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Rollover risk and credit spreads in the financial crisis of 2008

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Abstract

This paper investigates the asset pricing implications of rollover risk, i.e., the risk that firms might not be able to refinance their due liabilities. I find that firm-specific rollover risk coupled with deteriorating credit market conditions significantly increase firms' credit spreads. During the 2008−2009 financial crisis period, the one-year CDS spreads for high rollover risk firms are 32−72 basis points higher than the spreads of low rollover risk firms. Longer maturity CDS spreads show similar patterns with smaller magnitudes. During normal periods, however, CDS spreads are mostly explained by fundamental variables and rollover risk is not a significant determinant. Similar rollover risk effect is also observed in other financial markets, including corporate bond, stock, and options markets.

Keywords: Rollover risk; Credit spreads; Financial crisis

1. Introduction

Rollover risk refers to the risk that firms may not be able to refinance their due liabilities. Depending on firms own debt maturity choices, their maturing liabilities consist of both short-term debt and the expiring portion of long-term debt. Firms that rely heavily on short-term debt to fund their illiquid long-term assets, such as financial institutions, are particularly vulnerable to credit market conditions due to their needs to regularly tap the credit market for external financing. Similarly, firms that happen to have a significant portion of their long-term obligations coming due during credit crunch are also adversely affected by the diminishing supply of credit. The recent 2008 financial crisis represents such an episode of credit shortage.[2]

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[2] In the U.S. long-term corporate bond markets, the investment grade issuance slid approximately one third from $991 billion in 2007 to $664 billion in 2008, while the high yield issuance dropped approximately two thirds from $146 billion in 2007 to $46 billion in 2008. These issuance numbers include all non-convertible corporate debt, MTNs, and Yankee bonds, but excludes CDs and issues with maturities of one year or less. Data source: Thomson Reuters.

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Despite anecdotal evidences that refinancing needs might be a potential default trigger, the asset pricing implication of rollover risk remains an empirical question. In this paper, I investigate the impact of rollover risk on asset prices by exploring several financial markets. To measure rollover risk, I focus on the long-term debt and use the proportion of long term debt falling due within the year to measure firms' refinancing needs. The main reason is that firms' debt maturity choices, short-term versus long-term debt, have been shown in the literature to be endogenous decisions related to various firm characteristics such as size and ratings.[3] It is therefore difficult to draw clear conclusions from the empirical relations between firms' short-term debt position and their credit spreads.

On the other hand, the maturing portion of a firm's long-term debt is mainly determined by past cumulative and non-reversible managerial decisions on its debt maturity structure and repayment schedules. It is reasonable to assume that long-term debt refinancing needs only reflect a firm's rollover risk and are not directly related to its current credit risk profiles. Moreover, as the past 2008 financial crisis was largely unexpected, firms unlikely could foresee the credit crunch ex-ante and change their long-term debt maturity structure accordingly before the crisis. Long-term debt is also commonly held by various investors and hard to renegotiate on the spot, making it difficult for firms to adjust their long-term debt refinancing positions as the crisis unfolds. Overall, the maturing portion of long-term debt provides a relatively clean identification of firms' rollover risk during both normal and crisis periods.

I start my analysis from the credit default swaps (CDS) market, where CDS spreads are usually considered as clean measures of firms' default risk. I find that rollover risk substantially increases firms' CDS spreads during the financial crisis period. I define high rollover risk firms as those that need to refinance more than 20% of their long-term debt in the year of 2008. I then choose matching low rollover risk firms that are similar to the high rollover risk firms in terms of their credit qualities before 2008, except that they don't need to refinance substantial long-term debt in 2008. The one-year CDS spreads for both groups are close to each other until the early fall of 2007. After that, the spreads of the high rollover firms rise much faster than the matched low rollover risk firms. The difference in the average CDS spreads between the two groups reaches the first peak, at approximately 150 basis points, following the collapse of Bear Stearns in March 2008; remains stable until September 2008 when Lehman Brothers filed for bankruptcy; and eventually reaches its all-time high around March 2009.

Motivated by the above observations, I formally investigate the impact of rollover risk on credit spreads in a regression framework by analyzing a large panel of data from 2004 to 2009. Consistent with the results based on matched samples, I find that CDS spreads for high rollover risk firms are significantly higher during the financial crisis period, after controlling a variety of firm characteristics such as volatility, leverage, credit rating, firm and month fixed effects. This rollover risk effect on CDS spreads is the strongest during the peak period of the financial crisis (72 bps for one-year CDS spreads), and is less striking at the early and final stages of the crisis (32 bps for one-year CDS spreads).

In contrast to its large impact on CDS spreads during the crisis period, rollover risk is not a significant determinant of CDS spreads during normal periods. Instead, CDS spreads are mostly determined by fundamental variables such as rating, volatility, leverage, past return, and etc. Unlike the crisis period, credit is abundant during normal times and firms usually could refinance expiring long-term debt by issuing new debt. In other words, rollover risk mainly captures firms' short-term liquidity stress rather than their long-term fundamental solvency. Liquidity stress here refers to firms' ability to meet their immediate payment obligations, in contrast to the solvency risk which refer to the risk of default due to poor performance of firms' fundamental assets.[4]

Similar rollover risk effect also exists in the corporate bond market. I construct short-, medium-, and long-maturity bond spreads for every firm in my sample based on bond transaction prices obtained from the TRACE database. Although the relation between rollover risk and bond spreads are slightly weaker, it is largely in line with the results based on CDS spreads. For example, the short-maturity one-year bond spreads for high rollover risk firms are on average 25 bps higher than the spreads of low rollover risk firms during the second half year of 2008. Compared with the impact on CDS spreads, the magnitude is indeed smaller but remains statistically significant and economically important. Given that bond spreads are widely known as "noisy" measures of default risk, the overall consistent results confirm that rollover risk is an important determinant of credit spreads.

[3] See Refs.[19–21]

[4] It's worth noting that the "liquidity" stress discussed here is different from market liquidity, which usually refers to an asset's ability to be traded in a market without causing a significant movement in the price and with minimum loss of value.

I also investigate the impact of rollover risk in other asset markets. Theoretically, both equity and bonds are claims on the same underlying asset. Equity prices, similar to bond prices, could also reflect the underlying firms' default risk. In addition, certain type of options could offer similar downside risk protection as credit default swaps. To capture the credit risk information conveyed in stocks and options and most importantly put them on the same footing with the CDS and bond spreads, I calculate synthetic CDS spreads for every firm in my sample based on the simple Merton structural model. This approach also allows me to cover a much broader range of firms and substantially extend my sample size.

The key input of the synthetic CDS spreads calculation, aside from several balance sheet variables, is equity volatility. I consider two volatility candidates: the realized volatility (RV) estimated from historical stock returns and the implied volatility (IV) derived from option prices. Both volatility and synthetic CDS spreads increase more for firms that need to refinance a large portion of their long-term debt during the crisis. At the second half year of 2008, high rollover risk firms' average implied volatility is 10.9% higher than low rollover risk firms. Consistent with their higher volatility, high rollover risk firms' synthetic CDS spreads (SCDSIV) are on average 19 bps higher than low rollover risk firms. Realized volatility and synthetic CDS spreads (SCDSRV) show similar patterns. During normal periods, however, neither volatility nor synthetic CDS spreads can be explained by rollover risk. The overall empirical evidences in the stock and options markets are consistent with earlier discussions based on credit spreads.

