Restructuring Risk in Credit Default Swaps: An Empirical Analysis*

Antje Berndt† Robert A. Jarrow‡ ChoongOh Kang§

Current Version: November 18, 2005

Preliminary and Incomplete

Abstract

This paper estimates the price for bearing exposure to restructuring risk in the U.S. corporate bond market during 2000-2005, based on the relationship between quotes for default swap (CDS) contracts that include restructuring as a covered default event and contracts that do not. We find that on average the premium for exposure to restructuring risk amounts to 6% to 8% of the value of protection against non-restructuring default events. The increase in the restructuring premium in response to an increase in rates on default swaps that do not include restructuring as a covered event is higher for high-yield CDS and lower for investment-grade firms, and depends on firm-specific balance-sheet and macroeconomic variables. We observe that firms that offer a distressed exchange often experience a steep decline in their distance to default prior to the completion of the exchange. As an application, we propose a reduced-form arbitrage-free pricing model for default swaps, allowing for a potential jump in the risk-neutral non-restructuring default intensity if debt restructuring occurs.

*We thank Lombard Risk for Default Swap data. We are grateful to Jean Helwege, Yongmiao Hong, Philip Protter and Roberto Perli for useful comments.

†Tepper School of Business, Carnegie Mellon University.
‡Johnson Graduate School of Management, Cornell University.
§Department of Economics, Cornell University.

1 Introduction

This paper estimates the price for bearing exposure to restructuring risk in the U.S. corporate bond market during 2000-2005, based on the relationship between quotes for default swap (CDS) contracts that include restructuring as a covered default event and contracts that do not. We find that on average the premium for exposure to restructuring risk amounts to 6% to 8% of the value of protection against non-restructuring default events. The increase in the restructuring premium in response to an increases in rates on default swaps that do not include restructuring as a covered event is higher for high-yield CDS and lower for investment-grade firms, and it depends on firm-specific balance-sheet and macroeconomic variables. We find restructuring premia to be the highest in the Telephone, Service & Leisure and Railroad sectors, and much lower for firms in the Oil and Gas industry and for Gas utility firms.

We also extend the empirical work to explore the determinants of the default swap rates by controlling for the restructuring clause and the time to maturity of the contract, together with the time period with regard to regulations by the International Swaps and Derivatives Association (ISDA). To proxy for firm-specific default risk, we use distance to default, Merton default probabilities, and leverage ratios. Market variables include the level and slope of the risk-free interest rate, a volatility (VIX) index, Moody's Baa corporate yield, and the spread between Moody's Aaa yield and 20-year Treasury yield. After controlling for firm-specific and macroeconomic variables, we obtain a regression coefficient of determination of 60%, and even over 71% after taking logarithms.

We observe that firms which complete a distressed exchange often experience a steep decline in their distance to default prior to the completion of the exchange. As an application, we develop a reduced-form arbitrage-free pricing model for default swaps that explicitly takes into account the distinct restructuring clause of the CDS contract. We incorporate the effect of the restructuring event on the default risk by allowing for a jump in the default intensity should restructuring occur. The jump is allowed to be both positive or negative depending on investors expectation of the firm's financial health after the debt restructuring. (The model is similar to the primary-secondary framework in Jarrow and Yu (2001), where the primary firm's default causes the default intensity of the secondary firm to jump upward.) The restructuring event, if it happens prior to default, may directly affect the firm's default risk in two ways. On the one hand, it is possible that restructuring can successfully reduce the firm's financial burden to improve overall financial wellbeing of the firm, and its default probability can be lowered (successful restructuring). On the other hand, the restructuring event can serve as a signal to show that the firm is in a financially weak condition. In this case, investors will raise their estimates of the firm's default risk, and eventually the firm will be more likely to fall into more severe financial distress (unsuccessful restructuring).

The remainder of this paper is organized as follows: Section 2 gives a brief overview of the CDS market and discusses in detail the different restructuring clauses. Section 3 describes the Lombard Risk Systems CDS data base used for this study. Section 4 describes the regression results of modeling the restructuring risk premia. In Section 5 we develop a reduced-form pricing model for valuing credit default swaps under different restructuring clauses, and estimate the time-series behavior of risk-neutral default intensities for Ford Motor Co. as a case study. Finally, Section 6 concludes this paper.

2 Credit Default Swaps and Restructuring Rules

A credit default swap (CDS) is an over-the-counter derivative security that allows one counterparty, the seller of protection, to go long a third-party default risk, and the other counterparty, the buyer of protection, to be short on the credit risk. The buyer of protection agrees to pay periodic (often quarterly) insurance premiums, until the expiration of the contract or a contractually defined credit event time, whichever occurs earlier. If the credit event occurs, the protection buyer receives the face value of the debt under protection and delivers the underlying debt to the seller (physical delivery), or receives the difference in cash (cash delivery). The buyer also pays the accrued portion of the payment since the last payment date. The annualized fixed payment rate is called the CDS rate.

A contractually defined credit event can include one or more of the following: bankruptcy, failure to pay, obligation acceleration, obligation default, repudiation/ moratorium and restructuring. Among these, restructuring[1] has been considered to

[1]A restructuring credit event is triggered if one or more of the following events occur (2003 ISDA Credit Derivatives Definitions): i) a reduction in the interest rate or in the amount of principal; ii) a postponement or other deferral of dates for the payment of interest, principal, or premium; iii) a change in the ranking in priority of payment of any obligation that causes subordination of it to other obligations; and iv) any change in the currency or composition of any payment of interest or principal.

be the most contentious credit events.

Restructuring has been at the center of debate because it may constitute a soft credit event that would not necessarily result in losses to the owner of the reference obligation.[2] In relation to this soft credit event, restructuring retains a various coupon and maturity structures, so that bonds with lower coupons and longer maturities trade less favorably than others. Thus, the protection buyer's *cheapest-to-deliver* option has greater value under restructuring than other non-restructuring default events.

As a response, the International Swaps and Derivatives Association (ISDA) provides four choices under restructuring as a credit event:

- Full restructuring (FR), based on the ISDA 1999 Definition
- Modified restructuring (MR), based on the ISDA 2001 Supplement Definition
- Modified-modified restructuring (MMR), based on the ISDA 2003 Definition, and
- No restructuring (NR).

Each restructuring rule has different clauses regarding the maturity and transferability of deliverable obligations as shown in Table 1. We can see that the value of the cheapest to deliver option is more limited under MR or MMR than FR. Also, MR and MMR are more restrictive on the confirmation of restructuring event. Thus, the soft restructuring problem is alleviated under these rules. Detailed discussions on the contractual terms regarding restructuring can be found in FitchRatings (2003) and Packer and Zhu (2005).

Table 1: Limits on Deliverable Obligation. T is the maturity of CDS contract, and $\bar{T}$ denotes the maturity of the deliverable obligation.

Restructuring Clause	Deliverable Obligation
FR	Any bond of maturity up to 30 years
MR	$T \leq \bar{T} < (T + 30 \text{ months })$
MMR	Allow additional 30 months for the restructured bond. For other obligations, same as MR.

[2]For a description of the Conseco debt restructuring case, refer to Bomfim (2005), p.294.

3 Data

The main data source is the ValuSpread Credit Data (VSCD) provided by Lombard Risk Systems. For each reference name on a particular date, the data reports the "average" mid-market CDS rate derived from the available quotes information contributed by about 25 market makers. Additional information includes the seniority (senior/subordinated) and the currency of the underlying debt, the maturity of the CDS contract (1, 3, 5, 7, or 10 years), the standard deviation of the mid-market quotes, and most importantly the restructuring clause applied in the contract. Also reported is the average expected recovery rate under each restructuring clause. The frequency of the data has increased over time: monthly (month-end quote) from 1999 to 2001, biweekly from January 2002 to June 2002, weekly from July 2002 to May 2003, and daily from 15 May 2003. The version of the database we use covers the period from 31 July 1999 through 30 June 2005.

The standard deviation of the mid-market quotes can be a measure of reliability of each observation. If the standard deviation is too small, it is highly likely that there is only one or two contributors. In this case, the data can be biased due to small sample size. On the other hand, if the standard deviation is too large, it indicates that there are outliers in the sample. So we filter out observations with standard deviation of greater than 20% or less than 1% of the mean CDS rate.

The industry information for each reference name is obtained from the Fixed Investment Securities Database (FISD) from LJS Global Information Systems. Among the 2,781 tickers listed in VSCD, we could identify the industry information and CUSIP numbers for 1,521 tickers, of which 929 are U.S. names, 532 are non-U.S. names, and 60 are CDS indices such as TRAC-X and iBoxx. The number of identified tickers in each industry for U.S. and non-U.S. tickers are shown in Table 9 in Appendix D.[3]

Table 2 presents the number of CDS quotes by restructuring clause and adjustments to the ISDA definitions, and Table 3 provides the number of quotes per industry for U.S. firms. From Table 2 we see that the U.S. market has selected to transact according to the modified restructuring clause. Contrary to to the European market, the modified-modified restructuring clause (MMR) is the least popular in the U.S. market. In Table 4, it is of interest to note that under current market convention,

[3]Note that the number of reference name is about 2,100 which is less than the number of tickers because tickers may change according to the event such as mergers and acquisitions even though the company name does not change.

restructuring is more often excluded as a covered credit event for high-yield CDS contracts than it is for investment-grade default swap contracts: 36.2% of the quotes are under NR for speculative-grade firms, whereas, for investment-grade firms, only 24.1% of the quotes are under NR. We also note that the most of the CDS market liquidity still stems from the investment-grade firms: 83.4% of the total quotes are for investment-grade firms.

Table 2: Number of quotes by restructuring clause and period for U.S. firms whose industry information was verified using FISD data. The periods are divided based on the publication months of the 2001 ISDA supplements and the 2003 ISDA definitions.

Period	Restructuring clause	Number of quotes.
1999 - April 2001	FR	8,562
May 2001 - Jan 2003	NR	5,767
	MR	41,498
	FR	47,232
Feb 2003 - present	NR	112,520
	MMR	2,436
	MR	435,027
	FR	64,251

For our subsequent the analysis, we will focus on CDS contracts for senior, U.S. dollar-denominated debt. Let c^{XR} be the CDS rate under the restructuring rule XR, where $XR \in \{NR, MR, MMR, FR\}$. The *restructuring premium* (RP) of XR over BR (base rule) is defined as

$$RP_{X,B} = c^{XR} - c^{BR}, \tag{1}$$

and the *relative restructuring premium* (RRP) is defined as

$$RRP_{X,B} = \frac{c^{XR} - c^{BR}}{c^{BR}}. \tag{2}$$

The descriptive statistics for the restructuring premium (RP) and the relative restructuring premium (RRP) of each pair of restructuring rules are summarized in Table 10. We can see that the restructuring premium is not at all ignorable in the CDS pricing. The means and medians are all positive for the premia over NR as expected. The variations are quite large considering the magnitude of the average, and the median seems to be the more adequate summary statistic. Also note that

Table 3: Number of quotes by industry.

FISD Industry code	Number of observations[†]				
	Total	NR	FR	MR	MMR
Industrial					
10 Manufacturing	258,355	40,648	46,008	170,240	1,459
11 Media/Communications	48,693	12,192	7,682	28,819	0
12 Oil & Gas	38,429	5,972	6,269	26,188	0
13 Railroad	1,961	395	247	1,319	0
14 Retail	58,842	10,551	10,855	37,424	12
15 Service/Leisure	21,358	12,184	7,855	1,319	0
16 Transportation	20,301	3,613	3,950	12,738	0
32 Telephone	14,738	3,457	1,474	9,807	0
Finance					
20 Banking	30,990	3,391	7,528	20,071	0
21 Credit/Financing	28,256	5,130	6,193	16,933	0
22 Financial Services	38,567	4,323	6,283	27,961	0
23 Insurance	41,358	5,957	4,474	30,927	0
24 Real Estate	26,256	2,397	4,478	18,416	965
25 Savings & Loan	137	0	0	137	0
26 Leasing	1,629	273	108	1,248	0
Utility					
30 Electric	39,685	6,019	4,731	28,935	0
31 Gas	7,148	1,356	1,069	4,723	0
33 Water	0	0	0	0	0
Government					
40 Foreign Agencies	0	0	0	0	0
41 Foreign	0	0	0	0	0
42 Supranational	835	0	593	242	0
43 U.S. Treasuries	0	0	0	0	0
44 U.S. Agencies	2,151	429	248	1,474	0
45 Taxable Municipal	0	0	0	0	0
Miscellaneous					
60 Miscellaneous	0	0	0	0	0
99 Unassigned	0	0	0	0	0
Total	679,689	118,287	120,045	438,921	2,436

[†] These are the number of observations for U.S. names used in the analysis whose industry information is verified by the author using FISD data.

Table 4: Number of 5-year CDS rate quotes for U.S. firms by rating. For both investment-grade (IG) and speculative-grade (SG) firms, the entries under each restructuring clause are for number of quotes, percentage of total number of quotes, row percentage, and column percentage.

	Restructuring clause				Total
	FR	MM	MR	NR	
IG	42,228	733	152,212	61,869	257,042
	13.7	0.2	49.4	20.1	83.4
	16.4	0.3	59.2	24.1	
	87.9	98.0	85.0	76.9	
SG	5,818	15	26,921	18,581	51,335
	1.9	0.0	8.7	6.0	16.7
	11.3	0.0	52.4	36.2	
	12.1	2.0	15.0	23.1	
Total	48,046	748	179,133	80,450	308,377
	15.6	0.2	58.1	26.1	100.0

FR has positive mean and median premia over both MR and MMR.

While the mean and median of restructuring premia of FR, MR and MMR over NR are all positive, negative premia are observed for all restructuring rules for certain firms and dates. Although, in theory, the existence of negative premia could be explained if investors were to believe that a restructuring credit event will cause a non-restructuring default event such as bankruptcy or failure to pay soon after, and subject to recovery rates under restructurings being sufficiently higher than under bankruptcy or failure to pay, we believe that these occurrences are more likely due to different default-swap brokers and investment banks contributing to the composite quote for default swap contracts under different restructuring rules for a given firm on a given date. In what follows, therefore, we remove quotes with negative outcomes for the restructuring premium from the sample.

4 Regression Analysis

In order to obtain a simple and robust model of the relationship between the restructuring risk premia and the CDS rate under no restructuring, we undertake a regression analysis of 10,020 paired 5-year c^{NR} and c^{MR} observations from May 2002 through December 2004, for all U.S. firms in the Industrial and Utilities sector listed in Table 9. Results are summarized in the second columns of Table 5.

