The Determinants of Corporate Yield Spreads:

Before and After the Global Financial Crisis

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ABSTRACT

We study the impact of the recent global financial crisis on the determinants of corporate bond spreads, in particular, focusing on the impact of liquidity and credit risk on yield spreads using data regarding financial and non-financial bond issuers listed on the Korea Exchange (KRX). Our main findings reveal that the selected liquidity variables explain a relatively larger portion of the variation in yield spreads *before and during* the crisis period, whereas the credit risk component has become a more influential determinant of yield spreads *after* the crisis. This observation implies that Korean bond investors, who have not suffered from severe liquidity problems, are concerned about increased economic vulnerability in response to the liquidity dry-up in the U.S. financial market and, as a result, require more default risk premium in the post-crisis period.

JEL classification: G01; G12; G32

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1. Introduction

The recent global financial crisis affected financial investors' risk perception and their ensuing behavior. Thus, it is worthwhile to explore the key determinants of risk premium by examining the most powerful influences on the *global* market prices of risky assets *before* and *after* the onset of the crisis.

There is ample academic research on the risk factors of corporate bonds to elucidate the determinants of yield spreads.[1] Among many others, Delianedis and Geske (2001) argue that credit risk and spread are driven by recovery, tax, liquidity, and market risk factors. Collin-Dufresne, Goldstein, and Martin (2001) find that the changes in credit spreads are attributable to the supply/demand shock, which is independent of the proxies for both liquidity and credit risk. Huang and Huang (2012) demonstrate that credit risk explains a small portion of the yield spread for investment-grade bonds. Longstaff, Mithal, and Neis (2005) discover that credit risk is the main determinant of corporate yield spreads. Covits and Downing (2007) report similar findings with Longstaff, Mithal, and Neis (2005) through investigating very short-term commercial paper issued by non-financial U.S. corporations. By proposing a new illiquidity measure, Dick-Nielsen, Feldhütter, and Lando (2011) find a dramatic increment

[1] On the analysis of sovereign yield behaviors, Ejsing, Grothe, and Grothe (2012) classify the related literature into two major streams: The first employs proxies for liquidity and credit risk to explain the variations in the behavior of yield spreads. For example, using CDS spreads as a proxy for credit quality and effective bid-ask spreads as a measure of liquidity, Beber, Brandt, and Kavajecz (2009) discover that bond investors usually take both liquidity and credit risk into consideration; yet, their attention shifts toward the latter when the market is under stress. The second stream analyzes liquidity and credit risk by directly controlling either of the two factors. For example, Longstaff (2004) uses the difference in yields between Treasury and Refcorp bonds to examine whether a flight-to-liquidity premium exists in bond prices. Refcorp bonds have the same credit quality as sovereign bonds since they are fully guaranteed by the U.S. government.

with the onset of the subprime crisis in the spread contribution from liquidity factors in the corporate bond market.

Our study analyzes corporate bond yield spreads to shed additional light on the yield contribution from liquidity and credit components to the non-U.S. bond market before and after the recent global financial crisis. Particularly, the post-crisis period—specifically, the Korean bond market's post-crisis reaction to liquidity and credit risk—is of interest to us. In fact, previous literature regarding the recent financial crisis tends to focus on how illiquidity component contributed to the yield spreads with *the onset* of the financial crisis. Thus, they are prone to overlook how the relative importance between liquidity and credit risk changes *after* the global crisis. To give additional insight into the topic, this paper explores not only the spread contribution from liquidity and credit factors before the crisis (including times of crisis), but also how their contribution to bond spreads varies during the post-crisis period.

For this purpose, our data set incorporates both financial and non-financial corporate bond issuers listed on the Korean Exchange (KRX). It is noteworthy that despite the significant role the financial sector plays in the economy, prior related research has devoted little attention to financial firms. This negligence is not irrelevant to the estimation of firm-specific leverage or distance-to-default, a measure of the volatility-adjusted leverage of a firm, in a consistent and universal manner.[2] Specifically, traditional Moody's KMV method suggests that the standard level of distance-to-default is solely determined by the firm's current liabilities and its long-term debts, even though financial firms in general possess a large amount of liabilities that cannot be simply categorized as such. Hence, this conventional approach for estimating the distance-to-default tends to neglect a substantial part of a

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[2] Bharath and Shumway (2008) show that Merton's (1974) distance-to-default probability is useful for predicting default, but is seemingly insufficient to represent the statistics of default.

financial firm's debts, producing unreliable estimates for their likelihood of default. To overcome this challenge, we obtain distance-to-default estimates from the website of the Risk Management Institute at the National University of Singapore (NUS–RMI), which provides such estimates of listed firms worldwide, including both financial and non-financial firms listed on the KRX, by adopting the methodology proposed by Duan and Wang (2012).

For evaluating the role of liquidity and credit risk in determining corporate yield spreads, we run regressions of average corporate yield spreads on the proxies for liquidity (*Trade Volume*, *Cash over Asset*, *Maturity*, and *Roll*) and credit risk (*Rating*, *Coupon*, *Equity Volatility*, and *Distance-to-Default*) with data comprising 284 bond issues from 66 firms (financial and non-financial) between 2007–08 (before the crisis) and 558 issues from 118 firms between 2009–11 (after the crisis).[3] Overall, our results demonstrate that credit risk plays a more significant role in determining yield spreads after the crisis, and such findings are robust to the alternative proxies for liquidity risk with various model specifications. One explanation for this observation is that investors in Korean corporate bond markets more care about default risk in the post-crisis era due to the possibility that Korean economy will go into a recession, in response to the liquidity crisis in the U.S. financial market. Thus, bond investors, who do not face liquidity problem *directly*, seem to require more compensation for credit risks relative to the liquidity premia.[4]

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[3] Korea Securities Computer Corporation (KOSCOM), established by the Ministry of Finance (MOSF) and the Korea Exchange (KRX) in 1977, provides CheckExpert as a terminal for professional investors or brokers to offer real-time local and international financial information, news, and corporate data.

[4] It is remarkable that Korean market experienced the Asian crisis from 1997-98, triggered by the downgrade of sovereign credit accompanied by the possibility of (short-term) debt moratorium. Accordingly, the ensuing chain bankruptcy of large companies forced market participants to be more worried about credit deterioration, which

However, we note that credit risk alone does not explain the entire yield-spread behavior. This study provides evidence regarding the significant impact of liquidity on spread as well in both periods. Specifically, the empirical results show that the *Roll* measure is significantly related to spreads in our regression specifications even after controlling for credit risk factors.

As a robustness check, we explore whether other trading-based liquidity measures are significant determinants of yield spreads. For this purpose, we run a set of regression analyses including *Amihud* and *Turnover* instead of *Trade Volume* in the presence of other variables. Empirical results indicate that *Amihud* shows fairly good explanatory power, especially between 2009 and 2011, and the overall results remain intact. Furthermore, we investigate the nonlinear properties of *Equity Volatility* on corporate yield spreads. Our results reveal that non-trivial quadratic dimensions in such a variable may account for yield spreads on their squared terms in the presence of other control variables.

The rest of this paper is organized as follows. Section 2 describes our methodology and selected variables; Section 3 provides the data selection criteria; Section 4 elaborates on the empirical results; and Section 5 presents our conclusions, followed by a technical appendix.

2. Methodology

2. 1. Model Specification

The basic unit of analysis is corporate bond transactions. For estimating the impact of liquidity and credit risk on yield spread pricing, we run a cross-sectional regression of bond spreads on the proxies for liquidity and credit risk. The basic model specification is given by

$$\text{(Yield Spread)} = \beta_0 + \beta_1^T * \text{(Liquidity risk factors)} + \beta_2^T * \text{(Credit risk factors)} + \varepsilon$$

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the recent global financial crisis exposed emphatically, because they seemingly learned the expensive lessons from the previous Asian-crisis event.

The term "Liquidity risk factors" represents a set of possible proxies for liquidity risk. Similarly, the term "Credit risk factors" represents a set of possible proxies for the default risk of a bond issuer. Note that Covitz and Downing (2007) take log functions of each variable to reduce the impact of outliers, arguing that their basic conclusion does not change in the form of log-level regression.[5]

2. 2. Selected Variables

This study defines the *Yield Spread* as the yield differential between a corporate bond and a comparable-maturity, risk-free rate instrument such as a government bond. Our analysis employs the average yield spread as a dependent variable in the regression model.

The liquidity proxies used in this analysis include *Trade Volume*, *Cash over Asset*, *Maturity*, and the *Roll* measure.[6] The first measure, *Trade Volume*, is obtained by dividing the total trading volume with the number of (corresponding) months during which the issue is traded.[7] Accordingly, *Trade Volume* is expected to have an inverse relation with the yield

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[5] Although such a log-transformation tends to weaken the explanatory power of the selected factors, the major results are generally intact.