This paper makes several contributions to the literature. Empirical papers on credit spreads, including[1−4]; usually do not consider rollover risk in their tests. This paper contributes to this part of the literature by first documenting and quantifying the impact of rollover risk on firms' credit spreads. There are only a handful of empirical papers that address the relation between rollover risk and credit risk.[5] argue that rating agencies systematically underestimate rollover risk.[6] find that market illiquidity affects corporate bond spreads through the rollover risk channel. However, both papers use rollover risk measures based on firms' short-term debt positions and need to address potential endogeneity issues. By exploring the maturing portion of long-term debt, our results benefit from a cleaner identification of rollover risk.

Our empirical results highlight the importance of firms' debt maturity structure on credit risk. Standard structure models, such as Refs.[7−10], do not model debt maturity structure directly.[11] extend the structural model in [8] with mixed debt maturities and illiquid bond market, and then show that firms face rollover risk because of the intrinsic conflict of interest between equity and debt holders.[12] propose a dynamic capital structure model with maturity choice. In their model, firms can manage their systematic risk exposures through optimal maturity choice, which then endogenously determine their default risk.

This paper also complements recent studies on rollover risk and financial crisis. Morris and Shin [13] and Morris and Shin [14] analyze rollover risk through coordination failure in short-term creditors.[15] study a dynamic model of panic runs of creditors triggered by fear of a firm's future rollover risk.[16] show that high rollover frequency can diminish debt capacity of risk assets.[17] study the real effect of rollover risk during the 2008 financial crisis period.

The remainder of the paper is organized as follows. Section 2 describes the data and the rollover risk measure. Section 3 discusses the rollover risk effects in the CDS and corporate bond markets. Section 4 investigates the rollover risk effects in the stock and options market. Section 5 concludes.

2. Data and variable construction

2.1. Data

I use several data sources in this paper. For firms' balance sheet information, I merge COMPUSTAT North America Fundamentals Annual, S&P ratings, and the FISD Mergent database. I start from all firms in the Annual files, and delete all ADRs and firms in the regulated industry (SIC code in range 4900 and 4939). I also drop firms with negative or missing values for total assets (at), fiscal year-end price (prcc_f), number of shares outstanding (csho) and debt maturity variables (dd1, dd2, dd3, dd4, dd5, dltt). I exclude firms with total assets below $10 million, and those who file annual report for less than 5 years to avoid biases coming from very small and young firms.

I also apply several filters to remove inconsistent data entries. First, I require that firms' total asset (at) is larger than the sum of current asset (act) and property, plant and equipment (pent). Because COMPUSTAT variables dd1, dd2, dd3, dd4, dd5 and dltt represent the dollar amount of long-term debt payable in the first (second, third, fourth, fifth and beyond first) year, I delete firms with negative debt maturity variables (dd1, dd2, dd3, dd4, dd5 and dltt), with total

Table 1
Cross-section distribution of *RO*, dd1/at, leverage.

Year	#Firms	RO (%)			dd1/at			Leverage		
		10%	Med	90%	10%	Med	90%	10%	Med	90%
2004	418	0.00	2.29	16.16	0.00	0.57	4.50	0.13	0.25	0.51
2005	400	0.00	2.39	17.14	0.00	0.56	3.86	0.13	0.25	0.51
2006	389	0.00	1.87	16.60	0.00	0.44	4.47	0.11	0.24	0.51
2007	357	0.00	1.99	19.02	0.00	0.42	4.70	0.11	0.23	0.48
2008	347	0.00	1.86	15.48	0.00	0.53	4.72	0.13	0.27	0.57
2009	327	0.00	2.49	15.93	0.00	0.58	4.91	0.13	0.28	0.56
KS p-value (2008 vs 2004−2007)				0.52			0.67			0.94
KS p-value (2009 vs 2004−2007)				0.73			0.95			0.19

RO is the ratio between COMPUSTAT item dd1 and item dd1 + dltt. dd1 is the total amount of long-term debt maturing within the year. at is the total assets. Leverage is the long-term book leverage calculated as the ratio between the total long-term debt (dd1 + dltt) and the total book assets (at). The p-values of Kolmogorov−Smirnov goodness of fit tests are reported.

long-term debt (dd1 + dltt) larger than total assets (at), and with the long-term debt maturing in more than one year (dltt) smaller than the sum of long-term debt maturing between 2 and 5 years (dd2 + dd3 + dd4 + dd5). To ensure that firms in my sample are quality firms that can tap the long-term debt market, I require all firms' total assets (at) consist at least 5% long-term debt maturing beyond one year (dltt). In addition, I exclude firms not rated by S&P and firms that don't issue any public bond from 2004 to 2009.

CDS data is obtained from CMA via Datastream. For each firm, I calculate the monthly average of daily CDS spreads quotes from 2004 to 2009. The bond spreads are calculated using bond transaction prices from TRACE. The stock and options data are obtained from CRSP and OptionMetrics.

2.2. Measure long-term debt rollover risk

I use the maturing portion of a firm's total long-term debt to measure its rollover risk (RO). The RO for fiscal year t is calculated as the ratio between the total long-term debt due within one year (dd1) and the total long-term debt (dd1 + dltt), where dd1 and dltt are based on the fiscal year $t-1$ balance sheet information.[5] Table 1 reports the distribution of RO, together with other related long-term debt variables.

The rollover risk measure RO varies substantially across firms. From 2004 to 2009, the first decile of RO is always 0%, the median ranges from 1.86% to 2.49%, and the ninth decile ranges from 15.48% to 19.02%. During the financial crisis period (2008 and 2009), the distributions of RO, along with other long-term debt variables, are similar to the distributions during normal times. This observation suggests that firms didn't actively adapt their long-term debt structure because they unlikely could foresee the financial crisis ex-ante. It is reasonable to conjecture that the credit crunch in the past financial crisis represents an exogenous negative shock to the supply of credit, which significantly increases the refinancing risk for firms that need to rollover a large chunk of their debt.

3. Rollover risk and credit spreads

3.1. Preliminary results based on matching estimators

I start my analysis by first presenting the preliminary results based on the matching estimators approach. I first identify the "treated" group, firms that need to refinance more than 20% of their long-term debt in the year of 2008.[6] I

[5] Long-term debt structure usually is not easy to adjust because they are held by various different in-vestors. However, [22] show that some high credit quality firms actively managed their loan maturity structure and early refinanced their outstanding loans before the financial crisis. This concern has been discussed in Ref.[12], where the authors propose several alternative measures to identify high rollover firms at the fiscal year t: $dd4/(dd1+dltt)$ at the fiscal year $t-4$, $dd3/(dd1+dltt)$ at the fiscal year $t-3$, and $dd2/(dd1+dltt)$ at the fiscal year $t-2$. Using a setup very similar to this paper, they find that the results are almost identical to those based on $dd1/(dd1+dltt)$ at the fiscal year $t-1$.

