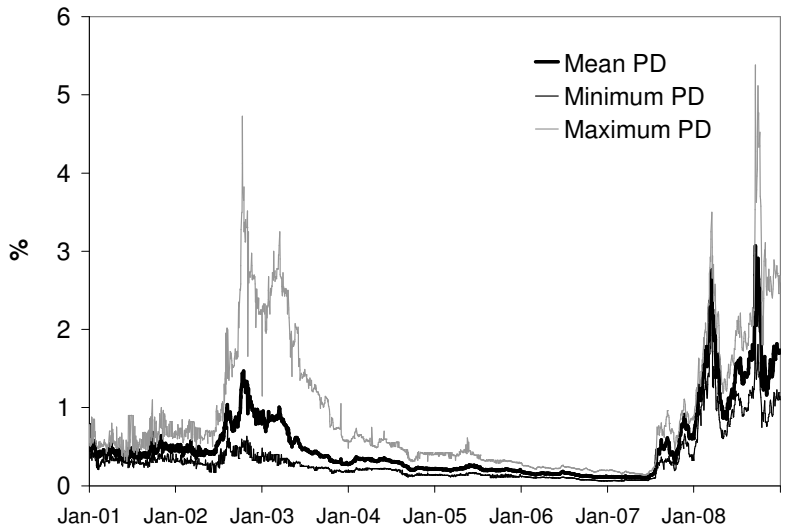


Table 1: Data

The data set includes daily senior and subordinate CDS spreads, daily share prices, daily credit ratings and annual financial statement information on 20 large European banks from seven countries over the period 2001-2008 (41,760 observations). We report means and medians for the full sample period and for the period after the beginning of the global financial crisis.. Credit ratings are issuer ratings from Standard & Poor's, Moody's, and Fitch.

		Full sample period (Jan 2001 – Dec 2008)		During the financial crisis (Aug 2007 – Dec 2008)	
Variable	Description	Mean	Median	Mean	Median
CDS^{SEN}	CDS spread for 5-year senior unsecured debt (bps)	29.51	18.00	72.91	67.83
CDS^{SUB}	CDS spread for 5-year subordinate unsecured debt (bps)	51.76	30.40	122.44	117.73
$DIF^{SUB, SEN}$	$CDS^{SUB} - CDS^{SEN}$ (bps)	22.25	12.23	49.51	44.93
$RATIO^{SUB, SEN}$	CDS^{SUB} / CDS^{SEN}	1.74	1.73	1.65	1.62
CDS^{SEN} % bid ask	$(CDS^{SEN, ask} - CDS^{SEN, bid}) / CDS^{SEN, mid}$ (%)	23.01	23.34	8.46	8.26
CDS^{SUB} % bid ask	$(CDS^{SUB, ask} - CDS^{SUB, bid}) / CDS^{SUB, mid}$ (%)	17.67	16.91	7.81	7.31
SHARE	Share price (index, Jan 2, 2001 = 100)	111.68	101.01	127.13	124.21
TA	Total assets (in million Euro)	617,107	505,811	917,986	636,133
SUBTA	Subordinate debt to total assets (%)	2.46	2.47	2.25	2.03
DEPTA	Deposits to total assets (%)	37.37	37.05	35.76	34.89
IBTA	Interbank liabilities to total assets (%)	15.57	14.08	11.69	11.06
CAPTA	Capital ratio (%)	3.99	3.51	4.01	3.01
RATING	Average credit rating of the S&P, Moody's and Fitch rating (measured on a 17 scale; AAA=1, AA+ = 2, …, BBB = 9, …, CCC+ = 17)	4.50	4.00	4.18	4.00

Table 2: The contemporaneous link between CDS spread changes and stock returns

This table reports the contemporaneous link between changes in senior and subordinate CDS spreads and the same banks' stock returns R. Data comes from 20 large European banks and covers the period from 2001 to 2008. We report p-values from robust standard errors, clustered at the bank-level and adjusted for heteroskedasticity. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05, and 0.10-level.

Panel A: Before the financial crisis (Jan 2001 – Jul 2007)

Dep. Var.	ΔCDS_t^{SEN}			ΔCDS_t^{SUB}		
	Coeff.	p-val.		Coeff.	p-val.	
R^{SHARE}	-0.0854	0.016	**	-0.0920	0.005	***
Const.	-0.0493	0.084	*	-0.0157	0.001	***
R^2		0.0012			0.0035	
Obs.		20,999			19,425	

Panel B: During the financial crisis (Aug 2007 – Dec 2008)

Dep. Var.	ΔCDS_t^{SEN}			ΔCDS_t^{SUB}		
	Coeff.	p-val.		Coeff.	p-val.	
R^{SHARE}	-0.7038	0.000	***	-0.9833	0.000	***
Const.	0.1342	0.001	***	0.2094	0.000	***
R^2		0.0934			0.0766	
Obs.		5,150			5,150	