This simple preliminary OLS reveals that the restructuring premium increases on average by roughly 5 basis points for each 100 basis points increase in the no-restructuring CDS rate. The associated coefficient of determination is 0.518. The estimate of the intercept is 0.537 basis points, meaning that the price of protection against restructuring risk is almost zero for firms with low prices for exposure to the non-restructuring default risk (including bankruptcy and failure to pay). To the extent, however, that the market for no-restructuring CDS is less liquid than that for the default swaps with restructuring as a covered credit event (as suggested, at least for the later part of our sample period, by the numbers in Table 4), these results might be corrupted in the sense that after accounting for different liquidity effects. The scatter plot (not shown) also reveals substantial heteroscedasticity, which also casts doubt on the linearity of the relationship.[4] We also control for investment-grade (IG) or speculative-grade (SG) status of the firms, and for changes in the restructuring premia across industries. The results are listed in columns 4 and 6 of Table 5. Both the difference in level- and slope-effect for investment grade and speculative-grade firms are significant at the 1% level. Holding the value of a no-restructuring CDS contract constant, the modified restructuring premia is highest in the Telephone, Service & Leisure and Railroad sectors, and lowest for firms in the Oil and Gas industry and for Gas utility firms.

Because the restructuring premium is the price differential between CDS rates with and without protection against the restructuring credit event, intuition about the determinants of the restructuring risk can be obtained by understanding the explanatory variables for the CDS rates themselves. Default swap rates are mainly driven by the *(1)* the likelihood of default, *(2)* the expected recovery rate at default, *(3)* the likelihood of restructuring, *(4)* the expected recovery rate at restructuring, and *(5)* the expected, if any, change in the likelihood of default after the restructuring event. Each of these issues will now be addressed. Descriptive statistics for the firm-specific (market and accounting), and macro-economic variables discussed below are provided in Tables 11, and the regression results for modified risk premia on these covariates are shown in Table 6

For the likelihood of default and the recovery rate at default, the base CDS rate (CDS rate under NR) itself can be a good measure. Preliminary examination shows

[4]We also experimented log-log specification, which reduces the heteroscedasticity. The coefficient of determination, however, was reduced to 0.437.

Table 5: Results of OLS regression of the modified restructuring premium, $c^{MR} - c^{NR}$, on the CDS rate under no restructuring, c^{NR}, as well as credit-quality and sector fixed effects. The reference sector is Manufacturing. Results for the full restructuring risk premia are available upon request.

	estimate	SD	estimate	SD	estimate	SD
Intercept	0.537	0.045	0.748	0.059	0.683	0.069
c^{NR}	0.051	0.000	0.050	0.001	0.049	0.001
SG			-2.010	0.162	-2.093	0.164
SG$\times c^{NR}$			0.006	0.001	0.007	0.001
Media & Comm					0.397	0.132
Oil & Gas					-0.167	0.142
Railroad					0.678	0.424
Retail					-0.040	0.113
Service & Leisure					0.641	0.115
Transportation					0.197	0.190
Telephone					0.668	0.198
Electric					0.099	0.146
Gas					-0.210	0.265
R^2	0.518		0.521		0.522	
no obs	25814		25814		25814	

that the base CDS rate alone explains 51.8% of the restructuring premium of MR over NR. We can also consider the market leverage[5] or the distance to default based on Merton (1974), but the base CDS rate shows the highest performance. In addition, we combine ratings information with the base CDS rate by adding speculative grade dummy variable for both intercept and slope with respect to the base CDS rate. It is defined to be 1 if the firm is rated to be speculative grade (rated BB or lower by Standard and Poor's) and 0 otherwise. Note that the likelihood of default and the recovery rate also depend on the state of the economy. Thus, we also consider the 5-year constant maturity Treasury rate to control the state of the economy, and the Moody's seasoned Baa corporate bond yield to control the state of the overall credit market.

Since the restructuring is a method for a firm to overcome financially distressed situation, it is reasonable to assume that the likelihood of restructuring is proportional to the likelihood of default. More relevant information is the likelihood of restructuring relative to the likelihood of default, and this can be interpreted as the likelihood that the decision makers (debtors and creditors) come to agree to choose a pre-default debt restructuring as the "first attempt" to handle a financial distress. The restructuring event relevant to CDS contracts can be considered as a soft version of private workouts in the sense that we only consider the debt restructuring prior to any violation of the contract: if the firm violates the terms of contract, the event is classified as default such as failure to pay, and this cannot constitute a restructuring event. Noting this, we still rely on existing literature on the choice between private workouts and formal bankruptcy under the subject of financial distress[6] to obtain reasonable variables that might affect the relative likelihood of restructuring. In theory, it is known that private workouts are more likely than bankruptcy for firms with the following characteristics: higher economic viability, less severe coordination problem, and relatively high leverage[7]. For our research, we consider market and balance-sheet

[5]Here we define the market leverage as $D/(D+E)$, where D is the book value of total debt, E is the market value of equity following Collin-Dufresne, Goldstein, and Martin (2001).

[6]See John (1993) for an overview on the methods to deal with financial distress. Chatterjee, Dhillon, and Ramirez (1996) provides an empirical examination on the determinants of the choice of debt restructuring methods: Chapter 11 reorganizations, prepackaged bankruptcies (prepacks), and workouts.

[7]Firms with relatively higher leverage (more debt) have an incentive to prefer the private debt restructuring to the formal bankruptcy since these firms are expected to suffer less erosion in economic value before default is triggered as Jensen (1989) suggests. Also, Ross, Westerfield, and Jaffe (1996) argue that firms with more debt will experience financial distress earlier than firms with less debt, and will have more time for private workouts to handle the distressed situation appropriately.

variables examined in Chatterjee, Dhillon, and Ramirez (1996) and Chen (2003) for factors affecting the choice between private debt restructuring and other restructuring options.

If the financially distressed firm is still economically viable, it is optimal to restructure debt and continue operations. The debt restructuring can also be processed under bankruptcy (Chapter 11), but Chatterjee, Dhillon, and Ramirez (1996) show that firms with better quality prefer private workouts than bankruptcy. We use the ratio of operating income to total liabilities and the average stock return over the past twenty business days to proxy the economic viability of a firm.

Private workouts require voluntary coordination among debtors and creditors. If the coordination problem is severe, the formal bankruptcy would be the only plausible option to resolve the problem at hand. We can expect that the coordination cost is higher if the size of the firm is larger and the the debt structure is more complex. Also, the information asymmetry between debtors and creditors will make the coordination cost higher. We consider total assets, total sales, and total liabilities to proxy the size of the firm. It turns out that these variables are highly correlated, and cause the multicollinearity problem in the regression. Thus, we only use the logarithm of total sales in the analysis. We also use the logarithm of the number of employees to proxy for the cost of coordination with labor. Next, we consider the ratio of subordinated debt to total liabilities and the ratio of secured debt to total liabilities to measure the complexity of the debt structure of the firm. To measure the information asymmetry, we use auditor's opinion[8] dummy to consider the level of information disclosure following Chen (2003). The dummy variable is 1 if the auditor's opinion is the "unqualified opinion" (highest disclosure) and 0 otherwise. Chen (2003) also uses stock return volatility, but this variable is not considered here because we can expect that stock return volatility causes multicollinearity problem since it might be highly correlated with the likelihood of default based on the model in Merton (1974): Preliminary investigation shows that the correlation between the volatility and the

We can thus expect that firms with high leverage have higher likelihood of restructuring. However, it should be noted that the leverage can also proxy the likelihood of default, and we cannot disentangle the effect of leverage on the likelihood of restructuring and on the likelihood of default. So we do not consider the leverage effect here.

[8]COMPUSTAT annual data provides auditor's opinion information for non-banks. The item consists of six categories: unaudited, adverse opinion, qualified opinion, no opinion, unqualified opinion with explanatory language, and unqualified opinion. The "unqualified opinion" is regarded to represent the highest level of accounting transparency: it indicates that the financial statement reflect no significant exceptions as to the accounting principles, the consistency of their application, and the adequacy of of information disclosed (from the Compustat User's Guide).

base CDS rate is around 50%, and the coefficient of the volatility is statistically insignificant in the regression analysis.

For recovery rate at restructuring, it is reasonable to assume that the determinants are almost the same as those of the recovery rate at default. However, we should also consider the cheapest to deliver option inherent in the CDS with restructuring because the protection buyer would deliver the debt which is the cheapest among the deliverable debts in the market. If the value of this option is higher, the CDS with restructuring is more valuable. The cheapest debt will often be the debt with the longer maturity and lower coupon rate. Under modified restructuring clause, the maturity of the delivered debt should not be earlier than the original maturity of the CDS contract and must not exceed thirty months after the original maturity date of the CDS contract. Thus, the deliverable obligations under MR should mature in 5 to 7.5 years for 5-year CDS contracts. Under full restructuring clause, the maturity limitation is much more generous to allow all the obligations maturing in 30-years. We try the ratio of the debt maturing after five years to long-term debt as a proxy for the value of the cheapest to deliver option. However, since the value of the deliverable debt also depends on its coupon structure, it is still arguable whether this variable can proxy the value of the delivery option or not.

The expected change in the likelihood of default after the restructuring event depends on the market's expectation on the probability that the firm's pre-default debt restructuring will be successful or unsuccessful. This is closely related to the likelihood of restructuring: the debtors and creditors would agree to take private pre-default debt restructuring if they expect it to be successful. Thus, we expect that the variables for this are practically the same as those of the likelihood of restructuring.

Table 6 shows the result of the regressions of the restructuring premium, $c^{MR} - c^{NR}$, on the covariates discussed so far. In summary, the regression results show that the coefficients of the covariates suggested by the literatures on financial distress are statistically significant, but have very little impact for explaining the restructuring premium compared to the base CDS rate itself: the R^2 increases from 51.8% (with the base CDS rate c^{NR} alone) to 54.6% (with all the covariates).

*** To be developed further. ***

4.1 The Effect of Restructuring Rules on CDS Rates

In this section, we examine to what extent different restructuring clauses impact CDS rate quotes, along with other possible determinants, in a panel-regression setting.

Table 6: Results of OLS regression of the modified restructuring premium, $c^{MR} - c^{NR}$, on the CDS rate under no restructuring, c^{NR}, as well as credit-quality, firm-specific accounting data and macro-economic variables. The covariates are described in Table 11 in the appendix. Results for the full restructuring risk premia are available upon request.

	estimate	SD	estimate	SD	estimate	SD
Intercept	-4.980	0.791	-10.495	1.113	-9.005	1.118
c^{NR}	0.046	0.001	0.045	0.001	0.045	0.001
SG	-1.779	0.162	-4.062	0.227	-4.391	0.225
SG$\times c^{NR}$	0.009	0.001	0.019	0.001	0.019	0.001
Gov5yr	-1.865	0.119	-2.274	0.155	-2.281	0.155
Baa	1.899	0.135	2.399	0.175	2.383	0.175
EBITDA/TtlDebt			6.783	1.439	7.778	1.354
StockRet20days			128.519	11.677	124.144	11.763
log(sales)			0.428	0.065	0.390	0.066
log(no employee)			-0.311	0.056	-0.335	0.057
SubDebt/TtlDebt			11.338	1.191	12.822	1.228
SecDebt/TtlDebt			3.340	0.640	4.011	0.649
AuditorOp			0.354	0.104	0.259	0.106
Intangible/TtlAsset			2.542	0.287		
Collateral/TtlAsset					-1.079	0.221
Deliverable			0.198	0.037	0.165	0.037
R^2	0.527		0.546		0.546	
no obs	25,814		14,539		14,495	

Few empirical work has been done on the determinants of the CDS rates except the works by Benkert (2004), Ericsson, Jacob, and Oviedo-Hlfenberger (2004) and Aunon-Nerin, Cossin, Hricko, and Huang (2002). So the control variables for the analysis is selected from literatures on the determinants of the default (or bankruptcy) probabilities and the credit spreads such as Duffee (1998), Collin-Dufresne, Goldstein, and Martin (2001), Elton, Gruber, Agrawal, and Mann (2001) and Vassalou and Xing (2004) among others. For firm-specific variable, we use distance to default (DD), Merton default probability ($\Phi\,(\mathrm{DD})$) and leverage (Lev). Market variables include the level and slope of the risk-free interest rate (Level, Slope), VIX index (VIX), Moody's Baa corporate yield (Baa), and market spread, the spread between Moody's Aaa yield and 20-year Treasury yield (Spread). Detailed descriptions of these variables are in the Appendix A.

In addition, we consider the following dummy variables:

- **Restructuring Rule Dummy (XR).** To see how restructuring rules affect the CDS rate, we consider dummy variables for each restructuring rules: NR (no restructuring), FR (full restructuring), MR (modified restructuring) and MMR (modified modified restructuring).

- **Period Dummy (ISDAyr).** These dummy variables are to capture possible structural changes caused by the development of the CDS market which are implied by the changes in ISDA credit derivatives definitions; The 2001 ISDA supplements, which defined modified restructuring rule (MR), was issued in April 2001 and the 2003 ISDA definitions, where modified modified restructuring rule (MMR) was added as an another choice, was issued in January 2003. To consider the market's adjustment time to new definitions, we allow time lags for the cut-off dates of each dummy variables. Based on the first appearing date of each restructuring rule in our data, we set ISDA99 to be 1 if the date is before 30 June 2001, and 0 otherwise; ISDA01 to be 1 if the date is between 1 July 2001 and 31 May 2003, and 0 otherwise; and ISDA03 to be 1 if the date is after 1 June 2003, and 0 otherwise.

- **Industry Dummy (INDj).** The default intensity and the recovery rate are also affected by the industry-specific environment. Following Chava and Jarrow (2004), we classify the industry as i) other industry (IND1); ii) manufacturing, oil&gas (IND2); iii) transportation, media/communications, utility (IND3); and iv) finance (IND4).

- **Maturity Dummy (Tyr).** The CDS rate depends on the time to maturity. Though the distance to default measure already considers the maturity of the CDS, it may not be sufficient to capture the whole effect of the time to maturity. Also, the maturity dummies can capture the different liquidity premium on the CDS with different maturities.

Tables 12, 13, and 14, and Table 15 show the result of the regression of CDS and logarithm of CDS, using leverage, Merton default probabilities, and distance to default, respectively. We also report the results with the CDS rate divided by the reported loss given default in Tables 16 and 17. Finally, Table 18 regresses the reported loss given default on distance to default in order to gain intuition about the relationship between recovery estimates and expected default frequencies.

We use CDS rate with 5 years maturity (T5) under no restructuring (NR) in finance industry (IND4) observed in ISDA03 period as the base. The proxies of default probability used in the tables are the 1 year distance to default (DD1), the Merton 1 year default probability (NDD1) and leverage (Lev). The regressions using T-years DD and NDD where T is the corresponding CDS maturity are not reported here. Although not all estimates are significant, the signs and magnitudes of coefficients of restructuring dummies and maturity dummies are all coincides with our expectation. In each time period between changes to ISDA regulations, CDS rates are, on average, highest under full restructuring and lowest under no restructuring.