[6] Existing literature such as Acharya, Davydenko, and Strebulaev [23] also choose 20% as the cutoff for high rollover risk firms. Most of the empirical results in the paper are robust to cutoff values in the range between 15% and 25%.

then find the "control" firms in the non-treated population that best match the "treated" ones in terms of their credit qualities before 2008. The impact of rollover risk on credit spreads are estimated as the average treatment effect for the treated (ATT), by comparing the ex-post credit spreads of the treated and control firms.

To address the heterogeneity in firms' credit qualities, I use a list of variables suggested in the credit risk literature to match firms. These variables include both discrete variables, industry classification and long-term S&P ratings, and continuous variables including long-term debt leverage, equity return, equity volatility, size, and profitability. I employ the bias-corrected, heteroskedasticity-consistent matching estimators proposed in Ref.[18] For every treated firm, the Abadie-Imbens estimator finds a control firm that "exact" matches on the discrete variables and closest on the continuous variables. The procedure includes a component to reduce biases caused by discrepancy in continuous variables. Since the early concerns on the housing market started from the late summer of 2007, it is not clear whether the last quarter of 2007 should be part of the financial crisis period. Thus, I use the average CDS spreads in the first three quarters of 2007 and compared it with the average CDS spreads during the first three quarters of 2008.

The results for the matching estimators are summarized in Table 2. Panel A reports the median values for the matching continuous variables and the CDS spreads at 1-, 5-, and 10- year maturities in 2007 and 2008. Before the crisis, treated and control firms don't display statistically significant differences in their matching variables and CDS spreads, confirming that they have similar credit qualities during the pre-crisis period and only differ in the amount of their upcoming long-term debt liabilities.

The rollover risk effects on credit spreads is reported in the panel B of Table 2. In the first three quarters of 2007, the treated and control firms have similar CDS spreads at various maturities. On average, the CDS term structure for both treated and control firms are upward sloping, with 1-year CDS spreads close to 14 bps and 10-year CDS spreads at approximately 64 bps to 75 bps. In 2008, the CDS spreads for both the treated and control firms hike up, but significantly more for the treated firms. At one-year maturity, the CDS spreads for the treated firms jump to 257 bps compared to 75 bps for the control ones. The difference-in-difference estimator suggests that CDS spreads increase by 181 bps more for the treated firms, relative to the control firms. This increase is statistically significant at the 5% level

Table 2
Comparing treated and control groups in 2007 and 2008.

Panel A: Firm characteristics (median) for the treated and control groups in 2007

	N	Ret	σ^E	Size	Leverage	Profitability	CDS1	CDS5	CDSX
Treated	24	0.234	0.223	10.055	0.260	0.107	8.586	29.358	47.763
Control	24	0.161	0.195	9.627	0.227	0.120	7.750	23.351	35.253
Diff		0.073	0.028	0.428	0.033	−0.014	0.836	6.008	12.510
p-value		0.192	0.122	0.958	0.085	0.217	0.476	0.394	0.170

Panel B: Average CDS spreads from 2007 to 2008

	1-year CDS			5-year CDS			10-year CDS		
	2008	2007	2008−2007	2008	2007	2008−2007	2008	2007	2008−2007
Treated	256.58***	14.01***	242.57***	274.25***	48.70***	225.55***	254.96***	75.12***	179.84***
	(94.44)	(3.26)	(91.83)	(79.12)	(9.84)	(71.06)	(67.50)	(14.70)	(56.23)
Control	75.36***	14.11***	61.26***	133.64***	43.44***	90.21***	141.97***	64.39***	77.58***
	(19.01)	(4.80)	(14.40)	(23.95)	(11.69)	(13.82)	(23.04)	(14.26)	(11.83)
Diff	181.21**	−0.10	181.31**	140.61*	5.26	135.35*	112.99	10.74	102.25*
	(90.52)	(3.80)	(88.49)	(78.74)	(12.60)	(69.82)	(69.05)	(17.14)	(56.35)
ATT			168.76*			128.94**			101.52**
			(94.07)			(63.81)			(47.40)

The treated firms are firms that have more than 20% long-term debt maturing in 2008 and the non-treated firms are firms that have less than or equal to 20% long-term debt maturing in 2008. Control firms are selected from the non-treated firms to best match the treated firms based on a set of firm characteristic variables: industry classification, credit rating, equity return, equity volatility, size, leverage and profitability. Return and volatility are annualized stock return and volatility. Size is the log of total assets (*at*). Leverage is long-term book leverage calculated as the ratio between total long-term debt (*dd*1+*dltt*) and book assets (*at*). Profitability is defined as the earnings before interest (*ebitda*) normalized by total assets (*at*). Panel A reports the median characteristics of the treated and control firms in 2007. The CDS spreads are the average spreads in the first three quarters of 2007. The p-value for the differences of the medians are calculated based on the continuity-correct Pearson's χ^2 statistics. Panel B reports the change in the average CDS spreads from the first three quarters of 2007 to the first three quarters of 2008. ATT is the Abadie-Imbens bias corrected average treated effect matching estimator. Heteroskedasticity-consistent standard errors are reported in the parentheses. *, **, *** indicate statistical significant at the 10%, 5%, and 1% levels, respectively.

Table 3
Comparing treated and control groups in 2005 and 2006.

Panel A: Firm characteristics (median) for the treated and control groups in 2005

	N	Ret	σ^E	Size	Leverage	Profitability	CDS1	CDS5	CDSX
Treated	29	0.099	0.227	9.611	0.193	0.128	12.430	40.425	61.419
Control	29	0.080	0.206	9.352	0.205	0.115	8.032	29.499	50.095
Diff		0.019	0.021	0.258	−0.012	0.013	4.398	10.926	11.324
p-value		0.888	0.056	0.888	0.754	0.773	0.284	0.284	0.184

Panel B: Average CDS spreads from 2005 to 2006

	1-year CDS			5-year CDS			10-year CDS		
	2006	2005	2006−2005	2006	2005	2006−2005	2006	2005	2006−2005
Treated	14.60***	24.98***	−10.37*	56.33***	65.26***	−8.93	80.17***	90.01***	−9.84
	(3.66)	(8.15)	(5.54)	(13.11)	(14.93)	(6.12)	(15.58)	(16.49)	(6.58)
Control	14.28***	19.97***	−5.69**	50.38***	56.45***	−6.07	72.07***	78.08***	−6.01
	(4.55)	(6.15)	(2.41)	(12.79)	(14.32)	(3.74)	(14.45)	(15.73)	(4.37)
Diff	0.32	5.00	−4.68	5.95	8.81	−2.86	8.09	11.93	−3.84
	(3.64)	(7.46)	(4.28)	(11.59)	(14.41)	(5.66)	(13.56)	(15.70)	(6.48)
ATT			−4.21			−2.43			−3.61
			(5.72)			(8.86)			(9.50)

The treated firms are firms that have more than 20% long-term debt maturing in 2006 and the non-treated firms are firms that have less than or equal to 20% long-term debt maturing in 2006. Control firms are selected from the non-treated firms to best match the treated firms based on a set of firm characteristic variables: industry classification, credit rating, equity return, equity volatility, size, leverage and profitability. Return and volatility are annualized stock return and volatility. Size is the log of total assets (*at*). Leverage is long-term book leverage calculated as the ratio between total long-term debt (*dd*1+*dltt*) and book assets (*at*). Profitability is defined as the earnings before interest (*ebitda*) normalized by total assets (*at*). Panel A reports the median characteristics of the treated and control firms in 2005. The CDS spreads are the average daily spreads in 2005. The p-value for the differences of the medians are calculated based on the continuity-correct Pearson's χ^2 statistics. Panel B reports the change in the average CDS spreads from 2005 to 2006. ATT is the Abadie-Imbens bias corrected average treated effect matching estimator. Heteroskedasticity-consistent standard errors are reported in the parentheses.

and is economically large. The bias-correcting Abadie-Imbens estimates (ATT) is slightly lower in terms of magnitudes (169 bps), but is still statistically significant at the 10% level. CDS spreads at 5- and 10-year maturities show similar pattern, although less striking compared with the short-term 1-year CDS spreads. It's also worth noting that the term structure of CDS spreads become much flatter in 2008, especially for the treated firms.