[6] We considered including (*Average) Trading Number* as another liquidity measure in our analysis, but decided against it because of its possible multicollinearity with the *Trade Volume* variable. Note that Covitz and Downing (2007) incorporate both variables together in their study.

[7] Brunnermeier and Pederson (2009) argue that liquidity risk can be classified into market liquidity and funding liquidity. Market liquidity can be considered "good" when a security is easily traded in the market, measuring the ease of asset trade with a limited or no price impact. On the other hand, funding liquidity refers to the ability to settle obligations immediately. In this paper, we employ the *Trade Volume* variable as a proxy for market liquidity.

spreads.

The second liquidity measure is *Cash over Asset*. It is defined as the ratio of the sum of cash and marketable short-term securities (e.g., trading securities) to the amount of total assets, indicating the issuer's ability to meet its short-term obligations. A higher level of cash over total assets indicates a higher funding liquidity profile of the bond issuer. In general, therefore, this variable is expected to be negatively related to yield spreads assuming that a lower liquidity profile represents higher liquidity demand from the bond issuer's perspective.

Maturity is the time left until maturity from the issuance date of a security. As mentioned in Longstaff, Mithal, and Neis (2005), the rationale behind this variable is that there might be maturity-sensitive clientele for corporate bonds. Accordingly, it is expected that the shorter the maturity, the more liquid the bond. This study expects the coefficient of maturity to be positive.[8]

The last liquidity variable we consider is the *Roll* measure. Roll (1984) develops an illiquidity measure based on the covariance of the consecutive changes in asset prices given by

$$Roll = 2 * \sqrt{-cov(R_i, R_{i-1})}$$

However, the *Roll* measure cannot be defined if the covariance value inside the square root takes the positive values. Thus, we make the covariance terms to have absolute values following Harris (1989), Lesmond (2005), and Kim and Lee (2013) in the form of

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[8] Longstaff, Mithal, and Neis (2005) demonstrate that the time to maturity is a significant factor for explaining the non-default component of spreads, arguing that the result is consistent with intuition—shorter-maturity bonds are more liquid than longer ones. Covits and Downing (2007) maintain that a classification as to whether the time to maturity is a liquidity or credit factor is somewhat ambiguous. However, they treat it as a liquidity measure.

$$Roll = 2 * \sqrt{|\, cov(R_i, R_{i-1})\, |}$$

The common expectation is that liquid assets have lower covariance than illiquid. Thus, the *Roll* measure is expected to have positive relation with the yield spread.

This study considers four credit risk factors as explanatory variables. The first proxy, *Rating*, is the credit rating assigned to each security that a firm issues. As in the case of yield-to-maturity, the rating offered by CheckExpert is the average of the credit ratings given by three major Korean credit rating agencies: the National Information and Credit Evaluation Inc., Korea Asset Pricing (or Korea Ratings, an affiliate of Fitch Ratings), and Korea Investors Service (a Moody's affiliate). Our study adopts the coding method of Covitz and Downing (2007) for credit ratings: AAA = 1, AA+ = 2, …, and BBB- = 10. Obviously, a positive relationship is expected between yield spreads and credit ratings. Some might say that dummy variables could be used for coding credit ratings. However, that is unlikely, at least in this analysis, since only investment-grade firms are included in our data set.[9]

Coupon refers to the coupon rate of bonds. In the Korean corporate bond market, firms typically issue their bonds at par value.[10] As expected, bonds issued by firms with higher default risk are significantly discounted upon issuance, other things being constant. Our assumption is that firms raise the coupon rate in order to adjust the bonds to their face value. Thus, we expect the coefficient of the coupon rate to be positive.[11]

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[9] Covitz and Downing (2007) mention that whether credit ratings are coded by using dummy variables or numeric values, there are little or no changes in their results.

[10] This convention is verifiable from the Bonds tab or Information Center (Publication) tab on the KRX website: http://eng.krx.co.kr/. [Accessed on August 3, 2012]

[11] Longstaff, Mithal, and Neis (2005) use the coupon rate of bonds as a determinant of the non-default component of bond spreads (i.e., tax effects), showing that the coupon rate of bonds is significant at least at the

The *Distance-to-Default* (*DtD*) measure is based on Merton's (1974) bond pricing formula.[12] *DtD* represents how far a firm is from default; a smaller *DtD* value means a higher probability of default. The month-to-month default probabilities of every listed firm on the KRX are available at the website of the NUS–RMI, free of charge. This study takes the average of the *DtD* estimates of the period while a specific issue is outstanding. Obviously, the *DtD* variable is expected to have a negative relationship with bond spreads.

The last credit risk proxy we consider is *Equity Volatility*, estimated from historical stock price data.[13] Assuming there are 252 trading days per year (equivalently, 21 days per month), we obtain a monthly standard deviation, which is congruent with other variables such as *Trade Volume* or *Distance-to-Default* in terms of its frequency. It is well known that as a firm approaches default, the risk associated with its debt also increases, and such risk is correlated to the equity risk. Accordingly, we expect the calculated equity return volatility to have a positive correlation with bond spreads.

3. Data and Sample

3. 1. Sample Period

We split our sample period (2007-2011) into the pre- (2007:Q1-2008:Q4) and post-crisis periods (2009:Q1-2011:Q4) based on the time-series behavior of the difference between 3-

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90% level in any model specifications employed in their study. Bharath and Shumway (2008) report the results of regressing bond yield spreads on a number of independent variables including coupons. They show that coupon rates have significantly positive correlation with yield spreads. See also Chen, Liao, and Tsai (2011) or Lin, Wang, and Wu (2011).

[12] (Source) *National University of Singapore, Risk Management Institute, CRI database.* Available at: http://rmicri.org [Accessed on August 3, 2012]

[13] For details of the estimation procedure, see Hull (page 286-288, 6th edition), for example.

year BBB- corporate bond yields and the corresponding risk-free interest rate.[14] The data are obtained from the Bloomberg terminal. As illustrated in the Figure 1, the time series of these proxies were stable until the 2008 financial crisis during which their values soared rapidly.

(Figure 1 here)

Despite looking slightly unstable compared to the data before 2008, the proxies during the post-crisis period seem to maintain relatively high values. The assumption behind this finding is that the 2008 financial crisis brought about a structural break and changed the whole context by putting the Korean economy into a new regime.

3. 2. Data Description

The daily time-series data for Korean corporate bond spreads per issue were obtained from the CheckExpert. The database also provides data for the average of the yield-to-maturity estimates of three Korean credit rating agencies.[15] For refined data collection, our sample only uses straight bonds by excluding the issues with embedded options such as calls or puts, whose prices are, in many cases, determined by the option's premium rather than fundamental risk factors specific to the issuer.

It is noteworthy that our dataset includes corporate bonds issued by financial firms, whereas numerous academic papers exclude such issuers, dismissing the financial sector's

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[14] Dick-Nielsen, Feldhütter, and Lando (2012) study the liquidity component of bond spreads using TRACE transactions data during 2005-2009. They split the sample into pre- (2005:Q1-2007:Q1) and post-subprime (2007:Q2-2009:Q2) to see how liquidity factor behaves differently between the two regimes. Their finding—that market has suffered from a shortage of liquidity *after* the onset of the subprime crisis—is comparable with our *pre-crisis (including times of crisis)* results.

[15] Korean regulations require issuers of non-guaranteed bonds to obtain ratings from at least two such agencies.

significant role in the economy. The Credit Rating Initiative (CRI) Technical Report of NUS–RMI provides the estimation methods of the *Distance-to-Default* for financial firms as well as for non-financial ones.

In addition, individual bond issues with face values of less than 1 billion KRW (also called "baby bonds") are excluded to avoid random sampling and to minimize the impact of extreme statistical figures on empirical results. Won and Lee (2007) maintain that baby bonds are mainly traded among individuals. In such cases, securities companies, the other party to a transaction, charge and garner huge commissions, as reflected in the interest rate, which, in turn, might distort the true level of interest rates.

Furthermore, our analysis considers the fixed coupon, exchange-listing, and Korean-denominated issues. It is possible to obtain reliable stock data such as stock return volatility or market capitalization only when exchange-listed issues are used. In particular, the most critical inputs in evaluating *Distance-to-Default*, which is employed as a proxy for credit risk, include both the market values of and the volatility of equity. (See Appendix A for details of Merton's (1974) *Distance-to-Default* model and its calculation.) Our sample excludes unlisted companies for the aforementioned reasons.

Similarly, we exclude both guaranteed bonds and subordinated ones. The prices of guaranteed bonds are generally determined by the credibility of the assurers rather than that of the issuing company itself. Meanwhile, the prices of subordinated bonds vary depending on the priority precedence of the debt issues even though the business entity's credit qualities are identical.