*** To be developed further. ***

4.2 The Effect of Restructuring Events on Default Probabilities

The restructuring event, if it happens prior to default, may directly affect the firm's default risk in two ways. On the one hand, it is possible that restructuring can successfully reduce the firm's financial burden to improve overall financial health of the firm, and its default probability can be lowered (successful restructuring). On the other hand, the restructuring event can serve as a signal that the firm is in a financially weak condition, in which case, investors will raise their estimates of the firm's default risk, and eventually the firm will become financially distressed (unsuccessful restructuring).

Examples for both successful and unsuccessful restructuring are provided in Figure 1 which plots the distance to default for eight firms that did experience a distressed exchange[9], starting six months prior to the completion of the distressed exchange to six months afterward. The distance to default is a proxy of survival probability of a firm based on Merton (1974). Note that the exchange offer is usually announced several weeks to months before the completion date. From the plots, we can find that six out of eight firms experienced notable drop in the distance to default upon the distressed exchange event. This implies that the probability of default jumps upward at the time of the restructuring event.

5 A Reduced-Form Pricing Model for CDS Contracts Under Different Restructuring Clauses

In this section, we develop a reduced-form arbitrage-free pricing model for default swaps that explicitly takes into account the restructuring clause in the contract. To keep notation simple, we will distinguish between two categories of credit events: restructuring and non-restructuring default events, where the latter includes bankruptcy and a material failure by the obligor to make payments on its debt issue.

We suppose that the restructuring of a given firm occurs at the first event time of a (non-explosive) counting process N^R, relative to a probability space with measure $\mathbb{P}$ (actual or data-generating measure) and an increasing family $\{\mathcal{F}_t\}_{t\geq 0}$ of information sets defining the resolution of information over time, that satisfy the usual conditions (see, for example, Protter (2004)). Assuming the arbitrage-free and frictionless market, Harrison and Kreps (1979) and Delbaen and Schachermayer (1999) show that, under mild technical conditions, there exists a "risk-neutral"(or "equivalent martingale") measure $\tilde{\mathbb{P}}$, under which the price P_t at time t of a security paying a single, possibly random, amount Z at some stopping time $\tau > t$ is

$$P_t \;=\; \tilde{E}\left(e^{-\int_t^\tau r_s\,ds} Z|\mathcal{F}_t\right), \tag{3}$$

where r is the short-term interest rate process,[10] and $\tilde{E}$ denotes expectation under

[9]Distressed exchange, as a category of default by Moody's, is defined to occur when "(i) the issuer offers bondholders a new security or package of securities that amount to a diminished financial obligation (such as preferred or common stock, or debt with a lower coupon or par amount), or (ii) the exchange had the apparent purpose of helping the borrower avoid default,"see Keenan, Hamilton, Shtogrin, Zarin, and Stumpp (2000) for details. Since the debt restructuring is processed through exchange offer, we consider the distressed exchange to be almost equivalent to the restructuring event.

[10]The short-rate process r is progressively measurable with respect to $\{\mathcal{F}_t\}_{t\geq 0}$ with $\int_0^t |r_s|\,ds$

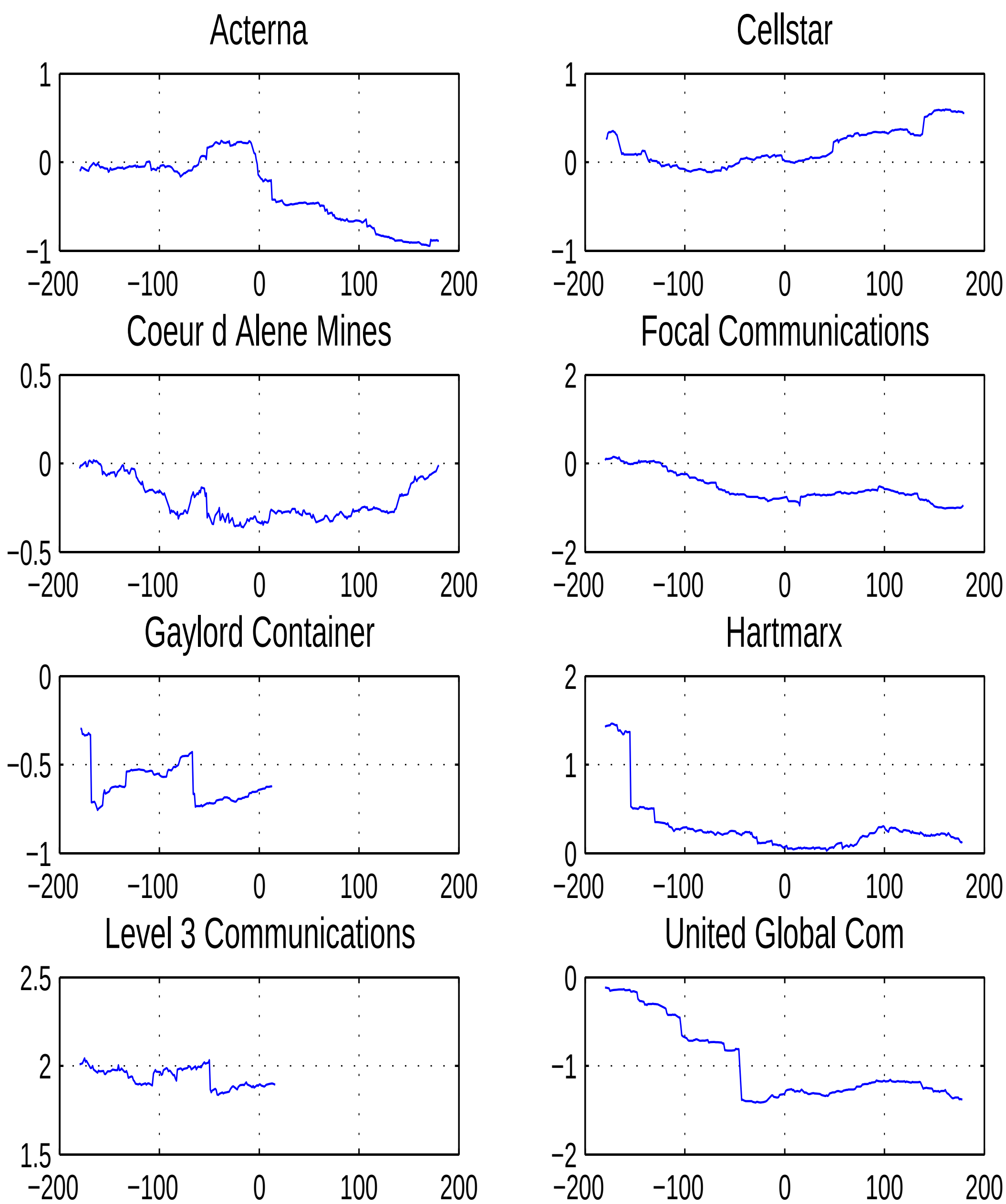

Figure 1: Distance to default for eight firms that experienced a distressed exchange during 2000-2004.

the risk-neutral measure $\tilde{\mathbb{P}}$. Note that the market is not required to be complete, so the martingale measure $\tilde{\mathbb{P}}$ is not assumed to be unique. However, we suppose that the measure is determined uniquely by the market in equilibrium. Restructuring of the firm occurs at time τ^R, the first jump time of the counting process N^R, with a risk-neutral restructuring intensity process λ^R, for which we will assume the doubly-stochastic property under $\tilde{\mathbb{P}}$. The doubly-stochastic, or Cox-process, assumption implies that the risk-neutral conditional probability at time t that the obligor will not restructure on or before time T is

$$s^R(t,T) \;=\; \tilde{\mathbb{P}}\left(\tau^R > T|\mathcal{F}_t\right) = \tilde{E}\left(e^{-\int_t^T \lambda_s^R\,ds}|\mathcal{F}_t\right). \tag{4}$$

Similarly, we assume that the non-restructuring default occurs at the first event time τ^D of a (non-explosive) counting process N^D, with a risk-neutral non-restructuring default intensity process h^D. We will extend the doubly stochastic setting of arrival of credit events under the risk-neutral measure under $\tilde{\mathbb{P}}$ to include h^D. Motivated by the observed negative jumps in the distance-to-default around the time a distressed exchange offer was made for several of the companies, as shown in Figure 1 in Section 4, we opted to specify a model under which h^D allows for a, possibly random, jump in the risk-neutral non-restructuring default intensity. Specifically, we assume

$$h_t^D \;=\; \lambda_t^D + k_1\,1_{\{t\geq\tau^R\}} + k_2\,\lambda_t^D\,1_{\{t\geq\tau^R\}}, \tag{5}$$

where k_1 and k_2, $k_2 > -1$, are random variables. Note that, in our model, a debt restructuring event, if it occurs, always precedes non-restructuring default events such as bankruptcy and failure to pay. In fact, the debt issues are also restructured under bankruptcy or other default processes. However, at the time of these restructuring events, all the default swap contracts are already terminated by the other default events. So it is meaningless to consider any restructuring after a non-restructuring default event.

Model specification (5) allows for both upward and downward jumps in the risk-neutral non-restructuring default intensity, capturing the possibility for both unsuccessful and successful debt restructurings.[11] It may be compared to the primary-

$\tilde{\mathbb{P}}$-almost surely and $\tilde{E}(e^{-\int_0^t r_s\,ds}) < \infty$, for all t. See Protter (2004) for details.

[11] Recall that Figure 1 exhibits a negative jump to the distance to default, and therefore a possible positive jump in the default intensities, for six out of eight firms. For the other two firms, Cellstar and Focal Communications, the impact was somewhat in the opposite direction as the distance to default did increase or, in the later case, stayed relatively flat.

secondary framework of Jarrow and Yu (2001), where a primary firm's default causes the default intensity of the secondary firm to jump upward by a constant amount. The primary-secondary structure violates the standard Cox process framework in Lando (1998). However, as discussed in Collin-Dufresne, Goldstein, and Hugonnier (2004), the no-jump condition in Duffie and Singleton (1999) is still satisfied. This enables us to utilize the standard pricing machinery, in the sense that the fundamental relationship between the conditional survival probability and the default intensity holds

$$s^D(t,T) \;\; = \;\; \tilde{\mathbb{P}}(\tau^D > T|\mathcal{F}_t) = \tilde{E}\left(e^{-\int_t^T h_s^D\, ds}|\mathcal{F}_t\right). \tag{6}$$

The conditional risk-neutral probability of survival until time T, given that a credit event (including both restructuring and non-restructuring default) did not occur by time t, is

$$s(t,T) \;\; = \;\; \tilde{\mathbb{P}}(\tau^D \wedge \tau^R > T|\mathcal{F}_t) = \tilde{E}\left(e^{-\int_t^T \lambda_s^D + \lambda_s^R\, ds}|\mathcal{F}_t\right), \tag{7}$$

where $\tau^D \wedge \tau^R = \min\left\{\tau^D, \tau^R\right\}$ which will be denoted by τ hereafter. In our doubly-stochastic setting, conditional on the paths of the intensities, the probability that both restructuring and non-restructuring credit events happen at the same time is zero.

Equation (6) can be rewritten as

$$\begin{aligned}
s^D(t,T) \;\; &= \;\; \tilde{\mathbb{P}}(\tau > T|\mathcal{F}_t) + \tilde{\mathbb{P}}(\tau^D > T, \tau^R \leq T|\mathcal{F}_t) \\
&= \;\; \tilde{E}\left(e^{-\int_t^T \lambda_s^D + \lambda_s^R\, ds}|\mathcal{F}_t\right) \\
&\quad\;\; + \tilde{E}\left(e^{-\int_t^T \lambda_s^D ds} \int_t^T e^{-\left(k_1(T-v) + k_2 \int_v^T \lambda_s^D\, ds\right)} \lambda_v^R e^{-\int_t^v \lambda_s^R ds} dv|\mathcal{F}_t\right) \\
&= \;\; \tilde{E}\left[e^{-\int_t^T \lambda_s^D ds} \underbrace{\left(e^{-\int_t^T \lambda_s^R ds} + \int_t^T e^{-\left(k_1(T-v) + k_2 \int_v^T \lambda_s^D\, ds\right)} \lambda_v^R e^{-\int_t^v \lambda_s^R ds} dv\right)}_{RF} \Bigg| \mathcal{F}_t\right],
\end{aligned} \tag{8}$$

where RF can be interpreted as an adjustment factor due to the restructuring risk. It equals 1 if a restructuring event has no direct impact on the non-restructuring default intensity, that is, when $k_1 = k_2 = 0$, and it is different from 1 otherwise. If the jump size is positive ($k_1 \geq 0$ and $k_2 \geq 0$), the restructuring adjustment factor (RF) falls between 0 and 1, implying a decrease in the risk-neutral survival probability $s^D(t,T)$.

In case the jump size is negative ($k_1 \leq 0$ and $k_2 \leq 0$), RF will exceed 1 and lead to an increase in $s^D(t, T)$.

Considering a default swap contract with T years to maturity, we assume that the risk-neutral mean loss in the event of a restructuring at time t, L_t^R, and in the event of a non-restructuring credit event, L_t^D, equal

$$L_t^D = (1 - \delta^D)\, p(t, T), \tag{9}$$

and

$$L_t^R = (1 - \delta^R)\, p(t, T), \tag{10}$$

where δ^D and δ^R are positive constant, and $p(t, T)$ is the time-t price of a zero-coupon Treasury bond with maturity T. This is known as the "Recovery of Treasury"assumption which helps to reduce the computational burden, see Jarrow and Turnbull (1995) for example.

The Lombard Risk Systems CDS database reports, in many instances of firm, date and restructuring rule triplets, a constant recovery value, as a fraction of face value. Given this information, we can calibrate δ^D and δ^R using (9) and (10) and assuming, for simplicity, $\tau^D \approx \frac{T}{2}$ or $\tau^R \approx \frac{T}{2}$ if the credit events happen before the maturity T of the CDS contract. Let $\bar{\delta}^D$ and $\bar{\delta}^R$ be the reported recovery rates, then

$$\delta^D \approx 1 - \left(1 - \bar{\delta}^D\right) \frac{p\,(0, T/2)}{p\,(0, T)} \tag{11}$$

and

$$\delta^R \approx 1 - \left(1 - \bar{\delta}^R\right) \frac{p\,(0, T/2)}{p\,(0, T)}. \tag{12}$$

To simplify the notation, we account for the heterogeneity in recovery rates by using proportional values for δ^D and

$$\delta^R = n\, \delta^D, \tag{13}$$

where n is a constant. Varma and Cantor (2005) report the average par-weighted recovery rates on defaulted bonds and loans for North American corporate issuers during 1983 to 2003 by the initial credit event. On average, the recovery rate at the distressed exchange event is 52.8%, which is roughly 1.5 times higher than the recovery rate at the other events, see Table 20 for details.

5.1 Pricing Credit Default Swaps

We now derive the pricing formula for default swaps under different restructuring clauses. The derivation is an extension of the existing literatures such as Duffie (1999), Hull and White (2000), and Jarrow and Yildirim (2002). As an approximation, we assume a continuous payment structure, where the protection seller receives a fixed payment flow of c dollars per unit time, called the at-market CDS rate, until maturity T of the contract or until a covered credit event occurs, whichever arrives first.