The above results suggest that firms with high rollover risk do have higher credit spreads during the financial crisis period. It's worth noting that one important assumption of the rollover risk measure is that firms with large amount of maturing long-term debt have difficulty to refinance their due liabilities. The overall credit market conditions play a key role for this assumption to work. During normal times when credit is easy to obtain, I expect that firms' rollover risk may not be priced in credit spreads. To test this, I repeat the same matching strategy for year 2006, and define the new treated group as firms that need to refinance more than 20% of their long-term debt in 2006. The results for the matching samples are summarized in Table 3. Indeed, I don't observe the adverse effects of maturing long-term debt on CDS spreads in 2006. Firms in the treated group have similar CDS spreads as those in the control group. The average changes in CDS spreads from 2005 to 2006 are not statistically significant and small economically.[7]

The important role of the credit market condition can also be seen from the time series of the average CDS spreads of the treated and control groups, as shown in Fig. 1. Firms in the treated group are rebalanced each year to capture firms with high rollover risk. At each year-end, I assign firms that need to refinance more than 20% of their long-term debt in the coming year to the treated group. The control firms are chosen in the non-treated population that have similar credit qualities.

As shown in Fig. 1, the average CDS spreads for the treated and control firms are close to each other until the early Fall of 2007. In other words, rollover risk is not reflected in firms' credit spreads during normal periods because the probability of failure to refinance is very small. During crisis, the average CDS spreads for the treated firms rise much faster than the corresponding control firms, and reaches its first peak in March 2008 when Bear Stearns collapsed. Following the bankruptcy of Lehman Brothers in September 2008, the average CDS spreads for both the treated and

[7] The matching results for firms that need to refinance more than 20% of their long-term debt in 2005 and 2007 are similar.

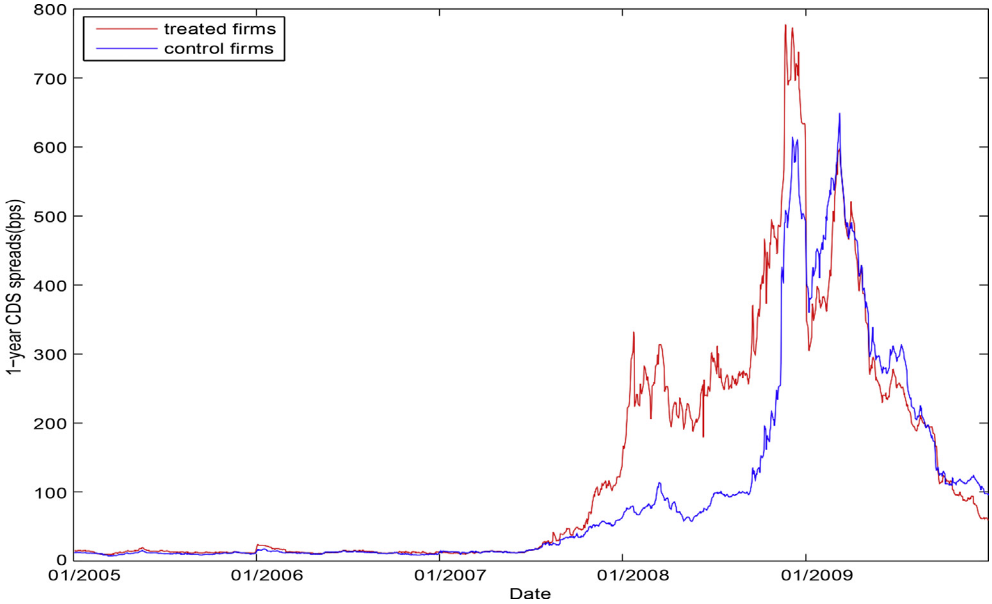

Fig. 1. Average CDS spreads for the yearly-rebalanced treated and control groups. At each year-end, the treated group is rebalanced to select high rollover risk firms that need to refinance more than 20% of their long-term debt in the coming year. The control firms are chosen in the non-treated population that have similar credit qualities.

control firms continue to rise until the end of the year and the treated firms consistently have higher CDS spreads than the control firms. In 2009, the CDS spreads for the treated and control firms start to converge as credit market conditions gradually recovered.

3.2. Main regression results

To examine the cross−sectional relation between rollover risk and CDS spreads, I estimate a panel specification:

$$\text{Spreads}_{i,t} = \alpha_0 + \beta_1\,\text{RO\_CutOff}_{i,t} + \beta_2\,\text{RO\_CutOff}_{i,t} \times \text{Crisis Dummies}_t + \gamma\,\text{X}_{i,t} + \text{Firm FE} + \text{Time FE}, \qquad (1)$$

where the subscripts i and t represent firm i at month t. The dependent variable $\text{Spreads}_{i,t}$ is the log of the average daily CDS spreads of firm i in month t. $\text{RO\_CutOff}_{i,t}$ is a dummy variable which takes value 1 if firm i needs to refinance more than 20% of its long term debt in the calendar year of month t. Crisis Dummies_t are indicators of whether month t falls into five periods of the past financial crisis: second half of 2007, first half of 2008, second half of 2008, first half of 2009 and second half of 2009. $X_{i,t}$ denotes variables to control for other firm characteristics and insolvency risk, including stock returns, stock volatility, leverage, profitability, size, BM and credit ratings. I also control time and firm fixed effects. The estimation results are reported at Table 4, where t-values are based on robust standard errors double clustered at the individual firm and time level.

The first three columns of Table 4 report the estimation results in a regression setting without the interaction effect between rollover risk and crisis dummies. The positive but insignificant coefficients for RO_CutOff indicate that the exposure to rollover risk alone is not a significant determinant of credit spreads. The last three columns of Table 4 show interesting relations between rollover risk and credit spreads during the financial crisis period. The coefficient for the interaction variables RO_CutOff × Crisis Dummies are mostly positive and statistical significant, suggesting that firms with high refinancing risk indeed have higher CDS spreads during the financial crisis period, after controlling other determinants of credit risk. The impact of rollover risk on credit spreads starts to pick up from the second half year of 2007, peaks during the second half of 2008, then gradually declines and becomes insignificant at the second half of 2009. This pattern is consistent with the development of the past financial crisis which reaches its most critical stage around September 2008 following the collapse of Lehman Brothers. Again, it shows that credit market condition is a key component that determines the impact of the rollover risk on firms' credit spreads.