In addition, the issues with at least 6 months remaining to maturity come within the boundary of the sample. According to a 2011 report of Korea Ratings, bonds with less than 1 year remaining to maturity are usually accompanied by a rapid decline in liquidity. This is mainly attributable to the need for securing funding liquidity rather than the desire for higher investment returns. In this regard, Jung and Kook (2002) exclude issues with less than 6 months remaining to maturity when calculating the implied default rate per issue. Therefore, we solely analyze bond issues with at least 6 months remaining to maturity to avoid facing the distortion of yield spreads by liquidity factors.

Lastly, our dataset contains bond issues outstanding for at least 1 year throughout the sample period, both from March 1, 2007 to December 31, 2008 and from January 1, 2009 to December 31, 2011. For example, bond A, issued at the beginning of 2008 and expired at the end of 2011, is included in the sample, while bond B, issued at the end of November 2011 and still outstanding, is excluded. Unlike sovereign bonds that have abundant liquidity, corporate bonds are traded less frequently in the market, implying that more reliable empirical results can be obtained by including only the issues that provide data for a long-term period; here, "long-term period" refers to one year or more. Tables 1-1 and 1-2 summarizes the composition of our data set before and after the crisis, respectively.

(Table 1-1 here)

(Table 1-2 here)

As a result, a total of 66 firms are used in the analysis for the pre-financial crisis period: AAA (5), AA+ (7), AA (5), AA- (14), A+ (9), A (10), A- (7), BBB+ (4), BBB (4), and BBB- (1). Similarly, we included 118 firms in the post-crisis sample as follows: AAA (6), AA+ (10), AA (10), AA- (25), A+ (17), A (22), A- (15), BBB+ (6), BBB (6), and BBB- (1).[16]

Here, one issue arises when we count the number of firms in the sample. For a

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[16] Speculative-grade bonds (also known as junk bonds) are not actively traded in the market, making it hard to calculate their fair value, which renders them less useful for the analysis of liquidity and credit risk. Therefore, this study includes only investment-grade firms (i.e., those rated BBB- or higher).

hypothetical example, bonds A-1 and A-2 can be rated differently during a certain sample period, even if they are issued by the same firm. One seemingly obvious explanation for this could be that A-1 and A-2 are issued on different dates. To adjust for such a difference, firms are treated the same in this study even if their credit rating is altered during the analysis period.

Issues before the crisis number 284, and they are specified as follows: AAA (64), AA+ (34), AA (17), AA- (49), A+ (30), A (42), A- (21), BBB+ (11), BBB (13), and BBB- (3). The number of issues after the crisis for all investment-grade ratings totals 558 as follows: AAA (119), AA+ (54), AA (35), AA- (93), A+ (70), A (92), A- (48), BBB+ (20), BBB (26), and BBB- (1).

3.3. Summary Statistics

Tables 2-1 and 2-2 provide the summary statistics for the variables used in the analysis before and after the financial crisis, respectively.

(Table 2-1 here)

During the pre-crisis period, as seen from Table 2-1, the average of the dependent variable is about 1.239%, with a standard deviation of 0.577%. As seen from the median, the distribution of the *Yield Spread* has a long right tail, indicating that some of the very wide yield spreads skew the distribution to the right. *Trade Volume* registers a value of about 53 (x10^8 Korean won) every month per issue, reflecting some large values in the right tail of the distribution, while *Cash over Asset* averages about 0.215, again with a long right tail. The average of *Maturity* as of issuance is 3.982 years, and the median is 3 years. *Roll* averages about 1.5, with a standard deviation of 0.443. The mean value of *Coupon* is around 5.5, with a standard deviation 0.91, while *Equity Volatility* averages 17.39% per month, with a standard deviation of approximately 4.01, where the lowest value is 8.752 and the highest 25.91. The average credit rating score is about 4.46 (between AA- and A+), with a standard deviation of 2.613. The credit ratings range from 1 (AAA) to 10 (BBB-).[17] Finally, *Distance-to-Default* averages about 2.14 per issue, with a standard deviation of about 1.4%.

(Table 2-2 here)

During the post-crisis period, as shown in Table 2-2, the average of the dependent variable is about 1.470%, with a standard deviation of 1.166, indicating that the average value of *Yield Spread* increased by 0.231% after the crisis. *Trade Volume* shows a monthly value of about 108 (x10^8 Korean won) per issue, while *Cash over Asset* averages about 0.23, again with a long right tail. We can find that *Trade Volume* considerably increased from 53 to 108 (x10^8 Korean won) since the onset of the global financial crisis. The average of *Maturity* is 3.555 years (and the median is exactly 3 years), implying that the distribution is fairly balanced. *Roll* averages approximately 1.301, which slightly decreased from its mean value before the crisis. *Coupon* averages about 5.9, with a standard deviation 1.42, ranging from 0 to 10.7. The average of *Equity Volatility* is about 12.314% per month, with a standard deviation of about 2.708. One noticeable observation is that both the average and standard deviation of *Equity Volatility* significantly decreased after the crisis. The average *Rating* is about 4.274 (between AA- and A+), with a standard deviation of 2.406 (about 2 notches). Finally, *Distance-to-Default* averages 2.284 per issue, with a standard deviation of about 1.22%.

Tables 3-1 and 3-2 show the pair-wise correlation coefficients among the independent

[17] As mentioned previously, this study solely includes bonds with an investment-grade or higher since speculative-grade bonds are not actively traded. For this reason, the size of bond issuers in our sample tends to be large and they are well capitalized.

variables before and after the global financial crisis, respectively.

(Table 3-1 here)

(Table 3-2 here)

As confirmed from Table 3-1, *Trade Volume* is negatively correlated with *Cash over Asset*, with a correlation coefficient of about -0.17 before the crisis. *Coupon*, *Equity Volatility*, and *Rating* are positively correlated with one another; the coefficient value between *Rating* and *Equity Volatility* is relatively high, while *Coupon* and *Equity Volatility* exhibit a weaker correlation. On the other hand, *Distance-to-Default* is negatively correlated with the other three credit risk measures; *Distance-to-Default* and *Equity Volatility* are highly correlated relatively, with a correlation coefficient of about -0.5, while *Distance-to-Default* exhibits a comparatively weak correlation with *Rating*, with a coefficient of -0.144. Among the correlation coefficients between variables in Table 3-1, the coefficient between *Rating* and *Equity Volatility* is the highest with a value of 0.558, while that between *Maturity* and *Trade Volume* is the weakest, with a value of -0.002.

Table 3-2 indicates that *Trade Volume* and *Cash over Asset* seem to be quite weakly correlated, with a correlation coefficient of about -0.033. Liquidity proxies are negatively correlated with each other after the crisis except for the pair-wise correlation between *Cash over Asset* and *Roll*. Meanwhile, *Coupon*, *Equity Volatility*, and *Rating* are positively correlated with one another again. Concretely, the correlation coefficient between *Rating* and *Coupon* is relatively high, while *Coupon* and *Equity Volatility* exhibit a weaker correlation. We also find that the correlation coefficients among these three variables, *Coupon*, *Equity Volatility*, and *Rating*, decrease after the global financial crisis. On the other hand, *Distance-to-Default*, as before the crisis, is negatively correlated with the other three credit risk measures; *Distance-to-Default* and *Rating* are comparatively highly correlated, with their correlation coefficient reaching -0.366, while *Distance-to-Default* exhibits a relatively weak relation with *Coupon*, with a coefficient of -0.215. The coefficient between *Roll* and *Coupon* is the highest with a value of 0.512, and that between *Roll* and *Cash over Asset* is the weakest, with a coefficient of 0.01 during the post-crisis era.