Let c^{RR} denote the CDS rate when restructuring is included as a covered credit event, and let c^{NR} denote the CDS rate if it is not. The default-free interest rate r is assumed to be independent of the default times τ^D and τ^R under the risk-neutral measure $\tilde{\mathbb{P}}$.[12] In addition, to keep computations simple, we assume that the restructuring intensity is proportional to the non-restructuring default intensity, that is

$$\lambda_t^R \;=\; m\lambda_t^D, \tag{14}$$

where m is a positive constant.

If restructuring is a covered credit event, the loss at default is

$$\begin{aligned}(1-\delta)\,p(\tau,T)\,1_{\{\tau\leq T\}} \;=\; & \left(1-\delta^D\right)p(\tau,T)\,1_{\{\tau^D\leq T,\tau^D<\tau^R\}} \\ & + \left(1-\delta^R\right)p(\tau,T)\,1_{\{\tau^R\leq T,\tau^R\leq\tau^D\}},\end{aligned} \tag{15}$$

and the default swap rate is given in Proposition 1. Proofs for the following results can be found in Appendix B.

Proposition 1 *If restructuring is included as a covered credit event, the T-year CDS rate c^{RR} is given by*

$$c^{RR} = \frac{p\,(0,T)\left(1-\frac{1+mn}{1+m}\,\delta^D\right)\left(1-\tilde{E}\left[e^{-\int_0^T(1+m)\lambda_s^D ds}\right]\right)}{\int_0^T p\,(0,v)\,\tilde{E}\left[e^{-\int_0^v(1+m)\lambda_s^D ds}\right]dv}. \tag{16}$$

If restructuring is not included as a covered credit event, the CDS can be computed as in Proposition 2. Note that c^{NR} depends on the likelihood of restructuring unless

[12] This assumption can be relaxed as in Jarrow and Yildirim (2002). However, Duffie (1999) shows that the CDS rate is not much affected by the dependency of the default intensity on the risk-free interest rate. So we can expect that this simplification does not significantly change the estimation result of this paper.

both k_1 and k_2 are equal to zero.

Proposition 2 *The T-year CDS rate under no restructuring, c^{NR}, is given by*

$$c^{NR} = \frac{p(0,T)\left(1-\delta^D\right)\left(1-\tilde{E}\left[1_{\{\tau^D>T\}}\right]\right)}{\int_0^T p(0,v)\,\tilde{E}\left[1_{\{\tau^D>u\}}\right]dv}, \tag{17}$$

where $\tilde{E}\left[1_{\{\tau^D>T\}}\right]$ is given in (8).

5.2 Simulation Study

The restructuring premium (RP) is defined as the difference between the CDS rate when restructuring is covered and the CDS rate under the no restructuring rule, that is,

$$RP \;\equiv\; c^{RR} - c^{NR}. \tag{18}$$

We define the relative restructuring premium (RRP) as

$$RRP \;\equiv\; \frac{c^{RR} - c^{NR}}{c^{NR}}. \tag{19}$$

In this section, using a simple model specification, we investigate how the (relative) restructuring premium is affected by the parameters m, n, and $k_1 = k$. To gain intuition while keeping things somewhat simple, from now on we set k_2 equal to zero. For the same reason, in this section, we assume constant restructuring and non-restructuring default intensities, and hold the risk-free rate r constant. Then, from (16) and (17), we have

$$c^{RR} \;=\; \frac{p(0,T)\left(1-\frac{1+mn}{1+m}\delta^D\right)\left(1-e^{-(1+m)\lambda^D T}\right)}{\int_0^T p(0,v)\,e^{-(1+m)\lambda^D v}dv}, \tag{20}$$

and

$$c^{NR} \;=\; \frac{p(0,T)\left(1-\delta^D\right)\left(1-\tilde{E}\left[1_{\{\tau^D>T\}}\right]\right)}{\int_0^T p(0,v)\,\tilde{E}\left[1_{\{\tau^D>u\}}\right]dv}, \tag{21}$$

where

$$\tilde{E}\left[1_{\{\tau^D > T\}}\right] = \begin{cases} \frac{1}{k - m\lambda^D}\left(ke^{-(1+m)\lambda^D T} - m\lambda^D e^{-\left(\lambda^D + k\right)T}\right) & \text{if } \lambda^D \neq \frac{k}{m} \\ \left(1 + m\lambda^D T\right) e^{-(1+m)\lambda^D T} & \text{if } \lambda^D = \frac{k}{m} \end{cases}.$$

First, we obtain reasonable parameter values for this illustration. The Lombard Risk Systems CDS database shows that, from May 2000 to December 2004, the median $\bar{\delta}^D$ is 0.4 and the median 5-year c^{NR} is 49.88 bps. From this we roughly calibrate λ^D to be $\frac{c^{NR}}{1-\bar{\delta}^D} = 83.13$ bps. The risk-free interest rate r is set to be 1.63%, the average 3-month Treasury rate during the same period. The estimate of m can be obtained from the Moody's annual and monthly surveys of global corporate defaults and recovery rates, see Table 19 in Appendix D. To obtain the estimate of n, we need recovery rates at each initial credit event, which are available from the research on the recovery rates from 1983 to 2003 by Varma and Cantor (2005), also see Table 20 in Appendix D. From this, we can obtain $n = 1.51$, which means that the recovery at restructuring has been, on average, 1.51 times higher that the recovery at default. We also present the estimates of m, n and $\bar{\delta}^D$ for high yield bonds during 2001 to 2003 in Table 21 in the appendix, constructed from the relative frequency and recovery rates for each of the different causes of credit events for high-yield bonds during 2001 to 2003, reported in FitchRatings (2004). From Table 19 and Table 21, we can see that m did increase from 2000 to 2004. Since most of our CDS observations are from the year 2003 and 2004, we set $m = 0.173$, the relative frequency of distressed exchange with respect to the other events during this period.

Jump Parameter Figure 2 shows the effect of the parameter k, the expected change in the default intensity at the occurrence of the restructuring event, on the restructuring premium. We first note that the CDS rate with restructuring, c^{RR}, is not affected by $k_1 = k$, see the c^{RR} formula (20). The restructuring premium decreases decreasingly as k increases.

The median RRP from our database is 6.3%. From Figure 2, we can verify that k is around 0.13 for our median CDS. This implies that investors expect that the restructuring event of the reference firm, if it happens, will be unsuccessful. It should also be noted that the restructuring premium can possibly be negative for high level of k: in our example, it becomes negative when k exceeds 0.56. [13]

[13]The negative premium can exist only when both the buyer and the seller have the right to deliver a credit event notification. If the buyer alone has the "option" to notify a credit event, the

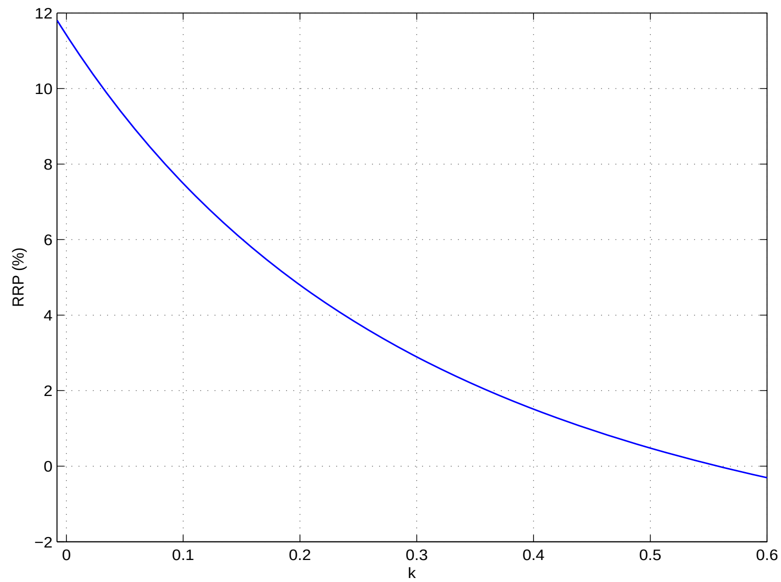

Figure 2: Relative restructuring premium with respect to k, the expected change in default intensity at restructuring event. Other parameters are fixed at $\lambda^D = 0.008313$, $\bar{\delta}^D = 0.4$, $m = 0.173$, $n = 1.51$, $T = 5$, and $r = 0.0163$.

Default Intensity Figure 3 shows how the restructuring premium and the relative restructuring premium changes as the default intensity changes. The restructuring premium increases as the default intensity increases almost linearly regardless of the sign of k. The relationship between the relative restructuring premium (RRP) and the default intensity can be both positive or negative depending on k: when k is -0.003 they show negative relationship, but as k increases, the slope becomes positive. This change in the sign of the slope can provide us a useful guide to test the hypothesis that the market expects the restructuring event will be successful. If RRP and default intensity are negatively related, it can be a sufficient, but not necessary, condition for the hypothesis to be true.[14]

CDS under restructuring rule is actually a portfolio of the CDS under no restructuring and the notification option: the protection buyer under restructuring rule will not deliver a notification if it is just a soft restructuring event and, for example, a bankruptcy event is expected to be imminent because the value of the debt that should be delivered to the protection seller is much lower under bankruptcy than under restructuring. Therefore, in this case, the CDS rate under restructuring rule is always greater than the CDS rate under no restructuring by the value of the option. In this paper, we do not consider this possible optionality in CDS contracts from the contractual specification of the notifying party, and we assume that both parties can deliver the credit event notification.

[14] Preliminary regression result shows that the coefficient of the panel regression of RRP on $c^{NR}/(1-\bar{\delta}^D)$, an approximation of λ^D, is significantly negative. This result implies that the market

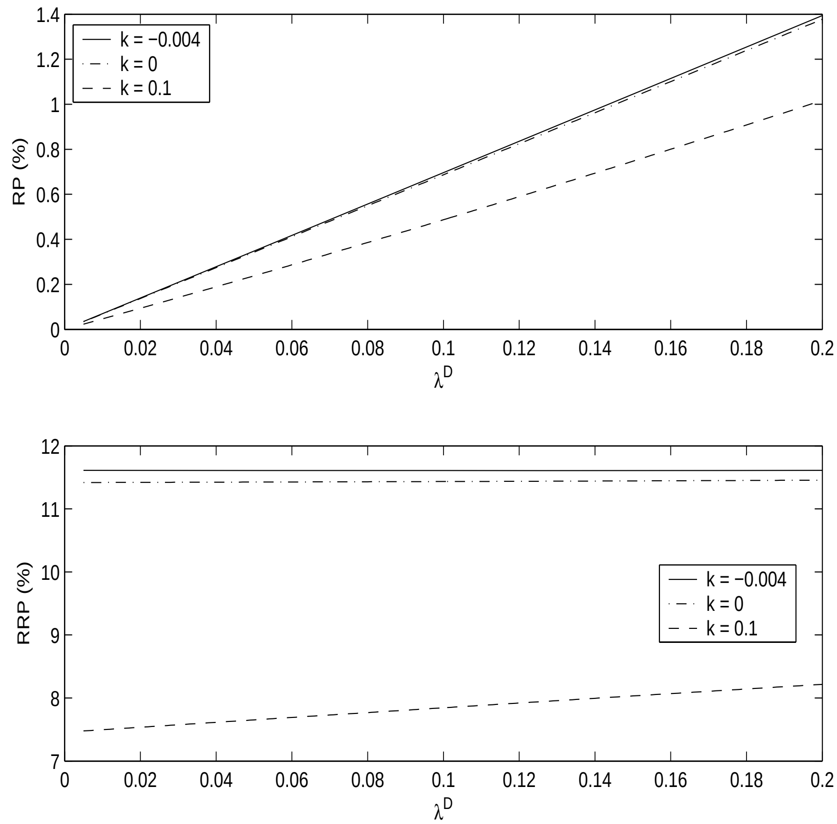

Figure 3: Restructuring premium (RP) and relative restructuring premium (RRP) with respect to the default intensity λ^D for various k, Other parameters are fixed at $\bar{\delta}^D = 0.4$, $m = 0.173$, $n = 1.51$, $T = 5$, and $r = 0.0163$.

Restructuring Intensity and Recovery Rate at Restructuring Now we investigate how the relative restructuring premium (RRP) is affected by $m \left(= \lambda^R/\lambda^D\right)$, the size of the restructuring intensity with respect to the default intensity, and $n \left(= \delta^R/\delta^D\right)$, the size of the recovery rate at restructuring with respect to the recovery rate at default. In summary, as shown in Figure 4 and Figure 5, we find the following: First, there is a positive relationship between m and RRP for all level of n if the restructuring is expected to be successful ($k < 0$), but if the restructuring is not expected to be successful ($k \geq 0$), m and RRP can have a negative relationship if n exceeds a certain high level - that is, when the recovery rate at restructuring is high. Second, n and RRP are always negatively related. The intuition follows if we look at the changes in c^{RR} and c^{NR} separately.

First, the relationship between c^{NR} and m is negative if $k < 0$ or positive if $k > 0$. When $k < 0$ (successful restructuring), as m increases, the likelihood of default decreases due to the increasing chance of successful restructuring; hence c^{NR} decreases as m increases. Oppositely, when $k > 0$ (unsuccessful restructuring), as m increases, the likelihood of default also increases, which causes c^{NR} to increase too.

For c^{RR}, as m increases, the probability of credit event happening (restructuring or default) increases, which forces c^{RR} to increase as well. However, since the recovery rate at restructuring is usually much higher than recovery rate at default, the expected loss given a credit event decreases as the probability of restructuring increases, and this forces c^{RR} to decrease. So there is a trade-off between the likelihood of credit event and the expected loss rate. Since the loss rate decreases as n increases, the positive relationship between c^{RR} and m becomes weaker as n increases. This argument is summarized in Table 7.

Table 7: The effect of m on c^{RR}, c^{NR}, and the restructuring premium ($c^{RR} - c^{NR}$).

	c^{RR}	c^{NR}	$c^{RR} - c^{NR}$
$k < 0$	positive	negative	positive
$k > 0$	positive (weaker at higher n)	positive	mostly positive (negative at extremely high level of n)

expects the restructuring event, once it happens, will be successful, so that the likelihood of default of a firm will decrease ($k < 0$) after the debt restructuring.