Table 4
CDS spreads and rollover risk.

Parameter	CDS1	CDS5	CDSX	CDS1	CDS5	CDSX
RO_CutOff × (200707−200712)				**0.307**	**0.160**	**0.102**
				[3.00]	[2.31]	[2.02]
RO_CutOff × (200801−200806)				**0.394**	**0.228**	0.132
				[2.56]	[2.46]	[1.71]
RO_CutOff × (200807−200812)				**0.516**	**0.387**	**0.322**
				[4.25]	[4.34]	[4.04]
RO_CutOff × (200901−200906)				**0.263**	**0.171**	0.127
				[2.91]	[2.24]	[1.79]
RO_CutOff × (200907−200912)				0.160	0.110	0.106
				[1.39]	[1.22]	[1.32]
RO_CutOff	0.048	0.020	0.011	−0.070	−0.055	−0.044
	[1.04]	[0.61]	[0.37]	[−1.40]	[−1.50]	[−1.40]
Ret	−0.140	−0.107	−0.092	−0.137	−0.106	−0.091
	[−5.51]	[−6.29]	[−6.67]	[−5.54]	[−6.37]	[−6.76]
Vol	1.039	0.776	0.765	1.013	0.757	0.750
	[7.77]	[7.36]	[8.79]	[7.91]	[7.47]	[8.95]
Leverage	0.762	0.660	0.580	0.745	0.652	0.575
	[2.07]	[2.41]	[2.47]	[2.08]	[2.42]	[2.47]
Profitability	−1.01	−0.211	−0.088	−0.984	−0.197	−0.081
	[−2.15]	[−0.62]	[−0.30]	[−2.24]	[−0.61]	[−0.29]
Size	0.160	0.201	0.156	0.160	0.201	0.156
	[1.88]	[3.14]	[2.73]	[1.91]	[3.15]	[2.74]
BM	0.081	0.051	0.048	0.082	0.052	0.049
	[2.16]	[1.81]	[2.00]	[2.29]	[1.92]	[2.10]
Rating	0.368	0.352	0.306	0.367	0.352	0.306
	[8.08]	[10.15]	[9.81]	[8.03]	[10.03]	[9.66]
NOBS	18644	18644	18644	18644	18644	18644
R2	0.887	0.903	0.890	0.888	0.904	0.890
Firm FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES

Observations are monthly. The dependent variables are the log of average daily 1-, 5- and 10-year CDS spreads (in basis points). RO CutOff is a dummy variable which takes value 1 if a firm needs to refinance more than 20% of its long term debt in the calendar year. Ret and Vol are annualized stock return and volatility calculated using daily stock return data in the previous 180 days. Leverage is long-term book leverage calculated as the ratio between total long-term debt ($dd1 + dltt$) and book assets(*at*). Profitability is defined as the earnings before interest (*ebitda*) normalized by total assets (*at*). Size is the log of total assets (*at*). BM is book value of equity (*ceq*) divided by market value of equity at the end of last fiscal year ($prcc_f$ *csho*). Rating is S&P long-term rating for the bond issuer, coded as 1 for AAA and 9 for C. T-values are reported in square brackets and are based on the standard deviations double clustered at both the firm and the month levels. Coefficients on RO CutOff × Crisis Dummies are in bold if they are 5% significant.

The impact of rollover risk on credit spreads is also large economically. From July 2017 to June 2019, the log one-year CDS spreads for firms that needs to refinance more than 20% of their long-term debt are on average 0.26 to 0.52 higher than similar firms without the refinancing needs. Compared with the average CDS spreads during this period (4.67 in log or 107 in bps), the CDS spreads for high rollover risk firms are 32 bps to 72 bps higher.

Moving from the short-end to the long-end maturities, the coefficients for RO_CutOff × Crisis Dummies are monotonically decreasing during the crisis period. This is not surprising because long-term spreads reflect the average default probabilities over time. This mono-tonic decreasing pattern suggests that rollover risk mainly affects firms' default likelihood in the near future while having limited power in explaining their fundamental long-term survivability. The slope of the coefficients can also provide useful information on the severity and persistence of the financial crisis. When the crisis first started in late 2007, the rollover risk coefficients decline quickly from 0.31 for 1-year to 0.10 for 10-year CDS spreads. The coefficients are much more persistent in the second half of 2008, 0.52 for 1-year versus 0.32 for 10-year CDS spreads. During this period, the financial crisis was at its worst conditions and the daunting credit market conditions were not expected to recovery soon. When the financial market showed signs of improvement in 2009, the rollover risk coefficients then quickly decline across maturities.

The coefficients on the control variables are consistent with theoretic predictions and empirical findings in previous work such as Refs.[1,2] Low rated firms with high leverage and high volatilities have wider credit spreads. Firms experienced negative stock returns have higher credit spreads.

Profitability lowers firm's credit spreads at the short-end maturity, but is not significant for long-term spreads. Growth firms, measured by BM ratios, have tighter spreads. Credit rating is also included in the regressions as a control variable for firms' credit quality. Rating agencies observe firms' debt maturity structure, and could have incorporated rollover risk in the ratings that they issued. The regression results show that the proportion of expiring long-term debt has additional explanatory power in explaining the cross-sectional variations in credit spreads, above and beyond information contained in credit ratings. The results are consistent with the widely held view that credit ratings are incomplete measures of credit risk. My results are also related to Gopalan, Song, and Yerramilli[5] where the authors show that rating agencies systematically underestimate the risk that firms may fail to refinance their short-term debt.

3.3. Rollover risk versus solvency risk during the financial crisis

Rollover risk mainly captures firms' short-term liquidity stress - the ability to meet their immediate payment obligations under stressed credit market conditions. This is different from firms' solvency risk which refers to the default risk caused by poor performance of their fundamental asset values. Previous discussions have shown that the impact of rollover risk on credit spreads is time-varying, significantly positive during the crisis period but negligible during normal times. It then raises an interesting question on the relative contribution of rollover risk and solvency risk on credit spreads under different market conditions.

To answer this question, I extend the regression setting in Equation (1) with additional variables interacted with the crisis dummies. I focus on leverage and volatilities because these are the two key variables suggested by the structural model literature to capture firms' fundamental solvency risk. Leverage and volatility have also been shown to be the two most important and robust determinants of credit spreads in the empirical literature. The regression results are reported at Table 5.

Interestingly, the impact of leverage and volatility on credit spreads decrease significantly during the crisis period relative to the normal times, especially on short-term CDS spreads. This observation is opposite to the impact of rollover risk on credit spreads. It suggests that investors in the credit market concern more on firms' short-term rollover risk, rather than their long-term fundamental survivability during the crisis period.[8] This is not surprising because rollover risk reflects a more “imminent” risk faced by firms when the supply of credit diminishes. Firms that have substantial amount of debt matures in the near term could be forced into bankruptcy even when they have positive net worth and probably good long-term prospects. By comparison, when the credit market functions efficiently during normal times, CDS spreads are mainly explained by fundamental risk variables such as leverage and volatility.