4. Empirical Analysis

4. 1. Determinants of Corporate Yield Spreads

The regression results for each sample are presented in Table 4-1 (before the crisis) and Table 4-2 (after the crisis). Models 1 to 4 includes only each of the liquidity proxies—*Trade Volume*, *Cash over Asset*, *Maturity*, and *Roll* in order, whereas Model 5 incorporates all liquidity variables. Models 6 to 9 enters each of the proxies for credit risk—*Coupon, Equity Volatility, Rating,* and *Distance-to-Default,* while Model 10 considers all credit variables. Model 11 employs all the variables.[18]

(Table 4-1 here)

(Table 4-2 here)

During the pre-crisis period, as indicated by Table 4-1, the estimated coefficient of the *Financial* dummy variable does not seem to be significantly different from zero, especially from the full model. On the other hand, all the coefficients become significant at the 99%

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[18] As a robustness check, we also conducted similar analyses by restricting the number of trades to be at least (i) multiple and (ii) five, respectively. The motivation behind these additional tests is to check whether the extremely low value of the variable might distort the results and whether the basic conclusion is robust to other specifications. However, we could not observe any meaningful difference in the results. In the scenario with a restriction that the number of trades be equal to 10 or more, the sample size — particularly for financial firms — is not large enough to draw a significant conclusion. Details are available from the authors upon request.

level after the crisis as reported by Table 4-2. We infer that *Financial* became more significant after the crisis, since the recent crisis originated from the vulnerability in the U.S. financial system. Thus, ceteris paribus, the participants in Korean bond markets require more compensation for their investment in corporate bonds issued by financial firms once they have passed though times of financial crisis, controlling for liquidity and credit factors.[19] Note that the signs of *Financial* change from negative to positive, when *Rating* is controlled for. This observation indicates a non-trivial credit-quality gap between non-financial and financial bond issuers, and is fairly consistent among model specifications in both Table 4-1 and Table 4-2.[20]

Table 4-1 indicates that the coefficient of *Trade Volume* shows a negative sign as expected, but becomes positive in the presence of other variables, remaining statistically significant at 95% level. After the crisis, however, *Trade Volume* loses its significance with a t-statistic of

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[19] Financial institutions' assets are mostly liquid, which might bring about more severe conflicts between managers and shareholders, according to the free cash flow hypothesis. Specifically, appropriation of such assets by insiders is relatively easy to undertake. In addition, it is well known that the corporate governance of financial institutions is substantially different from that of non-financial firms. Financial institutions are monopolistic in nature and implicitly benefit from governmental protection from exit; thus, financial firms might face a more serious agency problem than non-financial firms. Moreover, compared to non-financial firms, financial firms have a stronger capacity to react to illiquidity owing to rich, liquid assets even in the case of earning deterioration emanating from lax management. Thus, market surveillance over incompetent corporate management is known to be weaker in the case of financial firms.

[20] Longstaff et al. (2005) use a dummy variable for bonds issued by financial firms as a proxy for liquidity risk, explaining that financial firms presumably have better access to capital markets and that their bonds enjoy more liquidity in the market than those issued by other types of firms. The dummy variable was also significant in their findings, with the argument that the result is inconsistent with the hypothesis that securities issued by financial firms are easier to trade in the market with limited price impact.

0.76 (Model 11), indicating that *Trade Volume* cannot be a sufficient explanatory variable for yield spreads in general.

The coefficient of *Cash over Asset* exhibits positive signs in both pre- and post-crisis periods, and the sign is inconsistent with our previous understanding; A higher level of cash ratio indicates a higher funding liquidity capability of the bond issuer. As seen from Tables 4-1 and 4-2, combining both liquidity and credit variables in one spreads regression (Model 11) results in the coefficient of *Cash over Asset* losing some of its significance, but it still remains statistically distinguishable from zero, indicating that higher *Cash over Asset* drives up the *Yield Spread* to a higher level.[21] When it comes to our interpretation of the positive direction of the estimated coefficient, we refer to Jensen (1986) who defines free cash flow as cash flow in excess of that required to fund all positive net present value projects when discounted at the appropriate cost of capital. According to Jensen (1986), free cash flow in a corporation makes managers, agents for shareholders, waste available resources by choosing suboptimal investment portfolios and making decisions against the growth of firm value for their own benefit. Therefore, the market seems to expect that the corporation's free cash flow might be used in a direction against the maximization of shareholder's wealth rather than for enhancing the firm's funding capacity, for example, by reducing rollover risks.[22] Interestingly, the correlation coefficients between *Rating* and *Cash over Asset* take relatively high positive values both before and after the crisis, which might be interpreted to mean that riskier firms

[21] The NUS–RMI CRI Technical Report (2011) states that the ratio of the sum of cash and short-term investments over total assets has a significantly negative relationship with the firm's default risk across different countries.

[22] *Cash over Asset*, a liquidity variable in this study, is not necessarily the same as free cash flow. However, we conjecture that a higher cash ratio often leads to a higher chance of wasting corporate resources as suggested by the free cash flow argument. Also, refer to footnote 18.

tend to build a larger capital buffer in the form of cash and short-term investments.

Maturity has a negative sign and remains statistically distinguishable from zero before the crisis. *Maturity* retains its sign in the full model (Model 11) but loses its statistical significance, with a t-statistics of -1.79. The similar pattern appears after the crisis except one observation; the *Maturity* coefficients are negative, but their signs reverse into positive when credit variables are incorporated together. Table 4-2 shows that the positive coefficients are still significantly different from zero at the level of 99% of confidence, although the statistical power of *Maturity* becomes somewhat weaker in Model 11. This result is consistent with Helwege and Turner (1999) who note that the yield curve for high-yield firms appears upward-sloping, holding credit quality constant.[23] We observe that the t-statistics increases from -1.79. to 3.70 after the crisis, indicating the evidence of flight-to-liquidity behavior during the post-crisis period.

Roll has positive signs and remains statistically significant at the 99% level in both periods. As aforementioned, the common prediction is that liquid assets have lower covariance than illiquid assets. Thus, the coefficients of *Roll* are expected to have positive signs on the relation with the yield spreads. From Table 4-1 and 4-2, we can see that our findings are coherent with our previous expectations. That is, *Roll* takes a positive sign regardless of model specifications and is still powerful as a determinant of yield spreads even if its t-statistic noticeably decreases from 23.32 to 5.93 during the post-crisis era (Model 11). In addition, *Roll* shows the best performance among liquidity variables in both periods; *Roll*'s

[23] Helwege and Turner (1999) claim that related prior works, including the study by Jarrow, Lando, and Turnbull (1997) who argue that the yield curve for high-grade corporate issuers looks upward-sloping and that for speculative-grade firms is downward-sloping or hump-shaped, are subject to the potential selection bias issue.

adjusted R-squares are highest with a value of 0.4990 and 0.2275 before and after the crisis, respectively (Model 4).

We can also see that the coefficients on *Coupon* show positive signs in all specifications and are statistically different from zero. This is presumably consistent with the hypothesis that the price of securities issued by firms with high default risk is heavily discounted other things being constant, thus firms raise coupon rates to bring the bond price as of issuance to par value.[24] Note that this interpretation differs from that of Longstaff, Mithal, and Neis (2005) who use the coupon rate of bonds as a non-default component in the spread.[25]

Before the crisis, the coefficient of *Equity Volatility* is negative and statistically insignificant from the full model (Model 11). During the post-crisis period, it is still statistically insignificant, but takes on a positive sign in the presence of all relevant variables.[26]

Next, *Rating* demonstrates a significantly positive relationship with the *Yield Spread* in each regression in both pre- and post-crisis periods. These results are supportive of a common expectation that the lower the credit quality, the higher the yield spreads. The t-statistic of *Rating* represents its stronger explanatory power after the crisis than before as it changes from 8.50 to 19.49. Perhaps, this result indicates the presence of the flight-to-quality behavior

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[24] According to our understanding, all Korean corporate bonds are issued at face value.

[25] Kim, Ramaswamy, and Sundaresan (1993) suggest a corporate bond valuation model to incorporate the default risk with the coupon rates in the presence of dividends. Schuermann (2004) argues that default is often declared when a periodic interest payment is missed. Thus, it is expected that a higher coupon rate often induces a higher likelihood to observe defaults.

[26] In contrast, other empirical results such as Covits and Downing (2007) indicate that the coefficient on *Equity Volatility* is significantly different from zero.

in the corporate bond market during the post-crisis period. In addition, *Rating* consistently exhibits the best performance among proxies for credit risk in both periods. The univariate analysis demonstrates that the adjusted R-square of *Rating* is highest with a value of 0.424 and 0.639 before and after the crisis, respectively (Model 8).

The coefficients of *Distance-to-Default* (*DtD*) show the negative signs and are statistically significant with a t-statistic of -3.35 before the crisis. Similarly, the coefficients on *DtD* after the crisis also have negative ones and are significantly different from zero with a higher t-statistic of -4.58. From this result, we can infer that *DtD*, like *Financial* dummy, seems to reflect the credit risk premium formed in the market after the crisis. This observation is also related to the flight-to-quality behavior among investors.[27]

We conclude that the chosen credit factors are to be more influential determinants of corporate bond spreads after the crisis, whereas the liquidity factors explain a relatively larger portion of the variation in yield spreads before the crisis.[28] Specifically, The adjusted R-square in Models 5 (Table 4-1), which only includes liquidity variables, is higher than that in Model 10, which only enters credit variables before the crisis. However, during the post-crisis period, the adjusted R-square in Models 10 (Table 4-2) is higher than that in Model 5. These results seemingly support the prevailing claim that the recent global crisis stemmed from a shortage of liquidity in the U.S. financial system. In particular, Korean bond investors, who

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[27] *Distance-to-Default* is a measure of a firm's leverage, which is scaled by its asset volatility. A low value of *Distance-to-Default* represents high leverage, and vice versa. Accordingly, increasing *Distance-to-Default* should decrease the probability of default, leading to lower yield spreads in general.