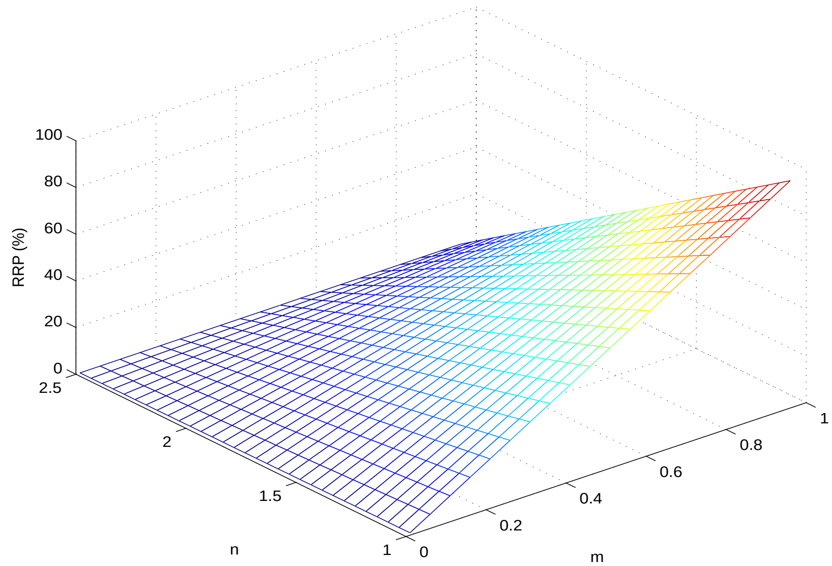

Figure 4: Relative restructuring premium with respect to m and n when $k = -0.003$, where $\lambda^R = m\lambda^D$ and $\delta^R = n\delta^D$. Other parameters are fixed at $\lambda^D = 0.008313$, $\bar{\delta}^D = 0.4$, $T = 5$, and $r = 0.0163$.

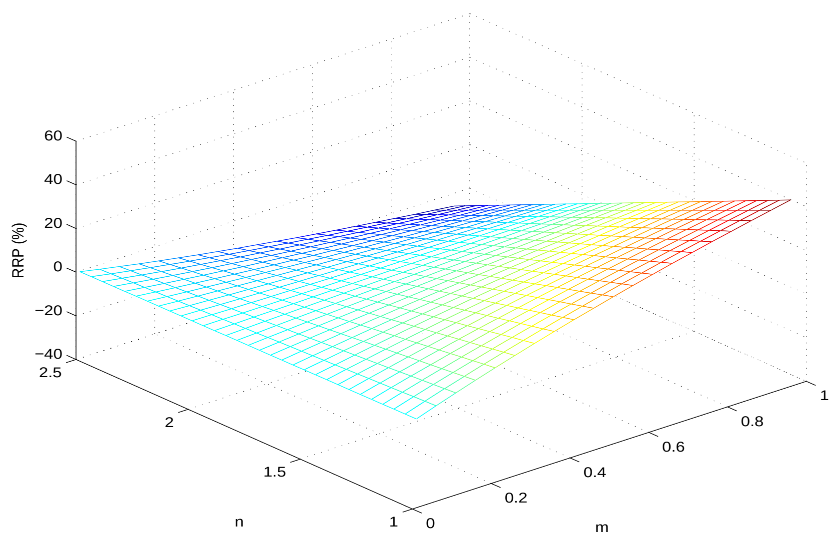

Figure 5: Relative restructuring premium with respect to m and n when $k = 0.2$, where $\lambda^R = m\lambda^D$ and $\delta^R = n\delta^D$. Other parameters are fixed at $\lambda^D = 0.008313$, $\bar{\delta}^D = 0.4$, $T = 5$, and $r = 0.0163$.

Term Structure Figure 6 shows the term structure of CDS rates and the relative restructuring premium. We can see that if we ignore the effect of restructuring event on the default risk of the firm ($k = 0$), c^{NR} is overestimated when the true value of k is negative. This is because the likelihood of successful restructuring reduces the likelihood of default. The case of positive k is the opposite. Since this effect is greater for longer maturity, the estimation bias is also higher for longer maturity. Accordingly, the bias from the true restructuring premium is higher for longer maturity.

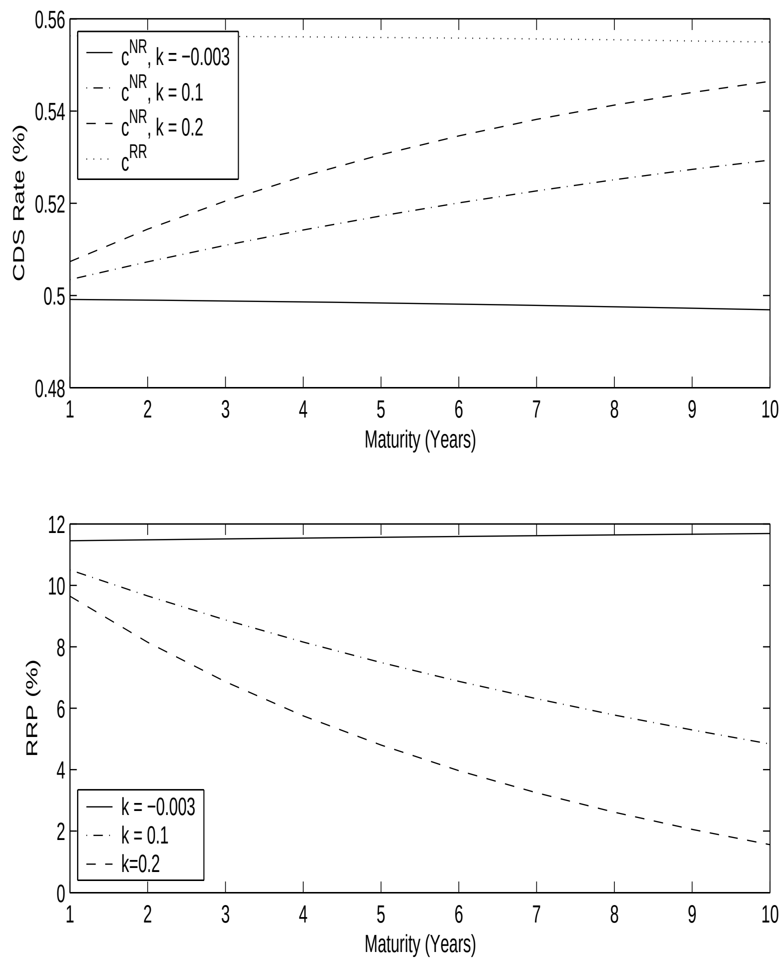

Figure 6: Term structure of CDS rates and the relative restructuring premium (RRP) for various k. Other parameters are fixed at $\lambda^D = 0.008313$, $\bar{\delta}^D = 0.4$, $m = 0.173$, and $r = 0.0163$.

In the remainder of this section, we provide an econometric model for pricing credit default swaps under restructuring risk, and discuss how to estimate the parameters.

5.3 Model Specification

The restructuring and non-restructuring default intensities are modeled as functions of a state variable X_t, which follows a square-root process

$$dX_t = (a - bX_t)\,dt + \sigma\sqrt{X_t}\,dW_t, \;\; X_0 > 0, \tag{22}$$

where W_t is a standard Brownian motion under the physical measure $\mathbb{P}$, a, b and $\sigma > 0$ are constants, and the boundary non-attainment condition, $a \geq \frac{\sigma^2}{2}$, holds to ensure that X_t stays positive $\mathbb{P}$-almost surely. Under the equivalent martingale measure $\tilde{\mathbb{P}}$, the default intensity process can be expressed as

$$dX_t = \left(\tilde{a} - \tilde{b}X_t\right) dt + \sigma\sqrt{X_t}\,d\tilde{W}_t, \tag{23}$$

where $\tilde{W}_t$ is a standard Brownian motion under $\tilde{\mathbb{P}}$. The market-price-of-default-risk process Λ_t is given by

$$d\tilde{W}_t = \Lambda_t dt + dW_t, \tag{24}$$

which implies

$$\Lambda_t = \frac{a - \tilde{a}}{\sigma\sqrt{X_t}} - \frac{b - \tilde{b}}{\sigma}\sqrt{X_t} \equiv \frac{\mu_1}{\sigma\sqrt{X_t}} - \frac{\mu_2}{\sigma}\sqrt{X_t}.$$

Under the classical affine term structure models, the parameter μ_1 is restricted to be zero, see Dai and Singleton (2000) for example. However, Cheridito, Filipović, and Kimmel (2004) show the existence of the equivalent martingale measure $\tilde{\mathbb{P}}$ (hence the absence of arbitrage) under this more general market price of risk specification if the boundary non-attainment condition holds under the measure $\tilde{\mathbb{P}}$ (i.e. $\tilde{a} \geq \frac{\sigma^2}{2}$). A desirable feature of this "extended" affine specification is that Λ_t does not approach zero even if the volatility of X_t approaches zero. Also, Λ_t can switch signs over time.[15]

We assume that the risk-neutral restructuring and non-restructuring default in-

[15]The correct sign of the market price of default risk can be forecasted in the model by looking at the expected return on defaultable bonds discussed in Yu (2002). In our model, Λ_t is negative in an economy where investors are risk-averse.

tensity are given by

$$\lambda_t^R = \frac{m}{1+m} X_t,$$

and

$$\lambda_t^D = \frac{1}{1+m} X_t.$$

The specification for the recovery rate process follows our description in (11) and (12). It is straightforward to show that the overall recovery rate for default swaps with restructuring is

$$\begin{aligned}
\delta^{RR} &\equiv \frac{\delta^D + m\delta^R}{1+m} \\
&= 1 - \left(1 - \frac{\bar{\delta}^D + m\bar{\delta}^R}{1+m}\right) \frac{p(0,T/2)}{p(0,T)} \\
&= 1 - \left(1 - \bar{\delta}^{RR}\right) \frac{p(0,T/2)}{p(0,T)}.
\end{aligned}$$

We also have that $\bar{\delta}^R = n\bar{\delta}^D$ if $\delta^R = n\delta^D$, and

$$\begin{aligned}
m &= \frac{\delta^{RR} - \delta^D}{\delta^R - \delta^{RR}} = \frac{\bar{\delta}^{RR} - \bar{\delta}^D}{\bar{\delta}^R - \bar{\delta}^{RR}} \\
&= \frac{\bar{\delta}^{RR} - \bar{\delta}^D}{n\bar{\delta}^D - \bar{\delta}^{RR}}.
\end{aligned} \tag{25}$$

The estimates of $\bar{\delta}^{RR}$ and $\bar{\delta}^D$ for individual names are available from the Lombard data. However, the estimates of m and n are only available for a group of firms, see Table 21 for speculative grade firms.

We also assume $k_2 = 0$ for analytical solution. In this case, as laid out in detail in Appendix B, to compute both c^{RR} and c^{NR}, we only need to calculate expectations of the form $\tilde{E}\left[e^{-\int_0^T (1+m)\lambda_s^D\, ds}\right]$ and $\tilde{E}\left[1_{\{\tau^R \leq T\}} e^{-k\left(T-\tau^R\right)} e^{-\int_0^T \lambda_s^D ds}\right]$. Appendix C shows that closed-form solutions are available when the non-restructuring default intensity follows an affine process.

5.4 Estimation Strategy

Zero-coupon bond prices are stripped from the constant maturity Treasury rate curve by assuming piecewise linear forward rate curve, see James and Webber (2000) for other zero-coupon bond stripping methods. We then follow a two-step procedure to estimate the intensity parameters. First, from CDS rates with restructuring, we estimate the parameters for the state variable process. Following Chen and Scott (1993), we assume that the 5-year CDS rates are priced without errors so that we can invert the default intensity λ_t^D from the CDS rate. The 1-year and 10-year CDS rate are assumed to be observed with measurement errors: u_t^1 for 1-year and u_t^2 for 10-year CDS rate. The measurement error is defined as

$$u_t \equiv c_t^{RR} - \widehat{c_t^{RR}},$$

where c_t^{RR} is the observed CDS rate and $\widehat{c_t^{RR}}$ is the predicted CDS rate, and it is assumed to be normally distributed with mean zero and standard deviation σ, and we let σ_1 and σ_2 be the standard deviation for 1-year and 10-year CDS rate, respectively.[16] The parameter set to be estimated in this step is then $\Theta = \left\{\sigma, a, b, \tilde{a}, \tilde{b}, \sigma_1, \sigma_2\right\}$. We take the maximum likelihood estimation method to obtain $\hat{\Theta}_{ML}$.

Given the estimate $\hat{\Theta}_{ML}$ and the implied state variable $\{X_t\}_{t=1}^N$, the CDS rate without restructuring, or the restructuring premium, is a function of m and k. In practice, it is hard to achieve stable estimates for both m and k. Since k is the least known parameter, it is reasonable to try to fix m. As shown in Tables 19, 20, and 21, we can use historical default experiences to obtain a reasonable value of m. We can also calibrate m from the estimate of n by using (25) given the recovery rates. The latter would be preferable if we believe that n is less variable across time than m.

5.5 Case Study

We conclude this section by investigating the case of Ford Motor Co. in form of a case study. The ML estimates of the default parameters and the standard deviations of the measurement errors estimated from the CDS rates under modified restructuring rule are reported in Table 8.

We set $m = 0.173$ from Table 19. At the current parameter estimates, Ford's RRP is quite volatile, which we believe must, at least to some extent, be attributed to substantial measurement errors. (Note that the standard deviations for the CDS

[16] Perhaps the desirable specification for u_t may be the AR(1), first-order autoregressive, process $u_{t+1} = \rho u_t + \epsilon_t$, where ϵ_t is the Gaussian white noise with standard deviation σ. However, this introduces an additional parameter ρ for each sequence of CDS rates measured with error, and hence requires more observations to obtain stable estimates.

Table 8: Preliminary Parameter Estimates for Ford Motor Co.

	σ	a	b	$\tilde{a}$	$\tilde{b}$	σ_1	σ_2
Estimate	0.0090	0.0003	0.0062	0.0022	-0.0057	0.0164	0.0019
Std. Dev.	0.0003	0.0003	0.0050	0.0004	0.0048	0.0000	0.0000

observations are higher that the corresponding restructuring premium.) As an alternative, and to obtain more robust results, we assume that the RRP is stable at the median level, and then re-calibrate $k = k_1$. The median RRP of Ford is 0.77% and k is calibrated to be 1.5618. The results, under very simplified settings, would imply that investors in the case of Ford expect non-restructuring default events to become much more likely, risk-neutrally, once a distressed exchange offer has been made by the firm.

6 Conclusion

In this paper, we provide an empirical study on the restructuring risk with regard to credit default swaps, and present a reduced-form model that incorporates the effect of the restructuring event on the default probability.

We explore the determinants of the restructuring premium, the additional payment for protection against the restructuring risk, in U.S. credit default swaps market during 2000-2005. We find that the restructuring premium is affected by credit spread, credit ratings, and industry dummies as well as those variables from literatures on credit spreads and financial distress. However, the explanatory power is still not satisfactory (R^2 of around 50%), and we suspect that the liquidity plays an important role for the rest of the part. Preliminary investigation shows that the restructuring premia of liquid names are significantly lower than the others, and our future research will be further directed in this way.