3.4. Rollover risk in the corporate bond market

In this section, I investigate the impact of rollover risk in the corporate bond market. Corporate bond spreads, similar to CDS spreads, are also widely used as the credit spreads for the underlying issuing firms. However, due to the illiquidity problems in the corporate bond market, corporate bond spreads are considered to have significant non-credit risk component. I obtain the bond pricing data from Finra Trace database and construct daily observed bond yields from 2004 to 2009. From all the transaction data contained in the Trace database, I filter out canceled, corrected, and special trades and also dropped cases where prices are obviously misreported. In addition, I the prices of the last trades before 5 PM that are at least 100 K as the daily closing bond prices. I obtain bond characteristics variables from the Mergent FISD database and drop callable, putable, convertible, and floating coupon bonds from my sample. Benchmark Treasury yields are daily constant maturity Treasury yields published by Fed. The corporate bond spreads are calculated as the difference between corporate bond yields and the corresponding treasury yields with the same maturity.

[8] This argument is further supported in Table 9 when I use synthetic CDS spreads calculated from the equity and option market to control for fundamental risk.

Table 5
Rollover risk versus solvency risk during the financial crisis.

Parameter	CDS1	CDS5	CDSX	CDS1	CDS5	CDSX
RO_CutOff × (200707−200712)	**0.307**	**0.157**	**0.101**	**0.296**	**0.153**	**0.099**
	[3.31]	[2.45]	[2.08]	[2.90]	[2.21]	[1.96]
RO_CutOff × (200801−200806)	**0.324**	**0.195**	**0.117**	**0.374**	**0.216**	0.125
	[2.27]	[2.27]	[1.59]	[2.42]	[2.33]	[1.62]
RO_CutOff × (200807−200812)	**0.494**	**0.374**	**0.314**	**0.490**	**0.370**	**0.312**
	[4.18]	[4.35]	[4.03]	[4.02]	[4.15]	[3.91]
RO_CutOff × (200901−200906)	**0.262**	**0.170**	0.132	**0.192**	0.120	0.095
	[3.05]	[2.39]	[1.95]	[2.00]	[1.52]	[1.30]
RO_CutOff × (200907−200912)	0.125	0.092	0.100	0.141	0.101	0.105
	[1.12]	[1.05]	[1.27]	[1.23]	[1.11]	[1.30]
Vol × (200707−200712)	0.542	0.098	0.071			
	[1.52]	[0.42]	[0.37]			
Vol × (200801−200806)	−0.555	**−0.589**	−0.291			
	[−1.83]	[−2.74]	[−1.55]			
Vol × (200807−200812)	**−0.976**	**−0.733**	−0.332			
	[−3.55]	[−3.48]	[−1.77]			
Vol × (200901−200906)	**−1.26**	**−0.922**	**−0.476**			
	[−4.73]	[−4.38]	[−2.51]			
Vol × (200907−200912)	**−1.01**	**−0.635**	−0.219			
	[−3.08]	[−2.49]	[−0.91]			
Leverage × (200707−200712)				−0.345	−0.091	0.016
				[−1.54]	[−0.59]	[0.13]
Leverage × (200801−200806)				**−0.795**	**−0.495**	−0.211
				[−2.99]	[−2.77]	[−1.46]
Leverage × (200807−200812)				**−1.07**	**−0.691**	**−0.371**
				[−3.73]	[−3.35]	[−2.06]
Leverage × (200901−200906)				**−1.31**	**−0.905**	**−0.561**
				[−5.01]	[−4.28]	[−2.77]
Leverage × (200907−200912)				**−0.590**	−0.322	−0.078
				[−2.40]	[−1.67]	[−0.42]
RO_CutOff	−0.069	−0.054	−0.045	−0.060	−0.049	−0.042
	[−1.40]	[−1.53]	[−1.41]	[−1.21]	[−1.35]	[−1.32]
Vol	2.017	1.501	1.103	1.074	0.800	0.776
	[7.71]	[7.29]	[6.03]	[8.45]	[8.00]	[9.42]
Leverage	0.787	0.675	0.587	1.245	0.959	0.725
	[2.25]	[2.57]	[2.54]	[3.33]	[3.40]	[2.95]
Other Controls	omitted	omitted	omitted	omitted	omitted	omitted
NOBS	18644	18644	18644	18644	18644	18644
R2	0.891	0.906	0.891	0.890	0.905	0.891
Firm FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES

Observations are monthly. All regressions contain month and firm fixed-effects. The dependent variables are the log of 1-, 5- and 10-year CDS spreads (in basis points). T-values are reported in square brackets and are based on the standard deviations double clustered at both the firm and the month levels. Coefficients for RO CutOff Crisis Dummies, Vol Crisis Dummies, Leverage. Crisis Dummies are highlighted in bold if they are 5% significant. Other control variables include Ret, Profitability, Size, BM and Ratings.

For each issuer firm, I select three benchmark bonds to represent its credit spreads at short, medium, and long maturities. This approach also ensures that the corporate bond sample is representative and is not biased toward a few firms with large number of bond issues. Specifically, I keep one bond that is the closest to the 1-year maturity with maturity in the range of 1 month and 4 years, one bond that is the closest to the 5-year maturity with maturity in the range of 3 years and 8 years, and one bond that is the closest to the 10-year maturity with maturity in the range of 8 years and 20 years. I average the daily bond spreads to get monthly observations. The summary statistics for the corporate bond spreads sample are reported in Table 6.

Similar to the base regression setup in section 3.2, I investigate the rollover risk effect in the corporate bond market by putting corporate bond spreads as the dependent variable on the left-hand side of Equation (1). The estimation

Table 6
Summary statistics of the sample of corporate bonds.

	1-Y Bonds		5-Y Bonds		10-Y Bonds	
	Mean	Std	Mean	Std	Mean	Std
RO	0.08	0.10	0.07	0.09	0.08	0.10
Spreads	4.83	1.04	5.13	0.91	5.18	0.74
Ret	0.13	1.03	0.14	1.05	0.11	0.97
Vol	0.35	0.29	0.35	0.29	0.34	0.28
Leverage	0.28	0.16	0.30	0.17	0.28	0.14
Profitability	0.13	0.08	0.13	0.08	0.13	0.07
Size	9.55	1.38	9.39	1.40	9.67	1.40
BM	0.48	0.61	0.49	0.60	0.48	0.50
Rating	3.78	1.01	3.95	1.12	3.72	0.97
Coupon (%)	6.17	1.56	6.42	1.56	6.25	1.18
Age	5.69	3.07	3.95	2.75	3.39	4.51
YTM	1.81	1.07	5.17	1.21	10.14	2.45
# Obs		12,785		15,314		9927
# Firms		415		449		343
# Firms (*RO* >20%) 2008		39		39		29
# Firms (*RO* >20%) 2009		34		28		23

Observations are monthly. *RO* is the ratio between COMPUSTAT item *dd*1 and item *dd*1 + *dltt*. Spreads are calculated as the log of the yield differences (in basis points) between bond yields and treasury yields with the same maturity. Ret and Vol are annualized stock return and volatility calculated using daily stock return data in the previous 180 days. Leverage is long-term book leverage calculated as the ratio between total long-term debt (*dd*1 + *dltt*) and book assets(*at*). Profitability is defined as the earnings before interest (*ebitda*) normalized by total assets (*at*). Size is the log of total assets (*at*). BM is book value of equity (*ceq*) divided by market value of equity at the end of last fiscal year ($prcc_f csho$). Rating is S&P long-term rating for the bond issuer, coded as 1 for AAA and 9 for C. Age is the number of years since a bond's issuance and YTM is the number of years to a bond's maturity.

results are summarized in Table 7. Consistent with the results in the CDS market, rollover risk affects bond spreads only during the crisis period, and has larger impact on the short-maturity bond spreads than on the long-maturity bond spreads. However, the coefficients of RO_CutOff × Crisis Dummies are much smaller in magnitudes and less significant in term of t-values. The log one-year bond spreads for high rollover risk firms are 0.185 higher than the spreads of low rollover risk firms during the second half year of 2008, compared to a difference of 0.53 in log CDS spreads. However, as corporate bond spreads are widely known as "noisy" measures of default risk, it is not surprising that the rollover risk effect is weaker for bond spreads. The general consistent results confirm that rollover risk coupled with adverse credit market conditions are important determinant of credit spreads.