[28] We also run a separate regression of financial and non-financial firm groups before and after the crisis, respectively. However, the analysis results are consistent with the ones in section 4.1. Details are available upon request.

do not suffer from a *direct* liquidity shortage, tend to require more compensation for bearing credit risks relative to the liquidity premium effect in that they are concerned about the possibility that Korean economy would be in a (deep) recession in response to the liquidity dry-up in the U.S. financial market after the crisis.[29]

4. 2. Incremental Importance of Each Variable

Table 5-1 and 5-2 provide the regression results for eleven specifications and show the incremental importance of each variable. Specifically, the first five models include all credit variables; Model 1 omits all the liquidity variables, while Models 2 to 5 in turn consider each of the liquidity proxies. The next five models include all liquidity variables; Model 6 leaves out all the proxies for credit risk, Models 7 to 10 employ each of the credit variables in turn, and Model 11 employs all the variables we consider.

(Table 5-1 here)

(Table 5-2 here)

We see that *Financial* variable shows very different patterns between before and after the crisis. Specifically, it does not seem to be significant in a statistical sense before the crisis. As seen from Table 5-2, however, the coefficients of *Financial* after the crisis are statistically distinguishable from zero at the 99% level in all model specifications. The same pattern is observed in Table 4-1 and 4-2.

As seen from Table 5-1, the coefficients of *Trade Volume* are not statistically distinguishable from zero in all the models. Moreover, its signs change randomly. However, *Trade Volume* has significantly negative signs in Models 6 to 8 (Table 5-2). From this, it might be tempting to say that there is a strong negative relationship between *Yield Spread* and

[29] Refer to footnote 4.

Trade Volume, to make it consistent with a common liquidity interpretation. However, in Model 11 (Table 5-2), which controls for the relevant variables, the significance of *Trade Volume* noticeably declines, with a t-value of 0.76. One possible explanation for this phenomenon, as specified before, is that Korean corporate bonds are not traded as frequently as other securities such as stocks or sovereign bonds; thus, trading-based liquidity measures might not fully reflect all the relevant information in bond prices. Also, there might be a non-linear component to the effect of *Trade Volume* on *Yield Spread*.[30]

The coefficients of *Cash over Asset* are consistently positive in all specifications and are remarkably different from zero in both periods. These results are consistent with the observations from Tables 4-1 and 4-2.

Interestingly, the beta-coefficients on *Maturity* have positive signs, holding credit quality constant. However, they show the opposite signs when a specific issue's credit is not controlled for. This finding corresponds to that of Helwege and Turner (1999). In addition, the analysis results in Table 5-1 and 5-2 are congruous with the hypothesis that shorter-maturity bonds are more liquid than longer ones. Notice that the above-mentioned patterns regarding the coefficients of *Maturity* are coherent with those in Tables 4-1 and 4-2.

The coefficients of *Roll* are consistently positive in all specifications and are remarkably distinguishable from zero in both periods although its explanatory power considerably decreases between 2009 and 2011. This result is also consistent with the observations from Tables 4-1 and 4-2.

We can see from Table 5-1 that Model 5, which considers *Roll*, shows the best performance with an adjusted R-square of 0.8258 between 2007 and 2008. During the post-

[30] As a robustness check, other trading-based liquidity measures such as *Amihud* or *Turnover* will be explored in the following section.

crisis period, the incremental importance of *Roll*, among all liquidity proxies, is also highest; the adjusted R-square rises by 1.73% with the addition of the *Roll* term to Model 1.

The regression coefficients for *Coupon* are significant and positive in all specifications in a consistent manner both before and after the crisis. We note that the significance of *Coupon*, a proxy for credit risk, has increased remarkably after the crisis. From this finding, we might infer that markets are more sensitive to credit quality during the post-crisis era.

The coefficients of *Equity Volatility* look quite unstable in terms of its signs and are statistically insignificant in both periods. These results are also coherent with the observations in Tables 4-1 and 4-2.

Rating also shows a significantly positive relationship with *Yield Spread* in all the regressions, clearly demonstrating the inverse relationship between spreads and credit qualities in both Tables 5-1 and 5-2. We also find that the statistical significance of *Rating* considerably increases more than that of *Coupon* after the crisis.

The coefficients on *Distance-to-Default* have negative signs and are significant at the 99% level in both periods (Full model). *Distance-to-Default* shows the best performance with a t-value of -8.00 in Model 10 (Table 5-1) where *Rating* variable is not included together; yet, its significance considerably declines if *Rating* is controlled for. However, the coefficient is still significantly different from zero in this case. The similar pattern can be also found in Table 5-2. This is likely owing to a high correlation between *Rating* and *Distance-to-Default*. Thus, perhaps the two terms seem to absorb each other's explanatory power when they are considered in a regression at the same time.

As seen from Model 7 to 10, the incremental importance of *Rating* is highest among all four credit proxies in both periods; an adjusted R-square rises by 12.08% with the addition of *Rating* term to Model 6 before the crisis, and by about 30% after the crisis. Model 7, which considers *Coupon*, exhibits the second-highest increase in the adjusted R-square before the crisis, and Model 8, which includes *Distance-to-Default*, shows the second-highest increase after. Moreover, as Table 5-1 and 5-2 suggest, while liquidity risk seems to better explain the behaviors of yield spreads before the crisis, credit risk appears to be a more important determinant of corporate spreads in the Korean bond markets after the global financial crisis. This pattern is also consistent with that in Table 4-1 and 4-2.

4. 3. Robustness Check with Alternative Liquidity Measures

In the previous section, we observe that *Trade Volume* was not sufficiently powerful as a liquidity factor to explain the yield spreads. One of the most persuasive explanations for this is that *Trade Volume* itself might not be a good liquidity measure specific to Korean corporate bond market. Thus, in this section, we try to see whether alternative trading-based liquidity factors show a strong explanatory power, or we should assert that trading-based might not contain the sufficient information on bond prices in general.

The new trading-based liquidity variables to be used instead of *Trade Volume* are *Amihud* and *Turnover*. First, *Amihud* measures the price impact of a trade per unit traded and is defined as the average of absolute value of returns r_i divided by the trade volume Q_i in the form of

$$Amihud = \frac{1}{N_t} * \sum_{i=1}^{N_t} \frac{|r_i|}{Q_i}$$

One advantage of *Amihud* measure is that it is simple to calculate and intuitive. This is expected to have a positive relation with the yield spreads.

The second alternative trading-based liquidity variable is *Turnover*, which is calculated as the total trade volume divided by total amount outstanding. It is expected to have the inverse relation with the yield spreads.

The regression results for each sample with *Amihud* are presented in Table 6-1 (before the crisis) and Table 6-2 (after the crisis). Models 1 includes only all liquidity proxies—*Amihud*, *Cash over Asset*, *Maturity*, and *Roll* whereas Model 2 enters all credit variables—*Coupon*, *Equity Volatility*, *Rating*, and *Distance-to-Default*. Models 3 employs all the variables and Model 4 adds the square term of *Equity Volatility* to the Model 3.

(Table 6-1 here)

(Table 6-2 here)

Financial dummy shows the similar pattern with the previous results in Table 4s and Table5s; *Financial* does not seem to be significantly different from zero, especially from the full model. However, its coefficients become statistically powerful at the 99% level after the crisis as reported by Table 6-2; a t-statistic of *Financial* remarkably increases from 1.05 to 6.20. We also see that the signs of *Financial* change from negative to positive when *Rating* is controlled for.

The coefficients of *Amihud* show negative signs, remaining statistically insignificant during the pre-crisis period. After the crisis, however, its coefficients become significant at the 99% level of confidence; when credit variables are included in the regression (Model 3 and 4), the statistical significance of *Amihud* declines, but is still powerful with a t-statistic of 9.27 and 8.75, respectively. The signs of it are also congruous with our previous expectation; the positive relation between *Amihud* and *Yield Spread*. Accordingly, we guess that *Amihud* leaves a room for a strong candidate for the attractive trading-based liquidity measure, especially for the post-crisis period.

The coefficients of *Cash over Asset* exhibit positive signs in both pre- and post-crisis periods as seen from Table 6-1 and 6-2, and remain statistically different from zero. This finding is also coherent with the previous empirical outcomes in Table 4s and 5s.

Maturity has a negative sign and remains statistically distinguishable from zero before the crisis. However, its coefficients after the crisis have positive signs and are significant at the 99% level as well. Particularly, its signs change from negative to positive during the post-crisis era, holding for credit quality. This result is consistent with Helwege and Turner (1999).

The coefficients on *Roll* are significantly positive at the 99% level in both periods. We can also find from Table 6s that although the t-statistic of *Roll* considerably decreases from 22.7 to 7.32 (Model 4), it is still remarkably significant as a determinant of yield spreads.