We next consider the possible effect of the restructuring event on the default probability at an individual firm level. The event study on the distressed exchange offer shows the possibility that the default probability of a firm can jump upward or downward at the time of the restructuring event. Motivated by this finding, we propose a reduced-form model of restructuring risk for pricing credit default swaps featured by the effect of the restructuring event on the default probability of the firm through the jump of the default intensity at the time of the restructuring event. Simulation study shows that the default intensity is expected to jump upward when the restructuring event happens, which implies that investors expect that the restructuring, if it happens, will be unsuccessful. The estimation of Ford Motor case also shows that the default probability is expected to increase after the restructuring event, though this result is not conclusive given the simple structure of the estimated model.

A Control Variables

1. **Distance to Default (DD).** This is a measure based on the structural model by Merton (1974) and the only firm-specific variable in our regression model. Berndt, Douglas, Duffie, Ferguson, and Schranz (2005) investigate the relation between the CDS rates and the EDF estimates by the Moody's KMV, which is based on Merton (1974) model. They ran the regression of the logarithm of the CDS rates over the logarithm of the EDFs and could obtain an R^2 of about 74%. Their result supports that the distance to default is a significant determinant of the CDS rate because the EDF estimate is basically $\Phi(-DD)$ where Φ is a cumulative distribution function; $\Phi(-DD)$ is the probability that the default event occurs in a given period. In the Merton model, Φ is the cumulative normal distribution function but KMV is known to use different distribution function. Duffie, Saita, and Wang (2005) directly use the distance to default as a covariate to predict bankruptcy and justify its use by the incomplete information model by Duffie and Lando (2001). Since the default intensity in the CDS pricing formulae is the intensity under the risk-neutral measure, we use the *risk-neutral* distance to default. The details of the construction procedure of the distance to default are explained in the following subsection. For a detailed description of the construction of the distance-to-default measure please refer to Appendix A in Duffie, Saita, and Wang (2005).

2. **Merton Default Probability (MDP).** We define the annualized risk-neutral Merton probability of default in T years to be

$$\tilde{\pi}_M(T) = 1 - (1 - \Phi(-DD_T))^{1/T},$$

where DD_T is the distance to default in T years.

3. **Leverage (Lev)** As an alternative to distance to default, we try the leverage ratio of a firm. Following Collin-Dufresne, Goldstein, and Martin (2001), the leverage is defined as $\frac{D}{E+D}$, where D is the book value of total debt and E is the market value of equity.

4. **Level and Slope of the Risk-free Interest Rate (Level, Slope).** We take 2-year Treasury yield for the level and the difference between 10-year and 2-year Treasury yields for the slope variable. These variables can represent the state of the economy. We use the daily data of 'Constant Maturity Treasury Rate' obtained from the Federal Reserve Bank of St. Louis. It provides the market yields on Treasury securities at fixed maturities - currently 1, 3 and 6 months and 1, 2, 3, 5, 7, 10 and 20 years, which are estimated from the closing market bid-side yields for on-the-run Treasury securities using a cubic spline curve-fitting model.

5. **VIX Index (VIX).** The VIX Index is the implied volatility of S&P 500 stock index option. This is an another variable to represent the state of the economy, recognized in the equity market[17]. The daily data is available at the Chicago Board Options Exchange (CBOE) website.

6. **Moody's Baa Corporate Yield (Baa).** This is to capture the state of the corporate bond market which is expected to be closely related with the CDS market. Moody's seasoned Aaa/Baa corporate bond yields are also obtained from the Fed of St. Louis. Morris, Neal, and Rolph (1998) document that these yields are constructed from an equally weighted sample of yields on 75 to 100 bonds issued by large non-financial corporations with initial maturities of greater than twenty years. Each bond issue included in the index must have a face value exceeding $100 million and a liquid secondary market.

7. **Market Spread (Spread).** This is the spread between the Moody's Aaa corporate yield and the 20-year Treasury yield which partly captures the illiquidity of the corporate bond market given that Aaa bonds are almost free of default risk. The liquidity of the CDS market is expected to be related with the liquidity of the corporate bond market.

8. **Firm Size (Size).** Following Duffie, Saita, and Wang (2005), firm size is measured by the logarithm of the firm's total assets (Compustat DATA44).

B Proofs

Proof of Proposition 1. The value of payments to the seller at time 0 for CDS under restructuring rule is

$$
\begin{aligned}
c^{RR}\int_0^T \tilde{E}\left[1_{\{\tau>v\}}e^{-\int_0^v r_s ds}\right]dv &= c^{RR}\int_0^T p\left(0,v\right)\tilde{E}\left[1_{\{\tau>v\}}\right]dv \\
&= c^{RR}\int_0^T p\left(0,v\right)\tilde{E}\left[e^{-\int_0^v (1+m)\lambda_s^D ds}\right]dv,
\end{aligned}
$$

from the independence assumption and the survival probability in (**??**). The value of protection by the seller at time 0 is

$$
\begin{aligned}
&\tilde{E}\left[(1-\delta)\,p\left(0,T\right)1_{\{\tau\le T\}}\right] \\
&= p\left(0,T\right)\tilde{E}\left[(1-\delta)\,1_{\{\tau\le T\}}\right] \\
&= p\left(0,T\right)\left\{\left(1-\delta^D\right)\tilde{E}\left[1_{\{\tau^D\le T,\tau^D\le\tau^R\}}\right]+\left(1-\delta^R\right)\tilde{E}\left[1_{\{\tau^R\le T,\tau^R\le\tau^D\}}\right]\right\},
\end{aligned}
$$

[17] We tried S&P500 Index return as a proxy for the state of the economy in addition to the VIX index, but couldn't improve the fit.

Here the probability of default happening prior to both maturity and restructuring is calculated as

$$\begin{aligned}
\tilde{E}\left[1_{\{\tau^D \le T, \tau^D \le \tau^R\}}\right] &= \tilde{E}\left[1_{\{\tau^D \le T\}} \tilde{E}\left[1_{\{\tau^D \le \tau^R\}} \middle| \mathcal{F}^X \vee \mathcal{F}^D\right]\right] \\
&= \tilde{E}\left[1_{\{\tau^D \le T\}} e^{-\int_0^{\tau^D} \lambda_s^R ds}\right] \\
&= \tilde{E}\left[\int_0^T \lambda_v^D e^{-\int_0^v \left\{\lambda_s^D + \lambda_s^R\right\} ds} dv\right] \\
&= \tilde{E}\left[\int_0^T \frac{\lambda_v^D}{\lambda_v^D + \lambda_v^R} \left\{\lambda_v^D + \lambda_v^R\right\} e^{-\int_0^v \left\{\lambda_s^D + \lambda_s^R\right\} ds} dv\right] \\
&= \frac{1}{1+m}\left(1 - \tilde{E}\left[e^{-\int_0^T (1+m)\lambda_s^D ds}\right]\right),
\end{aligned}$$

and the probability of restructuring happening prior to maturity and default is

$$\begin{aligned}
\tilde{E}\left[1_{\{\tau^R \le T, \tau^R \le \tau^D\}}\right] &= \tilde{E}\left[1_{\{\tau^R \le T\}} \tilde{E}\left[1_{\{\tau^R \le \tau^D\}} \middle| \mathcal{F}^X \vee \mathcal{F}^R\right]\right] \\
&= \tilde{E}\left[1_{\{\tau^R \le T\}} e^{-\int_0^{\tau^R} \lambda_s^D ds}\right] \\
&= \tilde{E}\left[\int_0^T \lambda_v^R e^{-\int_0^v \left\{\lambda_s^D + \lambda_s^R\right\} ds} dv\right] \\
&= \frac{m}{1+m}\left(1 - \tilde{E}\left[e^{-\int_0^T (1+m)\lambda_s^D ds}\right]\right).
\end{aligned}$$

The initial CDS rate is determined such that the value of payments to the seller is equal to the value of protection by the seller. Therefore, the result follows. ■
Proof of Proposition 2. Similar to the Proof of Proposition 1. ■

C Computation

In this appendix, we provide a closed-form approximations of credit default swap rates derived in equations (16) and (17) under the specification suggested in the case study.

C.1 Affine Transforms

We introduce here a simplified version of the main result by Duffie, Pan, and Singleton (2000) without a proof.

Suppose a discount rate $R(t)$ is an affine function of state variables $X(t)$,

$$R(t) = \rho_0 + \rho_1 \cdot X(t),$$

where $X_t = (X_t^1, X_t^2, \cdots, X_t^n)'$ follows an affine diffusion,

$$dX(t) = \mu(t, X(t))\, dt + \sigma(t, X(t))\, dW(t), \tag{C.1}$$

where

$$\mu(t, X(t)) = K_0(t) + K_1(t) X(t),$$

$$\left(\sigma(t, X(t))\, \sigma(t, X(t))'\right)_{ij} = (H_0(t))_{ij} + (H_1(t))_{ij} \cdot X(t),$$

and $W(t)$ is a standard n-dimensional Brownian motion; the coefficients $K = (K_0, K_1)$ and $H = (H_0, H_1)$ are time-dependent and assumed to be bounded continuous functions on $[0, \infty)$.

Proposition 3 (Duffie-Pan-Singleton) *Suppose that $X(t)$ follows an affine diffusion process defined by (C.1) and satisfies a technical condition stated in Duffie, Pan, and Singleton (2000). Then*

$$E_t\left[e^{u \cdot X(T)} e^{-\int_t^T R(X(s))ds}\right] = e^{\alpha(t;T) + \beta(t;T) \cdot X(t)}, \tag{C.2}$$

where $\alpha(t;T)$ and $\beta(t;T)$ satisfy the ordinary differential equations

$$\frac{d\beta(t)}{dt} = \rho_1 - K_1' \beta(t) - \frac{1}{2} \beta(t)' H_1 \beta(t), \tag{C.3}$$

$$\frac{d\alpha(t)}{dt} = \rho_0 - K_0 \cdot \beta(t) - \frac{1}{2} \beta(t)' H_0 \beta(t) \tag{C.4}$$

with the boundary conditions $\beta(T) = u$ and $\alpha(T) = 0$.

Generally, one can use fairly fast numerical procedures, for example Runge-Kutta method, to solve the ODEs in case that explicit solutions are not available.

To calculate the expectations that appear in our CDS rate computation, let us now consider a state variable $X(t)$ which follows a single-factor square-root process

$$dX(t) = (a - bX(t))\, dt + \sigma \sqrt{X(t)} d\tilde{W}(t),$$

and solve the transformation of $X(t)$,

$$\tilde{E}_t\left[e^{uX(T)} e^{-\int_t^T \rho X(s) ds}\right], \tag{C.5}$$

where the discount rate is set to be $R(X(t)) = \rho X(t)$. Under this setup, the ODEs (C.3) and (C.4) are written as

$$\beta'(t) = \rho + b\beta(t) - \frac{1}{2}\sigma^2 \beta(t)^2, \ \beta(T) = u$$

$$\alpha'(t) = -a\beta(t), \ \ \alpha(T) = 0$$

and these ODEs have closed-form solutions:

$$\beta(t) = \begin{cases} \frac{p-qCe^{-\frac{1}{2}\sigma^2(p-q)t}}{1-Ce^{-\frac{1}{2}\sigma^2(p-q)t}} & , \ u \neq p,q \\ p & , \ u = p \\ q & , \ u = q \end{cases}. \tag{C.6}$$

and

$$\begin{aligned} \alpha(t) &= a\int_t^T \beta(s)\,ds \\ &= \begin{cases} \frac{2a}{\sigma^2}\left(\ln\left|e^{\frac{1}{2}\sigma^2 pT} - Ce^{\frac{1}{2}\sigma^2 qT}\right| - \ln\left|e^{\frac{1}{2}\sigma^2 pt} - Ce^{\frac{1}{2}\sigma^2 qt}\right|\right) & , \ u \neq p,q \\ ap(T-t) & , \ u = p \\ aq(T-t) & , \ u = q \end{cases}. \end{aligned} \tag{C.7}$$

C.2 CDS Rate Calculation

To calculate CDS rates derived in the equation (16) and (17), we only need to solve three expectations of the form $\tilde{E}\left[e^{-\int_0^T\left\{\lambda_s^D+\lambda_s^R\right\}ds}\right]$, $\tilde{E}\left[1_{\{\tau^R\leq T\}}e^{-\int_0^{\tau^R}\lambda_s^D ds}\right]$, and $\tilde{E}\left[1_{\{\tau^R\leq T\}}e^{-k\left(T-\tau^R\right)}e^{-\int_0^T\lambda_s^D ds}\right]$.

From (C.5), the solution of the first form can be obtained as

$$\begin{aligned} \tilde{E}\left[e^{-\int_0^T\left\{\lambda_s^D+\lambda_s^R\right\}ds}\right] &= \tilde{E}\left[e^{-\int_0^T(1+m)\lambda_s^D ds}\right] \\ &= e^{\alpha_1(0;T)+\beta_1(0;T)\lambda_0^D} \end{aligned} \tag{C.8}$$

by setting $u = 0$ and $\rho = (1+m)$, where $\alpha_1(0;T)$ and $\beta_1(0;T)$ are given as (C.7) and (C.6).

For the second form, if credit events are assumed to happen only at time $\Delta, 2\Delta, \cdots, n\Delta(= T)$, it can be approximated as

$$\begin{aligned} &\tilde{E}\left[1_{\{\tau^R\leq T\}}e^{-\int_0^{\tau^R}\lambda_s^D ds}\right] \\ &= \sum_{j=1}^n \tilde{E}\left[1_{\{(j-1)\Delta<\tau^R\leq j\Delta\}}e^{-\int_0^{\tau^R}\lambda_s^D ds}\right] \\ &\approx \sum_{j=1}^n \tilde{E}\left[1_{\{(j-1)\Delta<\tau^R\leq j\Delta\}}e^{-\int_0^{j\Delta}\lambda_s^D ds}\right]. \end{aligned}$$

By the iterative conditioning, this is equal to

$$\sum_{j=1}^{n} \tilde{E}\left[e^{-\int_0^{j\Delta} \lambda_s^D ds} \tilde{E}\left[1_{\{(j-1)\Delta < \tau^R \leq j\Delta\}} \middle| \mathcal{F}^X \right] \right]$$
$$= \sum_{j=1}^{n} \tilde{E}\left[e^{-\int_0^{j\Delta} \lambda_s^D ds} \left\{ e^{-\int_0^{(j-1)\Delta} \lambda_s^R ds} - e^{-\int_0^{j\Delta} \lambda_s^R ds} \right\} \right]$$
$$= \sum_{j=1}^{n} \tilde{E}\left[e^{-\int_0^{(j-1)\Delta} \left\{ \lambda_s^D + \lambda_s^R \right\} ds} \tilde{E}\left[e^{-\int_{(j-1)\Delta}^{j\Delta} \lambda_s^D ds} \middle| \mathcal{F}_{(j-1)\Delta}^X \right] \right]$$
$$- \sum_{j=1}^{n} \tilde{E}\left[e^{-\int_0^{j\Delta} \left\{ \lambda_s^D + \lambda_s^R \right\} ds} \right].$$

In the first term, we have

$$\begin{aligned} &\tilde{E}\left[e^{-\int_0^{(j-1)\Delta} \left\{ \lambda_s^D + \lambda_s^R \right\} ds} \tilde{E}\left[e^{-\int_{(j-1)\Delta}^{j\Delta} \lambda_s^D ds} \middle| \mathcal{F}_{(j-1)\Delta}^X \right] \right] \\ &= \tilde{E}\left[e^{-\int_0^{(j-1)\Delta} (1+m) \lambda_s^D ds} e^{\alpha_2((j-1)\Delta; j\Delta) + \beta_2((j-1)\Delta; j\Delta) \lambda_{(j-1)\Delta}^D} \right] \\ &= e^{\alpha_2((j-1)\Delta; j\Delta)} \tilde{E}\left[e^{\beta_2((j-1)\Delta; j\Delta) \lambda_{(j-1)\Delta}^D} e^{-\int_0^{(j-1)\Delta} (1+m) \lambda_s^D ds} \right] \\ &= e^{\alpha_2((j-1)\Delta; j\Delta)} e^{\alpha_3(0; (j-1)\Delta, j\Delta) + \beta_3(0; (j-1)\Delta, j\Delta) \lambda_0^D}, \end{aligned} \tag{C.9}$$

where

$$\tilde{E}\left[e^{-\int_{(j-1)\Delta}^{j\Delta} \lambda_s^D ds} \middle| \mathcal{F}_{(j-1)\Delta}^X \right] = e^{\alpha_2((j-1)\Delta; j\Delta) + \beta_2((j-1)\Delta; j\Delta) \lambda_{(j-1)\Delta}^D}.$$

It should be noted that $\alpha_3\left(0; (j-1)\Delta, j\Delta\right)$ and $\beta_3\left(0; (j-1)\Delta, j\Delta\right)$ depend also on $j\Delta$.