4. Rollover risk in the stock and options market

In this section, I investigate whether rollover risk is priced in the stock and options markets. To do this, I use stock and options data to calculate synthetic CDS spreads based on the simple Merton structural model. Consistent with previous discussions based on CDS and corporate bond spreads, I find that rollover risk also increases firms' synthetic CDS spreads during the financial crisis period.

4.1. Synthetic CDS spreads

Following the standard Merton model in Merton[10]; I assume that the asset value V_t of a firm follows a geometric Brownian Motion process:

$$\frac{dV_t}{V_t} = (r-\delta)dt + \sigma_V dW_t \tag{2}$$

$$q(t) = N(-d_2)$$

Table 7
Rollover risk and Corporate Bond Spreads.

	1Y	5Y	10Y	1Y	5Y	10Y
RO_CutOff × (200707−200712)				**0.114**	**0.095**	0.042
				[2.30]	[2.79]	[1.11]
RO_CutOff × (200801−200806)				0.091	**0.133**	0.085
				[1.69]	[3.00]	[1.67]
RO_CutOff × (200807−200812)				**0.185**	**0.160**	0.058
				[2.22]	[2.66]	[1.02]
RO_CutOff × (200901−200906)				−0.019	0.016	−0.021
				[−0.29]	[0.27]	[−0.54]
RO_CutOff × (200907−200912)				0.026	0.058	0.072
				[0.32]	[0.72]	[1.29]
RO_CutOff	0.051	0.009	−0.012	0.020	−0.029	−0.032
	[2.21]	[0.47]	[−0.64]	[0.78]	[−1.56]	[−1.58]
Ret	−0.020	−0.019	−0.011	−0.020	−0.019	−0.011
	[−3.07]	[−4.08]	[−1.97]	[−2.97]	[−4.08]	[−1.93]
Vol	0.518	0.405	0.387	0.512	0.401	0.386
	[7.75]	[9.69]	[8.85]	[7.74]	[9.58]	[8.78]
Profitability	−0.917	−0.758	−1.01	−0.905	−0.761	−1.02
	[−3.09]	[−3.05]	[−3.77]	[−3.11]	[−3.08]	[−3.82]
Size	−0.079	−0.022	−0.066	−0.079	−0.022	−0.068
	[−1.55]	[−0.57]	[−2.23]	[−1.57]	[−0.56]	[−2.29]
BM	0.059	0.060	0.064	0.060	0.060	0.063
	[1.30]	[2.15]	[2.53]	[1.33]	[2.16]	[2.55]
Leverage	0.112	0.354	0.525	0.105	0.351	0.529
	[0.58]	[2.45]	[3.72]	[0.55]	[2.46]	[3.77]
Coupon	0.012	0.047	0.072	0.012	0.046	0.072
	[1.06]	[4.53]	[7.51]	[1.00]	[4.44]	[7.35]
AGE	0.020	0.008	0.003	0.020	0.008	0.003
	[4.59]	[1.86]	[1.17]	[4.66]	[1.89]	[1.14]
YTM	0.077	0.044	0.018	0.078	0.044	0.018
	[7.45]	[7.17]	[4.46]	[7.54]	[7.13]	[4.47]
Rating	0.211	0.188	0.154	0.212	0.188	0.154
	[6.26]	[8.07]	[6.86]	[6.25]	[8.09]	[6.82]
NOBS	12785	15314	9927	12785	15314	9927
R2	0.913	0.945	0.947	0.913	0.945	0.947
Firm FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES

Observations are monthly. All regressions contain month and firm fixed-effects. The dependent variables are the log of 1-, 5- and 10-year bond spreads (in basis points). T-values are reported in square brackets and are based on the standard deviations double clustered at both the firm and the month levels. Coefficients for RO CutOff × Crisis Dummies are highlighted in bold if they are 5% significant.

$$d_2 = \frac{\ln\left(\frac{V}{K}\right) + \left(r - \delta - 0.5\sigma_V^2\right)T}{\sigma_V} \qquad d_1 = d_2 + \sigma_V\sqrt{T}$$

I approximate the book value of debt K as the sum of debt in current liabilities and long-term debt (dlc + dltt), and the asset value V as the sum of market value of equity and the book value of debt E + K. I assume constant interest rate r and payout ratio δ for all firms in my sample. The interest rate is set to be 3% which is close to the average 1-year Treasury yields during my sample period. δ is set to be 4.5%, which is the weighted average of coupon rate and repurchase adjusted dividend yields in my sample. q(t) represents the risk-neutral cumulative default probability. The asset volatility σ_V is not directly observable, but can be derived from the equity volatility σ_E. The Merton model implies the following relation between σ_V and σ_E:

$$\sigma_E = \frac{V}{E} N(d_1)\sigma_V \tag{3}$$

I assume the recovery rate R to be a constant 50% for all firms in my sample. The synthetic 1-year CDS spreads (SCDS) can be calculated from the equation below:

$$SCDS\int_0^1 (1-q(s))e^{-rs}ds = (1-R)\int_0^1 q'(s)e^{-rs}ds. \tag{4}$$

The key input of the synthetic CDS spreads calculation is σ_E. I consider two candidates for the equity volatility: the realized volatility σ^{RV} estimated from historical stock returns and the implied volatility σ^{IV} derived from options prices. Compared with realized volatility, options implied volatility could potentially capture future volatility more accurately due to its forward-looking nature. On the other hand, implied volatility contains not only expected future volatility but also the risk premiums associated with the variations of future volatility. I therefore use both volatility measures in my calculation of the synthetic CDS spreads. The realized volatility is calculated as the standard deviation of daily stock returns in the previous 3 months and the implied volatility is the standardized 3-month at-the-money option implied volatility obtained from Optionmetrics.

Table 8 summarizes the distribution of the calculated synthetic CDS spreads and several key input variables. One advantage of using synthetic CDS spreads is that I am able to obtain a much broader sample of firms. The synthetic CDS sample is approximately three times larger than the CDS spreads sample. As a result, I am able to identify significantly more firms with high rollover risk (RO > 20%). Both the average realized and the average implied volatility are at approximately 30% before the financial crisis. The average realized volatility increases to 64% and the implied volatility increases to 58% in 2008. The synthetic CDS spreads were only a small fraction of the market CDS spreads before the financial crisis, but they increase quickly and are comparable to the market CDS spreads during the crisis period.