The coefficients of *Coupon*, as before, show positive signs and are statistically different from zero in all specifications. The t-statistic of *Coupon* slightly decreases from 7.87 to 5.85 during the post-crisis period. The findings are similar with the previous observations in Table 4s and 5s.

The coefficients on *Equity Volatility* are statistically insignificant in Model 3, but, interestingly, both *Equity Volatility* and its squared term exhibit statistical significance in both periods (Model 4). From the full model (Table 6-1), one can see that the marginal effect of *Equity Volatility* on *Yield Spread* is given by

$$\frac{\partial(Yield\ Spread)}{\partial(Equity\ Voltility)} = -0.142 + 0.008 * Equity\ Volatility \qquad (1)$$

From the full model (Table 6-2), one can see that the marginal effect of *Equity Volatility* on *Yield Spread* is given by

$$\frac{\partial(Yield\ Spread)}{\partial(Equity\ Voltility)} = -0.194 + 0.016 * Equity\ Volatility \qquad (2)$$

Equation (1) and (2) tell that, ceteris paribus, a higher level of *Equity Volatility* depresses spreads; yet, at a high level of *Equity Volatility*, an increase in volatility rather boosts spreads. One possible interpretation for this is that when the level of *Equity Volatility* is low, one unit of increase in volatility hikes expected profits, attracting more investors and outweighing the compensation for increased risk that investors bear. Above a certain level of risk, however, as the probability of default increases sharply, investors might require more compensation for the risk.

Next, *Rating* shows the similar patterns with the previous empirical results; it demonstrates a significantly positive relationship with the yield spread in both pre- and post-crisis periods. The t-statistics of *Rating* dramatically increased after markets have passed through the financial crisis.

The estimated coefficients of *Distance-to-Default* show negative signs, as expected, and are statistically significant with a t-statistic of -3.91 before the crisis, and of -3.83 after.

We can also confirm from the adjusted R-square that the chosen liquidity factors explain a relatively larger portion of the variation in yield spreads between 2007 and 2008. Presumably, this is because the recent global crisis began with liquidity crisis made in U.S., and such shock hit on the Korean economy. However, credit factors seem to be more influential determinants of corporate bond spreads between 2009 and 2011. Worth to explore is that market participants' caution shifts from liquidity risk to credit during the post-crisis period though liquidity factors are still important.

Now we turn to the results with the *Turnover* measure. The regression results for each sample are presented in Table 7-1 (before the crisis) and Table 7-2 (after the crisis). Models 1 includes only all liquidity proxies—*Turnover*, *Cash over Asset*, *Maturity*, and *Roll* whereas Model 2 enters only all credit variables—*Coupon*, *Equity Volatility*, *Rating*, and *Distance-to-Default*. Models 3 employs all the variables and Model 4 includes the square term of *Equity Volatility* into Model 3.

(Table 7-1 here)

(Table 7-2 here)

Financial dummy show the similar behaviors with the previous ones in Table 6s. Concretely, it is not significantly distinguishable from zero before the crisis, especially from the full model, however, the coefficients become statistically significant at the 99% level after the crisis as reported by Table 7-2; a t-statistics of *Financial* remarkably increases from 0.77 to 5.91.

Table 7-1 indicates that the coefficients of *Turnover* have positive signs, remaining statistically significant during the pre-crisis period. After the crisis, however, those of *Turnover* become significantly negative at the 99% level of confidence, producing somewhat perplexing outcomes between the two sample periods. The post-crisis results are congruous with our previous expectation; the higher *Turnover* the lower *Yield Spread*.

The coefficient on *Cash over Asset* consistently exhibits positive signs and remains statistically different from zero in both pre- and post-crisis periods.

The coefficients of *Maturity* have positive signs and are statistically significant after the crisis. Note that its sign changes from negative to positive, holding for credit quality during the post-crisis period.

Roll variable shows the similar pattern with in Table 6s; it has positive signs and remains statistically different from zero at the 99% level in both periods. We also find that even if t-statistics of *Roll* considerably decreases from 24.6 to 5.65 (Model 4), *Roll* is still powerful as a determinant of yield spreads.

The coefficients on *Coupon* are also significantly positive in all specifications. The findings in Table 7s are similar with the previous ones in Table 6s.

Equity Volatility's coefficient, as before, is not statistically crucial (Model 3) in both periods. Surprisingly, the coefficients of both *Equity Volatility* and its squared term show statistical importance in both periods as those in Table 6s. Specifically, the coefficient on *Equity Volatility* is significantly negative and the coefficient on its square term is significantly positive in both periods. From the full model (Table 7-1), one can see that the marginal effect of *Equity Volatility* on *Yield Spread* is given by

$$\frac{\partial(Spread)}{\partial(Equity\ Voltility)} = -0.134 + 0.008 * Equity\ Volatility \qquad (3)$$

From the full model (Table 7-2), one can see that the marginal effect of *Equity Volatility* on *Yield Spread* is given by

$$\frac{\partial(Spread)}{\partial(Equity\ Voltility)} = -0.257 + 0.02 * Equity\ Volatility \qquad (4)$$

Equation (3) and (4) imply that, other things constant, a higher level of *Equity Volatility* depresses spreads; yet, at a high level of *Equity Volatility*, an extra unit of volatility increases spreads.

Rating demonstrates a significantly positive relation with *Yield Spread* in both periods. The t-statistic of *Rating* shows its stronger explanatory power after the crisis than before; it dramatically increases from 9.28 to 20.44.

The coefficients of *Distance-to-Default* (*DtD*) show negative signs and are statistically powerful at the 99% level of confidence. This finding is consistent with our expectation that a negative relation between the *DtD* and bond spreads.

We can also see that liquidity risks seem to be more powerful determinants of bond spreads before the crisis, but the relative importance between liquidity and credit risk reverses during the post-crisis period in the sense that credit risks better explain the variation in yield spreads.

5. Summary and Concluding Remarks

This study employs Korean corporate bond data to analyze the relative importance of liquidity and credit proxies as the determinants of yield spreads. The data set includes the transactions of corporate bonds issued by both financial and non-financial firms listed on the Korean Exchange from March 1, 2007 to December 31, 2011.

While the results of this paper suggest a significant non-default component in corporate spreads before the crisis, they also indicate that credit risk is the dominant determinant of corporate bond spreads during the post-crisis; Market participants seem to more care about default risk after the crisis than before. These results are robust to alternative proxies for liquidity risk with various specifications.

This study also examines the incremental importance of each liquidity and credit variable. Our analysis results indicate that the *Roll* variable demonstrates the highest contribution to the quality of fit among liquidity proxies in both periods, controlling for all credit proxies—*Coupon, Equity Volatility, Rating, and Distance-to-Default*. Among the credit proxies, *Rating* exhibits the highest marginal contribution when controlling for the relevant liquidity proxies.

Moreover, we explore whether other trading-based liquidity measures are significant determinants of spreads by replacing *Trade Volume* with *Amihud* and *Turnover* in each regression model. Empirical results indicate that *Amihud* measure reveals fairly good explanatory power, especially during the post-crisis period.

This study also examines whether there is a quadratic component in *Equity Volatility* in the presence of *Amihud* and *Turnover*, respectively. Our analysis shows that the squared terms of *Equity Volatility* are statistically significant in both pre- and post- periods, suggesting a quadratic element to the effect of *Equity Volatility* on *Yield Spread*.

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Figure 1.

Time-Series Plot of the Proxies for Credit Premium in the Market

The plot shows the time series of the difference between 3-year corporate bond yields with a BBB- credit rating and the corresponding risk-free interest rate as a proxy for financial market liquidity or a global change in credit risk. (Source: Bank of Korea)