We now show that we also have a closed-form approximation for the third form. It can be written as

$$\tilde{E}\left[1_{\{\tau^R \leq T\}} e^{-k\left(T-\tau^R\right)} e^{-\int_0^T \lambda_s^D ds} \right]$$
$$= \tilde{E}\left[\tilde{E}\left[1_{\{\tau^R \leq T\}} e^{-k\left(T-\tau^R\right)} e^{-\int_0^T \lambda_s^D ds} \middle| \mathcal{F}^X \right] \right]$$
$$= \tilde{E}\left[e^{-\int_0^T \lambda_s^D ds} \tilde{E}\left[1_{\{\tau^R \leq T\}} e^{-k\left(T-\tau^R\right)} \middle| \mathcal{F}^X \right] \right].$$

If we assume that credit event happens only at time $\Delta, 2\Delta, \cdots, n\Delta\,(=T)$, it can be approximated as

$$
\begin{aligned}
&\tilde{E}\left[e^{-\int_0^T \lambda_s^D ds} \sum_{j=1}^{n} \tilde{E}\left[1_{\{(j-1)\Delta<\tau^R\leq j\Delta\}} e^{-k\left(T-\tau^R\right)} \middle| \mathcal{F}^X\right]\right] \\
=&\tilde{E}\left[e^{-\int_0^T \lambda_s^D ds} \sum_{j=1}^{n} e^{-k(T-j\Delta)} \tilde{E}\left[1_{\{(j-1)\Delta<\tau^R\leq j\Delta\}} \middle| \mathcal{F}^X\right]\right] \\
=&\tilde{E}\left[e^{-\int_0^T \lambda_s^D ds} \sum_{j=1}^{n} e^{-k(T-j\Delta)} \left(e^{-\int_0^{(j-1)\Delta} \lambda_s^R ds} - e^{-\int_0^{j\Delta} \lambda_s^R ds}\right)\right] \\
=&\sum_{j=1}^{n} e^{-k(T-j\Delta)} \tilde{E}\left[e^{-\int_0^{(j-1)\Delta}\left\{\lambda_s^D+\lambda_s^R\right\}ds} \tilde{E}\left[e^{-\int_{(j-1)\Delta}^{T} \lambda_s^D ds} \middle| \mathcal{F}^X_{(j-1)\Delta}\right]\right] \\
&-\sum_{j=1}^{n} e^{-k(T-j\Delta)} \tilde{E}\left[e^{-\int_0^{j\Delta}\left\{\lambda_s^D+\lambda_s^R\right\}ds} \tilde{E}\left[e^{-\int_{j\Delta}^{T} \lambda_s^D ds} \middle| \mathcal{F}^X_{j\Delta}\right]\right].
\end{aligned}
$$

The expectations in the last equation are readily available in closed-form approximation from (C.9).

D Additional Tables and Background Statistics

Table 9: Number of identified tickers in each industry for U.S. and non-U.S. firms.

FISD Industry Code	Number of Tickers		
	U.S.	Non-U.S.	Total
Industrial			
10 Manufacturing	307	118	425
11 Media/Communications	76	48	124
12 Oil & Gas	53	34	87
13 Railroad	2	1	3
14 Retail	47	20	67
15 Service/Leisure	74	12	86
16 Transportation	16	11	27
32 Telephone	10	10	20
Finance			
20 Banking	52	146	198
21 Credit/Financing	32	16	48
22 Financial Services	41	26	67
23 Insurance	55	18	73
24 Real Estate	53	4	57
25 Savings & Loan	2	3	5
26 Leasing	4	0	4
Utility			
30 Electric	81	29	110
31 Gas	15	3	18
33 Water	0	6	6
Government			
40 Foreign Agencies	0	14	14
41 Foreign	0	9	9
42 Supranational	3	3	6
43 U.S. Treasuries	0	0	0
44 U.S. Agencies	6	0	6
45 Taxable Municipal	0	0	0
Miscellaneous			
60 Miscellaneous	0	0	0
99 Unassigned	0	1	1
Index	-	-	60
Unverified	-	-	1260
Total	929	532	2781

Table 10: Restructuring Premium: Summary Statistics

Restructuring Premium of FR over NR

Variable	N	Mean	StdDev	Max	P99	Q3	Med	Q1	P1	Min
RP1Y	9,819	5.89	63.27	1465.33	102.50	8.50	2.56	-1.03	-54.35	-3356.00
RP3Y	17,046	5.72	93.00	1429.63	83.54	7.67	3.13	0.49	-25.10	-7170.33
RP5Y	19,719	6.89	64.99	1641.67	70.31	7.75	3.86	1.70	-19.25	-5080.50
RP7Y	16,538	7.65	39.70	1760.18	58.15	8.67	4.54	1.86	-14.50	-1277.90
RP10Y	13,534	8.18	58.84	1856.02	63.18	10.57	5.34	1.75	-18.63	-3193.70
RRP1Y	9,819	10.03	28.07	497.53	120.92	19.26	8.22	-3.57	-43.06	-72.20
RRP3Y	17,046	9.20	16.64	792.62	51.11	15.03	8.31	1.51	-18.26	-46.90
RRP5Y	19,719	8.43	8.81	212.50	32.54	12.21	7.95	4.02	-11.37	-48.90
RRP7Y	16,538	8.85	9.77	166.97	41.03	12.74	7.93	3.73	-12.07	-50.61
RRP10Y	13,534	8.69	12.30	252.24	52.56	13.05	7.56	2.86	-17.11	-49.38

Restructuring Premium of MR over NR

Variable	N	Mean	StdDev	Max	P99	Q3	Med	Q1	P1	Min
RP1Y	27,209	1.72	46.45	3813.34	74.35	4.50	1.19	-2.54	-62.00	-1658.44
RP3Y	52,460	3.16	31.67	1773.00	55.26	5.13	2.20	0.30	-45.18	-1604.66
RP5Y	56,952	3.78	33.86	2343.18	47.50	5.06	2.66	1.12	-34.68	-1898.73
RP7Y	46,978	3.97	34.02	4470.15	42.15	4.75	2.38	0.67	-20.97	-1065.70
RP10Y	45,558	4.12	33.76	2750.03	46.30	5.93	2.66	0.37	-31.85	-951.45
RRP1Y	27,209	4.34	23.92	468.29	89.77	12.40	4.01	-6.81	-47.02	-96.01
RRP3Y	52,460	5.90	11.64	262.31	44.16	10.47	5.70	0.78	-23.30	-94.87
RRP5Y	56,952	5.69	8.91	194.65	37.78	7.91	5.19	2.42	-16.21	-93.56
RRP7Y	46,978	4.86	9.76	249.30	37.39	6.93	4.07	1.26	-14.96	-93.20
RRP10Y	45,558	4.68	10.99	357.09	47.90	7.07	3.93	0.55	-18.55	-92.89

Restructuring Premium of FR over MR

Variable	N	Mean	StdDev	Max	P99	Q3	Med	Q1	P1	Min
RP1Y	15,322	3.86	70.34	1923.82	105.70	6.53	1.30	-2.28	-78.34	-3058.68
RP3Y	24,752	3.37	47.80	2672.97	72.06	4.27	0.97	-1.45	-46.52	-1691.49
RP5Y	27,355	3.95	54.49	2964.89	55.90	3.51	1.14	-0.45	-25.99	-3088.89
RP7Y	22,944	4.42	53.72	3219.04	57.28	5.40	2.07	-0.21	-24.26	-3088.89
RP10Y	18,784	3.61	58.31	3322.50	50.92	6.80	2.26	-1.30	-34.73	-3088.89
RRP1Y	15,322	9.64	44.29	966.18	139.98	17.71	4.12	-7.67	-47.44	-78.74
RRP3Y	24,752	4.36	20.13	528.63	62.65	9.21	2.59	-3.75	-25.60	-75.66
RRP5Y	27,355	3.72	14.30	334.21	49.97	6.26	2.35	-0.92	-19.52	-71.79
RRP7Y	22,944	4.95	13.86	246.94	58.01	8.04	3.67	-0.36	-20.70	-80.65
RRP10Y	18,784	4.48	15.63	449.46	59.75	8.58	3.30	-1.86	-26.61	-73.90

Table 11: Description of firm-specific, accounting, and macro-economic explanatory variables for restructuring risk premia.

Variables	Expected Effect	Description	COMPUSTAT Item Number
CDSrate	pos	Base CDS rate	
SG	neg	SG dummy	
Gov5yr	neg	5-year Treasury rate	
Baa	pos	Moody's seasoned Baa corporate bond yield	
EBITDA/TtlDebt	pos	Operating income / Total liabilities	D21, D54
StockRet20days	pos	Average stock return over past 20 business days	
log(sales)	?	log of total sales; proxies firm size	D2
log(no employee)	neg	log of Number of employees	AD29
SubDebt/TtlDebt	pos	Subordinated debt / Total liabilities	AD80, D54
SecDebt/TtlDebt	neg	Secured debt / Total liabilities	AD241, D54
AuditorOp	pos	Auditor's opinion dummy; 1 if "unqualified opinion", 0 otherwise.	AD149
Intangible/TtlAsset	pos	Intangible / Total assets	AD33, D44
Collateral/TtlAsset	neg	(Total net property, plant and equipment + Inventory) / Total assets	D42, D38, D44
Deliverable	pos	(LT debt - Debt maturing in 2 to 5 years) / LTdebt	AD91-94, D54

Table 12: Regression of CDS Rate on Leverage (Lev).

Variable	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	-48.451	3.247	-53.821	3.333	-214.162	6.377	-177.390	35.116
MR	8.631	3.244						
FR	17.903	3.244						
NR01			81.293	5.792	88.053	5.642	-48.066	8.617
MR01			98.735	5.792	105.496	5.642	-30.623	8.617
FR01			116.851	5.792	123.611	5.642	-12.508	8.617
MR03			6.569	3.551	6.569	3.450	6.569	3.376
FR03			13.772	3.551	13.772	3.450	13.772	3.376
IND1					146.599	5.181	90.057	5.659
IND2					136.131	4.928	86.180	5.285
IND3					209.260	5.475	166.148	5.696
T1					-12.608	4.401	-12.219	4.309
T3					2.936	3.687	2.261	3.609
T7					7.932	3.660	11.900	3.587
T10					16.349	3.886	19.594	3.807
Lev	436.316	6.499	407.911	6.488	454.634	6.638	493.171	6.890
Size							-32.147	1.420
Level							-0.852	0.084
Slope							-0.306	0.161
Baa							0.648	0.082
Spread							2.094	0.159
Obs.	25266		25266		25266		25266	
R^2	0.152		0.177		0.223		0.256	
adj R^2	0.152		0.177		0.223		0.256	

Table 13: Regression of CDS Rate on Merton Default Probability (MDP).

Variable	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	57.470	1.917	49.267	2.089	2.718	4.467	-177.973	29.553
MR	8.631	2.665						
FR	17.903	2.665						
NR01			50.445	4.786	55.619	4.737	-60.350	7.280
MR01			67.887	4.786	73.061	4.737	-42.908	7.280
FR01			86.003	4.786	91.177	4.737	-24.792	7.280
MR03			6.569	2.932	6.569	2.891	6.569	2.852
FR03			13.772	2.932	13.772	2.891	13.772	2.852
IND1					48.421	4.203	44.099	4.769
IND2					26.246	3.937	22.129	4.428
IND3					98.126	4.518	93.282	4.819
T1					-3.560	3.686	-2.258	3.638
T3					6.369	3.089	6.260	3.047
T7					8.290	3.067	10.568	3.029
T10					13.853	3.255	12.914	3.214
MDP	0.379	0.003	0.368	0.003	0.362	0.003	0.363	0.003
Size							-1.684	1.138
Level							0.294	0.072
Slope							0.204	0.136
Baa							-0.080	0.069
Spread							2.767	0.135
Obs.	25266		25266		25266		25266	
R^2	0.428		0.439		0.455		0.470	
adj R^2	0.428		0.439		0.454		0.469	

Table 14: Regression of CDS Rate on Distance to Default (DD).

Variable	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	1049.376	5.909	1045.541	6.180	934.285	6.718	1282.206	27.764
MR	8.631	2.378						
FR	17.903	2.378						
NR01			-1.627	4.396	3.528	4.243	-70.194	6.354
MR01			15.815	4.396	20.971	4.243	-52.752	6.354
FR01			33.931	4.396	39.086	4.243	-34.636	6.354
MR03			6.569	2.640	6.569	2.543	6.569	2.483
FR03			13.772	2.640	13.772	2.543	13.772	2.483
IND1					122.343	3.719	81.347	4.171
IND2					115.944	3.518	82.545	3.873
IND3					173.073	3.996	140.239	4.205
T1					-18.771	3.247	-18.404	3.173
T3					0.347	2.718	-0.738	2.655
T7					10.552	2.701	12.828	2.641
T10					11.904	2.870	11.488	2.805
DD	-445.985	3.189	-444.991	3.200	-443.209	3.116	-446.207	3.062
DD^2	60.703	0.546	60.688	0.545	59.530	0.533	59.052	0.522
DD^3	-2.553	0.028	-2.555	0.028	-2.471	0.027	-2.433	0.027
Size							-18.908	1.002
Level							1.118	0.065
Slope							0.710	0.119
Baa							-0.999	0.063
Spread							3.148	0.119
Obs.	25266		25266		25266		25266	
R^2	0.545		0.545		0.578		0.598	
adj R^2	0.545		0.545		0.578		0.597	

Table 15: Regression of Logarithm of CDS Rate.