Table 3: Price discovery for senior and subordinate CDS spreads before and during the crisis

This table reports the estimation results from the second stage of a Vector Error Correction Model (VECM). The first stage regression is $CDS_t^{SUB} = \mu + \rho CDS_t^{SEN} + \delta CRISIS_t + E_t$ and measures the long-run relation between the spread levels. $CDS^{SEN \text{ or } SUB}$ refer to daily senior and subordinate CDS spreads from the same bank and CRISIS is an indicator variable that equals one after July 26, 2007, and zero otherwise. The second stage regressions are based on daily changes in CDS spreads and indicate the short-run adjustment process:

$$\Delta CDS_t^{SEN} = \alpha_1 + \lambda_1 E_{t-1} + \beta_1 \Delta CDS_{t-1}^{SEN} + \gamma_1 \Delta CDS_{t-1}^{SUB} + \varepsilon_t$$
$$\Delta CDS_t^{SUB} = \alpha_2 + \lambda_2 E_{t-1} + \beta_2 \Delta CDS_{t-1}^{SEN} + \gamma_2 \Delta CDS_{t-1}^{SUB} + \varepsilon_t$$

The coefficients λ_1 and λ_1 of the lagged residual E_{t-1} serve as an error correction term in the second stage regressions. Data comes from 20 large European banks and covers the period from 2001 to 2008. We report p-values from robust standard errors, clustered at the bank-level and adjusted for heteroskedasticity. ***, **, * indicate that coefficients are statistically significant at the 0.01, 0.05, and 0.10-level.

Panel A: Before the financial crisis (Jan 2001 – Jul 2007)

Dep. Var.	ΔCDS_t^{SEN}			ΔCDS_t^{SUB}		
	Coeff.	p-val.		Coeff.	p-val.	
E_{t-1}	0.0427	0.003	***	-0.1206	0.000	***
ΔCDS_{t-1}^{SEN}	-0.2931	0.000	***	0.0526	0.407	
ΔCDS_{t-1}^{SUB}	0.0247	0.163		-0.2982	0.000	***
Const.	0.0364	0.125		-0.1309	0.029	**
R^2		0.1112			0.1312	
Obs.		26,125			26,125	

Panel B: During the financial crisis (Aug 2007 – Dec 2008)

Dep. Var.	ΔCDS_t^{SEN}			ΔCDS_t^{SUB}		
	Coeff.	p-val.		Coeff.	p-val.	
E_{t-1}	-0.0175	0.000	***	-0.0452	0.000	***
ΔCDS_{t-1}^{SEN}	0.1115	0.144		0.6285	0.000	***
ΔCDS_{t-1}^{SUB}	0.0738	0.107		-0.1353	0.066	*
Const.	0.2914	0.000	***	0.5104	0.000	***
R^2		0.0547			0.0876	
Obs.		7,171			7,171	

Table 4: CDS market-implied risk parameters before and during crisis

Nr.	Bank name	LGD_SEN before crisis	LGD_SEN during crisis	PD before crisis	PD during crisis
1	BNP Parisbas SA	66.27	63.72	0.24	0.89
2	DRESDNER BANK AG	55.81	61.28	0.44	1.28
3	SANPAOLO IMI SPA	56.27	58.45	0.31	1.01
4	UNICREDITO ITALIANO SPA	61.58	60.32	0.29	1.20
5	BAYERISCHE HYPO-UND VEREINSBANK AG	56.00	59.99	0.66	1.20
6	COMMERZBANK AG	55.27	53.78	0.67	1.43
7	CREDIT LYONNAIS	54.97	61.70	0.29	1.20
8	ABN AMRO BANK NV	55.01	61.94	0.28	1.22
9	UBS AG	60.51	67.12	0.21	1.53
10	DEUTSCHE BANK AG	61.63	62.48	0.35	1.32
11	BARCLAYS BANK PLC	60.00	66.30	0.22	1.43
12	INTESABCI SPA	58.16	66.44	0.49	1.38
13	ABBEY NATIONAL PLC	57.61	64.76	0.27	1.14
14	ING BANK NV	57.24	64.44	0.24	1.23
15	BANCA MONTE DEI PASCHI DI SIENA SPA	56.49	54.19	0.36	1.36
16	BANCO BILBAO VIZCAYA ARGENTARIA SA	57.39	61.40	0.27	1.14
17	STANDARD CHARTERED BANK	53.44	59.84	0.41	1.35
18	BANCO SANTANDER CENTRAL HISPANO SA	56.71	63.03	0.36	1.18
19	SOCIETE GENERALE	57.41	65.47	0.27	1.10
20	LLOYDS TSB BANK PLC	57.73	64.17	0.21	1.07
	Mean (equally weighted)	57.78	62.04	0.34	1.23