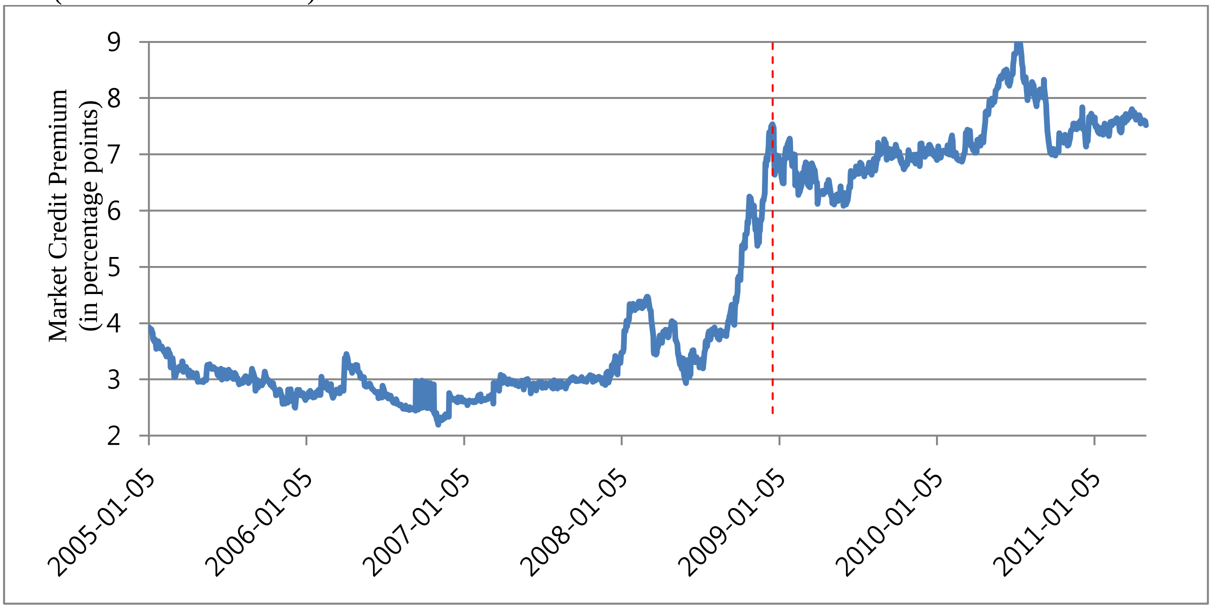

Table 1-1
Summary of Sample Composition

This study considers only investment-grade firms (rated BBB- or higher). The total firms in the sample number 66 and total bond issues, 284. The sub-sample period is March 1, 2007 to December 31, 2008.

	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	Total
Number of Firms	5	7	5	14	9	10	7	4	4	1	66
Number of Issues	64	34	17	49	30	42	21	11	13	3	284

Table 1-2
Summary of Sample Composition

This study considers only investment-grade firms (rated BBB- or higher). The total firms in the sample number 118 and total bond issues, 558. The sub-sample period is January 1, 2009 to December 31, 2011

	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	Total
Number of Firms	6	10	10	25	17	22	15	6	6	1	118
Number of Issues	119	54	35	93	70	92	48	20	26	1	558

Table 2-1
Summary Statistics

The table shows the summary statistics for variables used in the regression analysis. The variable "Yield Spread" is the difference between the yield-to-maturity on a corporate bonds and the corresponding risk-free rate; "Trade Volume" is the average of the total trading volume during which a specific issue is outstanding (in x10^8 Korean won); "Cash over Asset" is the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; "Maturity" is the years to maturity of the bonds; "Roll" is defined as two times the square root of absolute value of the covariance between consecutive returns; "Coupon" is the annual coupon interest; "Equity Volatility" is the volatility of the firm's daily equity returns during which a specific issue is outstanding; "Rating" is the credit rating assigned to each security, coded so that AAA=1; and "Distance-to-Default" is the probability of default based on Merton (1974). The sub-sample period is March 1, 2007 to December 31, 2008; the sample includes 284 bond issues.

Variable	Mean	Std. Dev.	Min	Med	Max
Yield Spread	1.2392	0.5768	0.3221	1.1191	3.2732
Trade Volume	52.834	68.885	0.4546	28.571	733.50
Cash over Asset	0.2151	0.1665	0.0106	0.1792	0.7976
Maturity	3.9824	1.5137	2.0000	3.0000	10.000
Roll	1.5080	0.4425	0.4604	1.5672	2.6363
Coupon	5.4638	0.9127	1.5000	5.3300	9.0000
Equity Volatility	17.394	4.0067	8.7521	18.017	25.907
Rating	4.4578	2.6132	1.0000	5.0000	10.000
Distance-to-Default	2.1406	1.3603	-0.0910	2.0543	6.0906

Table 2-2
Summary Statistics

The sub-sample period is January 1, 2009 to December 31, 2011; the sample includes 558 bond issues. For more details, see the notes for Table 2-1.

Variable	Mean	Std. Dev.	Min	Med	Max
Yield Spread	1.4701	1.1663	0.3631	1.0144	5.9820
Trade Volume	107.83	107.98	1.6667	74.457	807.78
Cash over Asset	0.2291	0.1633	0.0076	0.2102	0.8314
Maturity	3.5547	1.4960	1.5000	3.0000	10.000
Roll	1.3009	0.7339	0.3116	1.2024	4.7753
Coupon	5.9134	1.4165	0.0000	5.6500	10.700
Equity Volatility	12.314	2.7081	5.7174	12.266	21.293
Rating	4.2742	2.4055	1.0000	4.0000	10.000
Distance-to-Default	2.2839	1.2200	-0.3538	2.1988	7.2941

Table 3-1

Pair-wise Correlations between Independent Variables

The table shows the pair-wise correlation coefficients for the variables used in the regression analysis. The variable “Trade Volume” is the average of the total trading volume during which a specific issue is outstanding (in x10^8 Korean won); “Cash over Asset” is the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; “Maturity” is the years to maturity of the bonds; “Roll” is defined as two times the square root of absolute value of the covariance between consecutive returns; “Coupon” is the annual coupon interest; “Equity Volatility” is the volatility of the firm’s daily equity returns during which a specific issue is outstanding; “Rating” is the credit rating assigned to each security, coded so that AAA=1; and “Distance-to-Default” is the probability of default based on Merton (1974). The sample period is March 1, 2007 to December 31, 2008; the sample includes 284 bond issues.

	Trade Volume	Cash over Asset	Maturity	Roll	Coupon	Equity Volatility	Rating
Cash over Asset	-0.1719						
Maturity	-0.0022	-0.2341					
Roll	-0.0649	0.0576	0.0915				
Coupon	-0.0519	0.2867	-0.2927	0.1322			
Equity Volatility	-0.0676	0.2156	-0.3893	0.2953	0.3692		
Rating	-0.2739	0.4641	-0.5161	0.1823	0.4279	0.5577	
Distance-to-Default	0.0299	0.2857	0.1801	-0.1174	-0.2555	-0.5003	-0.1439

Table 3-2

Pair-wise Correlations between Independent Variables

The sample period is January 1, 2009 to December 31, 2011; the sample includes 558 bond issues. For more details, see the notes for Table 3-1.

	Trade Volume	Cash over Asset	Maturity	Roll	Coupon	Equity Volatility	Rating
Cash over Asset	-0.0332						
Maturity	-0.1044	-0.1839					
Roll	-0.2743	0.0098	-0.0693				
Coupon	-0.1724	0.1283	-0.3838	0.5118			
Equity Volatility	0.0140	-0.0099	-0.2216	0.0939	0.0770		
Rating	-0.2376	0.3976	-0.4430	0.2778	0.3728	0.2665	
Distance-to-Default	0.1313	-0.0234	0.2668	-0.1354	-0.2147	-0.2940	-0.3662

Table 4-1
The Determinants of Corporate Yield Spreads (Before the Crisis)

The table shows the regression results for the sample of 284 bond issues from March 1, 2007 to December 31, 2008. The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are: “Financial,” a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; “Trade Volume,” the average of the total trading volume during which a specific issue is outstanding (in x10^8 Korean won); “Cash over Asset,” the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; “Maturity,” the years to maturity of the bonds; “Roll” is defined as two times the square root of absolute value of the covariance between consecutive returns; “Coupon,” the annual coupon interest; “Equity Volatility,” the volatility of the firm’s daily equity returns during which a specific issue is outstanding; “Rating,” the credit rating assigned to each security, coded so that AAA=1; and “Distance-to-Default,” the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and ‘*,’ ‘**,’ and ‘***’ indicate significance at the 10%, 5%, and 1% levels, respectively. There are 66 firms in the sample.

	Model										
	1	2	3	4	5	6	7	8	9	10	11
Intercept	1.3252***	1.0154***	1.7466***	-0.0337	0.1659	-0.5762***	0.0293	0.5007***	1.7430***	-0.5600**	-0.9351***
	(31.06)	(16.20)	(19.42)	(-0.38)	(1.70)	(-3.43)	(0.22)	(7.56)	(25.96)	(-2.52)	(-5.95)
Financial	-0.3733***	-0.1634*	-0.3827***	-0.2590***	-0.0555	-0.3829***	-0.2522***	0.2112**	-0.6812***	-0.0239	0.0444
	(-3.98)	(-1.69)	(-4.41)	(-3.87)	(-0.91)	(-5.08)	(-3.16)	(2.50)	(-7.47)	(-0.24)	(0.73)
Trade Volume	-0.0005				-0.0002						0.0005**
	(-1.02)				(-0.65)						(2.18)
Cash over Asset		1.1607***			0.8643***						0.5624***
		(5.48)			(6.38)						(5.36)
Maturity			-0.1122***		-0.1167***						-0.0211*
			(-5.35)		(-8.70)						(-1.79)
Roll				0.8713***	0.9092***						0.7750***
				(15.75)	(20.28)						(23.32)
Coupon						0.3434***				0.1891***	0.1500***
						(11.37)				(6.26)	(8.47)
Equity Volatility							0.0719***			0.0235***	-0.0077
							(9.86)			(2.75)	(-1.48)
Rating								0.1582***		0.0906***	0.0822***
								(13.39)		(6.39)	(8.50)
Distance-to-Default									-0.1849***	-0.0198	-0.0537***
									(-7.54)	(-0.78)	(-3.35)
Adj.-R Square	0.0602	0.1477	0.1439	0.4990	0.6746	0.3539	0.2992	0.4240	0.2155	0.5220	0.8445