Variable	**Leverage** Parameter Estimate	Standard Error	**Merton Default Prob** Parameter Estimate	Standard Error	**Distance to Default** Parameter Estimate	Standard Error
Intercept	3.9864	0.1184	3.5491	0.1163	9.8921	0.0894
NR01	-0.0571	0.0291	-0.0840	0.0287	-0.2535	0.0205
MR01	0.0336	0.0291	0.0067	0.0287	-0.1628	0.0205
FR01	0.1111	0.0291	0.0842	0.0287	-0.0854	0.0205
MR03	0.0790	0.0114	0.0790	0.0112	0.0790	0.0080
FR03	0.1585	0.0114	0.1585	0.0112	0.1585	0.0080
IND1	0.5811	0.0191	0.3934	0.0188	0.4059	0.0134
IND2	0.3125	0.0178	0.0376	0.0174	0.3061	0.0125
IND3	0.6429	0.0192	0.3813	0.0190	0.5467	0.0135
T1	-0.2817	0.0145	-0.2376	0.0143	-0.3293	0.0102
T3	-0.0743	0.0122	-0.0521	0.0120	-0.0917	0.0086
T7	0.0556	0.0121	0.0424	0.0119	0.0931	0.0085
T10	0.1518	0.0128	0.1175	0.0127	0.1736	0.0090
Lev	2.2968	0.0232				
MDP			0.0011	0.0000		
DD					-1.0496	0.0099
DD^2					0.1009	0.0017
DD^3					-0.0035	0.0001
Size	-0.1848	0.0048	-0.0405	0.0045	-0.1295	0.0032
Level	-0.0013	0.0003	0.0015	0.0003	0.0094	0.0002
Slope	-0.0011	0.0005	-0.0003	0.0005	0.0047	0.0004
Baa	0.0008	0.0003	-0.0004	0.0003	-0.0088	0.0002
Spread	0.0110	0.0005	0.0123	0.0005	0.0200	0.0004
Obs.	25266		25266		25266	
R^2	0.413		0.429		0.711	
adj R^2	0.412		0.429		0.710	

Table 16: Regression of (CDS Rate)/(Loss Rate) on Distance to Default (DD).

Variable	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	1488.280	8.555	1470.177	8.956	1314.763	9.729	1772.034	40.165
MR	21.467	3.432						
FR	19.184	3.488						
NR01			13.679	6.381	20.531	6.157	-108.451	9.260
MR01			58.996	6.264	66.941	6.046	-62.728	9.193
FR01			57.208	6.299	65.410	6.079	-63.455	9.192
MR03			15.796	3.812	16.194	3.670	15.038	3.571
FR03			13.098	3.886	14.721	3.741	15.171	3.640
IND1					181.409	5.343	121.473	5.961
IND2					167.509	5.065	119.123	5.548
IND3					240.199	5.760	191.827	6.041
T1					-33.444	4.660	-32.930	4.536
T3					-2.829	3.960	-3.607	3.853
T7					13.219	3.927	16.940	3.824
T10					16.701	4.157	15.662	4.046
DD	-611.549	4.608	-607.728	4.620	-607.881	4.494	-611.308	4.398
DD^2	81.495	0.789	81.411	0.787	80.262	0.768	79.527	0.750
DD^3	-3.378	0.040	-3.385	0.040	-3.291	0.039	-3.237	0.038
Size							-27.808	1.438
Level							1.555	0.094
Slope							0.730	0.173
Baa							-1.245	0.090
Spread							4.595	0.170
Obs.	23910		23910		23910		23910	
R^2	0.550		0.552		0.585		0.607	
adj R^2	0.550		0.552		0.584		0.607	

Table 17: Regression of Logarithm of (CDS Rate)/(Loss Rate) on Distance to Default (DD).

Variable	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	7.2970	0.0223	7.2413	0.0233	6.7678	0.0239	9.9753	0.0924
MR	0.1039	0.0089						
FR	0.1009	0.0091						
NR01			0.0751	0.0166	0.1082	0.0151	-0.2287	0.0213
MR01			0.1976	0.0163	0.2348	0.0148	-0.1045	0.0211
FR01			0.1919	0.0164	0.2293	0.0149	-0.1078	0.0211
MR03			0.0995	0.0099	0.1012	0.0090	0.0957	0.0082
FR03			0.0966	0.0101	0.1030	0.0092	0.1058	0.0084
IND1					0.6651	0.0131	0.3797	0.0137
IND2					0.5015	0.0124	0.2752	0.0128
IND3					0.7390	0.0141	0.5085	0.0139
T1					-0.3211	0.0114	-0.3234	0.0104
T3					-0.0853	0.0097	-0.0909	0.0089
T7					0.0770	0.0096	0.0890	0.0088
T10					0.1755	0.0102	0.1706	0.0093
DD	-0.9712	0.0120	-0.9609	0.0120	-0.9659	0.0110	-0.9966	0.0101
DD^2	0.1002	0.0021	0.1000	0.0021	0.0964	0.0019	0.0938	0.0017
DD^3	-0.0037	0.0001	-0.0037	0.0001	-0.0034	0.0001	-0.0032	0.0001
Size							-0.1322	0.0033
Level							0.0087	0.0002
Slope							0.0041	0.0004
Baa							-0.0077	0.0002
Spread							0.0181	0.0004
Obs.	23910		23910		23910		23910	
R^2	0.565		0.567		0.643		0.704	
adj R^2	0.565		0.567		0.643		0.703	

Table 18: Regression of Loss Rate on Distance to Default (DD).

Variable	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	67.450	0.110	68.082	0.113	66.740	0.125	74.630	0.505
MR	-0.534	0.044						
FR	2.939	0.045						
NR01			-0.402	0.080	-0.336	0.079	1.004	0.116
MR01			-2.640	0.079	-2.566	0.078	-1.224	0.116
FR01			2.338	0.079	2.415	0.078	3.764	0.116
MR03			-0.130	0.048	-0.123	0.047	-0.146	0.045
FR03			2.988	0.049	3.003	0.048	3.023	0.046
IND1					1.234	0.069	0.942	0.075
IND2					1.166	0.065	0.946	0.070
IND3					2.046	0.074	1.721	0.076
T1					0.259	0.060	0.160	0.057
T3					0.124	0.051	0.080	0.048
T7					0.170	0.051	0.103	0.048
T10					0.172	0.054	0.169	0.051
DD	-3.890	0.059	-4.026	0.058	-3.984	0.058	-3.991	0.055
DD^2	0.591	0.010	0.593	0.010	0.579	0.010	0.558	0.009
DD^3	-0.026	0.001	-0.026	0.001	-0.025	0.001	-0.024	0.000
Size							-0.112	0.018
Level							0.025	0.001
Slope							0.067	0.002
Baa							-0.047	0.001
Spread							0.069	0.002
Obs.	23910		23910		23910		23910	
R^2	0.332		0.361		0.381		0.441	
adj R^2	0.332		0.360		0.381		0.441	

Table 19: The number of initial credit events of Moody's rated bonds in US from 2000 to 2004. The table is constructed from the Moody's annual and monthly surveys of global corporate defaults and recovery rates from 2000 to 2004. m is calculated as the number of distressed exchange divided by the number of other events.

Year	Failure to Pay	Bankruptcy	Distressed Exchange	Total	m
2000	83	40	2	125	0.016
2001	91	44	7	142	0.052
2002	55	22	11	88	0.143
2003	28	22	8	58	0.160
2004	17	8	5	30	0.200
2000-2004	274	136	33	443	0.080
2003-2004	45	30	13	88	0.173

Table 20: The number of initial credit events of Moody's rated bonds in North America from 1983 to 2003 and the corresponding mean recovery rate, reported in Varma and Cantor (2005). For distressed exchange, the recovery rate is the bond prices two weeks prior to the exchange as percent of face value. For the other events, the recovery rate is based on the 30-day post-default bid prices as percent of face value.

Initial Default Event	Observations	Recovery Rate
Distressed Exchange	86	52.8
Missed Interest Payment	584	33.7
Missed Principal	20	54.2
Grace Period Default	30	51.5
Prepackaged Chapter 11	12	37.7
Chapter 11	338	44.1
Chapter 7	14	16.4
All Defaults	1084	

Table 21: Parameters m, n, and $\bar{\delta}^D$ for high yield bonds during 2001 to 2003. Constructed from FitchRatings (2004).

Year	m	n	$\bar{\delta}^D$
2001	0.03	1.48	0.29
2002	0.05	2.41	0.20
2003	0.11	1.82	0.38
2001-2003	0.05	2.06	0.26

References

Aunon-Nerin, D., D. Cossin, T. Hricko, and Z. Huang, 2002, Exploring for the determinants of credit risk in credit default swap transaction data: Is fixed-income markets' information sufficient to evaluate credit risk?, FAME Research Paper No. 65. http://ssrn.com/abstract=375563.

Benkert, C., 2004, Explaining credit default swap premia, *Journal of Futures Markets* 24, 71–92.

Berndt, A., R. Douglas, D. Duffie, M. Ferguson, and D. Schranz, 2005, Measuring default risk premia from default swap rates and EDFs, Working paper, Carnegie Mellon University.

Bomfim, A. N., 2005, *Understanding Credit Derivatives and Related Instruments* (Elsevier Academic Press).

Chatterjee, S., U. S. Dhillon, and G. G. Ramirez, 1996, Resolution of financial distress: Debt restructuring via Chapter 11, prepackaged bankruptcies, and workouts, *Financial Management* 25, 5–18.

Chava, S., and R. A. Jarrow, 2004, Bankruptcy prediction with industry effects, *Review of Finance* 8, 537–569.

Chen, Nan, 2003, An empirical study of a firm's debt restructuring choices: Chapter 11 vs. workouts, Working Paper, Columbia University.

Chen, R., and L. Scott, 1993, Maximum likelihood estimation for a multifactor equilibrium model of the term structure of interest rates, *Journal of Fixed Income* pp. 14–31.

Cheridito, P., D. Filipović, and R. L. Kimmel, 2004, Market price of risk specifications for affine models: Theory and evidence, Working Paper, Princeton University.

Collin-Dufresne, P., R. Goldstein, and J. Hugonnier, 2004, A general formula for valuing defaultable securities, *Econometrica* 72, 1377–1407.

Collin-Dufresne, P., R. Goldstein, and S. Martin, 2001, The determinants of credit spread changes, *Journal of Finance* 56, 2177–2207.

Dai, Q., and K. J. Singleton, 2000, Specification analysis of affine term structure models, *Journal of Finance* 55, 1943–1978.

Delbaen, F., and W. Schachermayer, 1999, A general version of the fundamental theorem of asset pricing, *Mathematische Annalen* 300, 463-520.

Duffee, G. R., 1998, The relation between treasury yields and corporate bond yield spreads, *Journal of Finance* 53, 2225–2241.

Duffie, D., 1999, Credit swap valuation, *Financial Analysts Journal* pp. 73–87.

——— , and D. Lando, 2001, Term structures of credit spreads with incomplete accounting information, *Econometrica* 69, 633–664.

Duffie, D., J. Pan, and K. J. Singleton, 2000, Transform analysis and asset pricing for affine jump-diffusions, *Econometrica* 68, 1343–1376.

Duffie, D., L. Saita, and K. Wang, 2005, Multi-period corporate default prediction with stochastic covariates, Working Paper, Stanford University.

Duffie, D., and K. J. Singleton, 1999, Modeling term structures of defaultable bonds, *Review of Financial Studies* 12, 687–720.

Elton, E. J., M. J. Gruber, D. Agrawal, and C. Mann, 2001, Explaining the rate spread on corporate bonds, *Journal of Finance* 56, 247–277.

Ericsson, E. K., Jacob, and R. Oviedo-Hlfenberger, 2004, The determinants of credit default swap premia, Working Paper, McGill University.

FitchRatings, 2003, Fitch examines the effect of 2003 credit derivatives definitions, FitchRatings Credit Products Special Report, www.fitchratings.com.

——— , 2004, High yield credit default swaps: Restructuring as a credit event - A closer look, FitchRatings Special Report, www.fitchratings.com.

Harrison, M., and D. Kreps, 1979, Martingales and arbitrage in multiperiod securities markets, *Journal of Economic Theory* 20, 381-408.

Hull, J., and A. White, 2000, Valuing credit default swaps I: No counterparty default risk, *Journal of Derivatives* 8, 29–40.

James, J., and N. Webber, 2000, *Interest Rate Modelling* (Wiley).

Jarrow, R. A., and S. M. Turnbull, 1995, Pricing derivatives on financial securities subject to credit risk, *Journal of Finance* 50, 53–85.

Jarrow, R. A., and Y. Yildirim, 2002, A simple model for valuing default swaps when both market and credit risk are correlated, *Journal of Fixed Income* pp. 7–19.

Jarrow, R. A., and F. Yu, 2001, Counterparty risk and the pricing of defaultable securities, *Journal of Finance* 56, 1765–1799.

John, K., 1993, Managing financial distress and valuing distressed securities: A survey and a research agenda, *Financial Management* pp. 60–78.

Keenan, S., D. Hamilton, I. Shtogrin, F. Zarin, and P. Stumpp, 2000, Moody's approach to evaluating distressed exchanges, Special Comment, Moody's Investors Service.

Lando, D., 1998, On Cox processes and credit risky securities, *Review of Derivatives Research* 2, 99–120.

Merton, R., 1974, On the pricing of corporate debt: The risk structure of interest rates, *Journal of Finance* 29, 449–470.

Morris, C., R. Neal, and D. Rolph, 1998, Credit spreads and interest rates: A cointegration approach, Working Paper, Federal Reserve Bank of Kansas City.

Packer, F., and H. Zhu, 2005, Contractual terms and CDS pricing, *BIS Quarterly Review* pp. 89–100.

Protter, P., 2004, *Stochastic Integration and Differential Equations* (Springer Verlag) second edn.

Ross, S. A., R. W. Westerfield, and J. Jaffe, 1996, *Corporate Finance* (Irwin: USA) fourth edn.

Varma, P., and R. Cantor, 2005, Determinants of recovery rates on defaulted bonds and loans for north american corpporate issuers: 1983-2003, *Journal of Fixed Income* 14, 29–44.

Vassalou, M., and Y. Xing, 2004, Default risk in equity returns, *Journal of Finance* 59, 831–868.

Yu, F., 2002, Modeling expected return on defaultable bonds, *Journal of Fixed Income* 12, 69–81.