Next, I investigate the relation between rollover risk and synthetic CDS spreads. Using a similar regression setting specified in Equation (1), I estimate a panel regression on the synthetic CDS spreads, as well as the two equity volatility measures. The results are reported in Table 9.

Both volatility and synthetic CDS spreads increase more for firms that need to refinance a large portion of their long-term debt during the crisis. For these high rollover risk firms, the realized volatility is on average 11.4%−11.6% higher in 2008, and the implied volatility is on average 8.8%−10.9% higher in 2008. This difference in volatility is not only statistically significant but also large economically. Synthetic CDS spreads CDSRV and CDSIV display similar patterns. For high rollover risk firms, the log CDSRV spreads is on average 0.74 larger and the log CDSIV spreads is on average 0.92 larger during the second half year of 2008. Both numbers are statistically significant at the 5% level.

Table 8
Summary statistics of synthetic CDS spreads.

Year	#Obs	#Firms	#Firms $RO > 20\%$	#Firms wCDS	RO	σ^{RV}	σ^{IV}	MktLev	$SCDS^{RV}$	$SCDS^{IV}$	$CDS1$	$SCDS^{RV}$ (log)	$SCDS^{IV}$ (log)	CDS1 (log)
2004	7701	610	53	65	0.07	0.30	0.33	0.30	17.88	19.08	37.65	0.50	0.58	2.85
					(0.10)	(0.18)	(0.16)	(0.20)	(149.4)	(142.6)	(67.55)	(1.33)	(1.42)	(1.17)
2005	8137	676	68	172	0.07	0.28	0.32	0.28	9.95	11.27	35.13	0.35	0.48	2.67
					(0.10)	(0.15)	(0.15)	(0.19)	(71.39)	(57.75)	(112.1)	(1.11)	(1.28)	(1.09)
2006	8152	670	62	227	0.07	0.29	0.33	0.28	10.44	13.85	26.16	0.37	0.50	2.43
					(0.11)	(0.17)	(0.15)	(0.19)	(85.05)	(74.49)	(68.47)	(1.12)	(1.32)	(1.10)
2007	8657	713	74	248	0.07	0.32	0.35	0.28	24.24	29.31	41.02	0.55	0.66	2.68
					(0.11)	(0.20)	(0.18)	(0.20)	(137.3)	(147.3)	(120.1)	(1.45)	(1.59)	(1.24)
2008	8540	710	62	246	0.06	0.64	0.58	0.35	254.3	192.4	230.5	2.68	2.54	4.41
					(0.10)	(0.48)	(0.32)	(0.23)	(498.3)	(397.5)	(515.9)	(2.82)	(2.68)	(1.34)
2009	6206	697	59	254	0.06	0.61	0.61	0.42	262.0	243.6	376.4	3.00	3.16	5.02
					(0.09)	(0.40)	(0.30)	(0.23)	(468.1)	(420.1)	(867.1)	(2.79)	(2.69)	(1.26)

σ^{RV} is the realized stock volatility calculated using daily stock returns in the previous 3 month. σ^{IV} is the 3-month at-the-money (ATM) option implied volatility obtained from Optionmetrics. MktLev is K, where K is the book value of debt ($dlc + dltt$), and the asset value V is sum of market value of equity and the book value of debt. $SCDS^{RV}$ ($SCDS^{IV}$) is the synthetic CDS spreads calculated based on Merton model using σ^{RV} (σ^{IV}) as input for equity volatility. $CDS1$ is the one-year CDS spreads obtained via Datastream from CMA. Observations are monthly. Sample mean and standard deviations (in parenthesis) are reported.

Table 9
Rollover risk and synthetic CDS Spreads.

Parameter	σ^{RV}	$SCDS^{RV}$	σ^{IV}	$SCDS^{IV}$
RO_CutOff × (200707−200712)	**0.060**	**0.563**	**0.049**	**0.640**
	[2.36]	[2.17]	[2.38]	[2.32]
RO_CutOff × (200801−200806)	**0.116**	**1.019**	**0.088**	**1.043**
	[2.57]	[2.42]	[2.51]	[2.48]
RO_CutOff × (200807−200812)	0.114	**0.738**	**0.109**	**0.919**
	[1.77]	[2.19]	[2.55]	[2.55]
RO_CutOff × (200901−200906)	0.145	0.502	0.091	0.623
	[1.68]	[0.97]	[1.48]	[1.24]
RO_CutOff × (200907−200912)−0.023	0.333	0.050	0.523	
	[0.71]	[0.71]	[1.51]	[1.09]
RO_CutOff	−0.006	−0.005	−0.001	−0.047
	[−0.40]	[−0.04]	[−0.08]	[−0.38]
Profitability	−0.265	−2.35	−0.253	−2.59
	[−2.78]	[−3.06]	[−3.09]	[−3.28]
Size	−0.005	0.068	−0.006	0.094
	[−1.31]	[2.19]	[−1.67]	[2.84]
BM	−0.001	−0.001	−0.001	−0.001
	[−0.31]	[−0.05]	[−0.18]	[−0.36]
Rating	0.063	0.520	0.068	0.639
	[6.93]	[7.16]	[8.80]	[7.77]
NOBS	37884	37884	37884	37884
R2	0.554	0.557	0.629	0.549
Month FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

Observations are monthly. All regressions contain month and firm fixed-effects. $SCDS^{RV}$ and $SCDS^{IV}$ are log synthetic CDS spreads calculated using σ^{RV} and σ^{IV} as inputs for equity volatility. T-values are reported in square brackets and are based on the standard deviations double clustered at both the firm and the month levels. Coefficients for RO CutOff Crisis Dummies are highlighted in bold if they are 5% significant.

Clearly, high rollover risk firms indeed have higher volatilities and higher synthetic CDS spreads during the crisis period. During normal period, however, neither volatilities nor synthetic CDS spreads can be explained by rollover risk. Overall, the empirical evidences in the stock and options markets are consistent with earlier discussions based on credit spreads in the CDS and corporate bond markets.

5. Conclusion

I investigate the impact of rollover risk on asset prices in several financial markets. To avoid potential endogeneity biases associated with firms'own debt maturity choices, I use the maturing portion of long term debt to measure rollover risk. I start my analysis from CDS spreads, which are usually considered as clean measures of firms' credit risk. I find that the CDS spreads of high rollover risk firms are significantly higher than the spreads of low rollover risk firms during the financial crisis period. This rollover risk effect is the strongest during the peak period of the financial crisis and less striking at the early and final stages of the crisis. During normal times, CDS spreads are mostly explained by fundamental risk variables such as leverage and volatility, while rollover risk is not a significant determinant. In addition to the CDS market, rollover effect also exists in the corporate bond market. I construct bond spreads using bond transaction prices in the Trace database. Although the results are slightly weaker for bond spreads, they are largely in line with the observations based on CDS spreads. Rollover risk effect is also observed in the stock and options markets where credit spreads are measured using synthetic CDS spreads calculated from the Merton structural model.

Conflicts of interest

The author has none to declare.

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