Table 4-2

The Determinants of Corporate Yield Spreads (After the Crisis)

The table shows the regression results for the sample of 558 bond issues from January 1, 2009 to December 31, 2011. The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are:“Financial,” a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; “Trade Volume,” the average of the total trading volume during which a specific issue is outstanding (in x10^8 Korean won); “Cash over Asset,” the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; “Maturity,” the years to maturity of the bonds; “Roll” is defined as two times the square root of absolute value of the covariance between consecutive returns; “Coupon,” the annual coupon interest; “Equity Volatility,” the volatility of the firm’s daily equity returns during which a specific issue is outstanding; “Rating,” the credit rating assigned to each security, coded so that AAA=1; and “Distance-to-Default,” the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and ‘*,’ ‘**,’ and ‘***’ indicate significance at the 10%, 5%, and 1% levels, respectively. There are 118 firms in the sample.

	Model										
	1	2	3	4	5	6	7	8	9	10	11
Intercept	1.8640***	1.1118***	2.5535***	0.7470***	1.4198***	-0.9450***	0.3294	-0.4644***	2.7489***	-1.0479***	-1.7009***
	(27.72)	(12.22)	(22.15)	(7.85)	(8.32)	(-5.36)	(1.53)	(-5.98)	(30.14)	(-5.13)	(-6.72)
Financial	-0.8340***	-0.5837***	-0.8420***	-0.6349***	-0.3002***	-0.6976***	-0.9090***	0.6190***	-1.1413***	0.3366***	0.5448***
	(-6.56)	(-4.35)	(-6.91)	(-5.22)	(-2.62)	(-6.30)	(-7.21)	(6.42)	(-10.12)	(3.48)	(5.71)
Trade Volume	-0.0024***				-0.0018***						0.0002
	(-5.67)				(-4.85)						(0.76)
Cash over Asset		1.9661***			1.7324***						0.7398***
		(6.56)			(6.80)						(4.28)
Maturity			-0.2674***		-0.2337***						0.0779***
			(-9.00)		(-8.90)						(3.70)
Roll				0.6328***	0.5575***						0.2497***
				(10.47)	(10.05)						(5.93)
Coupon						0.4270***				0.2243***	0.1826***
						(14.97)				(11.05)	(7.97)
Equity Volatility							0.1043***			-0.0030	0.0001
							(6.14)			(-0.28)	(0.01)
Rating								0.4298***		0.3369***	0.3448***
								(29.41)		(20.40)	(19.49)
Distance-to-Default									-0.4811***	-0.1162***	-0.1145***
									(-14.27)	(-4.41)	(-4.58)
Adj.-R Square	0.1256	0.1416	0.1929	0.2275	0.4051	0.3411	0.1338	0.6385	0.3233	0.7133	0.7436

Table 5-1

The Incremental Importance of Each Variable (Before the Crisis)

The table shows the regression results for the full sample of 283 bond issues from March 1, 2007 to December 31, 2008. The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are: “Financial,” a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; “Trade Volume,” the average of the total trading volume during which a specific issue is outstanding (in $x10^8$ Korean won); “Cash over Asset,” the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; “Maturity,” the years to maturity of the bonds; “Roll,” the two times the square root of absolute value of the covariance between consecutive returns; “Coupon,” the annual coupon interest; “Equity Volatility,” the volatility of the firm’s daily equity returns during which a specific issue is outstanding; “Rating,” the credit rating assigned to each security, coded so that AAA=1; and “Distance-to-Default,” the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and ‘*,’ ‘**,’ and ‘***’ indicate significance at the 10%, 5%, and 1% levels, respectively.

	Model										
	1	2	3	4	5	6	7	8	9	10	11
Intercept	-0.5599**	-0.5549**	-0.4196*	-0.8902***	-1.2651***	0.1659*	-0.9948***	-0.3234**	-0.6417***	0.3908***	-0.9351***
	(-2.52)	(-2.49)	(-1.84)	(-3.32)	(-9.17)	(1.70)	(-7.70)	(-2.43)	(-6.44)	(4.23)	(-5.95)
Financial	-0.0239	-0.0344	-0.0149	0.0580	0.0895	-0.0555	-0.1341***	-0.0237	0.2962***	-0.2353***	0.0444
	(-0.24)	(-0.34)	(-0.15)	(0.55)	(1.49)	(-0.91)	(-2.63)	(-0.40)	(5.31)	(-3.94)	(0.73)
Trade Volume		0.0002				-0.0002	-0.0001	-0.0002	0.0005*	0.0002	0.0005**
		(0.65)				(-0.65)	(-0.43)	(-0.60)	(1.90)	(0.65)	(2.18)
Cash over Asset			0.4346**			0.8643***	0.5252***	0.8262***	0.6050***	1.0775***	0.5624***
			(2.40)			(6.38)	(4.54)	(6.36)	(5.53)	(8.60)	(5.36)
Maturity				0.0428**		-0.1167***	-0.0836***	-0.0866***	-0.0154	-0.0878***	-0.0211*
				(2.17)		(-8.70)	(-7.32)	(-6.13)	(-1.16)	(-6.95)	(-1.79)
Roll					0.7497***	0.9092***	0.8378***	0.8285***	0.7977***	0.8351***	0.7750***
					(22.04)	(20.28)	(22.35)	(18.13)	(21.80)	(20.12)	(23.32)
Coupon	0.1891***	0.1885***	0.1734***	0.1880***	0.1715***		0.2228***				0.1500***
	(6.26)	(6.23)	(5.65)	(6.26)	(9.39)		(11.48)				(8.47)
Equity Volatility	0.0235***	0.0226***	0.0201**	0.0266***	0.0006			0.0283***			-0.0077
	(2.75)	(2.63)	(2.35)	(3.10)	(0.11)			(5.14)			(-1.48)
Rating	0.0906***	0.0922***	0.0819***	0.1078***	0.0987***				0.1207***		0.0822***
	(6.39)	(6.41)	(5.64)	(6.68)	(11.52)				(12.85)		(8.50)
Distance-to-Default	-0.0198	-0.0222	-0.0441	-0.0100	-0.0131					-0.1238***	-0.0537***
	(-0.78)	(-0.86)	(-1.62)	(-0.39)	(-0.85)					(-8.00)	(-3.35)
Adj.-R Square	0.5220	0.5210	0.5300	0.5283	0.8258	0.6746	0.7787	0.7019	0.7954	0.7347	0.8445

Table 5-2

The Incremental Importance of Each Variable (After the Crisis)

The table shows the regression results for the sample of 567 bond issues from January 1, 2009 to December 31, 2011. The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are: "Financial," a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; "Trade Volume," the average of the total trading volume during which a specific issue is outstanding (in $x10^8$ Korean won); "Cash over Asset," the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; "Maturity," the years to maturity of the bonds; "Roll," the two times the square root of absolute value of the covariance between consecutive returns; "Coupon," the annual coupon interest; "Equity Volatility," the volatility of the firm's daily equity returns during which a specific issue is outstanding; "Rating," the credit rating assigned to each security, coded so that AAA=1; and "Distance-to-Default," the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and '*,' '**,' and '***' indicate significance at the 10%, 5%, and 1% levels, respectively.

	Model										
	1	2	3	4	5	6	7	8	9	10	11
Intercept	-1.0479***	-1.0028***	-1.1500***	-1.6841***	-0.9974***	1.4198***	-0.0085	0.5355**	-1.1461***	2.0254***	-1.7009***
	(-5.13)	(-4.84)	(-5.60)	(-6.81)	(-5.04)	(8.32)	(-0.03)	(2.11)	(-7.08)	(12.42)	(-6.72)
Financial	0.3366***	0.3318***	0.3735***	0.4203***	0.4218***	-0.3002***	-0.3226***	-0.3158***	0.7790***	-0.5520***	0.5448***
	(3.48)	(3.43)	(3.87)	(4.34)	(4.45)	(-2.62)	(-2.95)	(-2.81)	(8.41)	(-5.23)	(5.71)
Trade Volume		-0.0003				-0.0018***	-0.0015***	-0.0018***	0.00005	-0.0012***	0.0002
		(-1.29)				(-4.85)	(-4.34)	(-4.99)	(0.17)	(-3.66)	(0.76)
Cash over Asset			0.5593***			1.7324***	1.5946***	1.7764***	0.7607***	1.6190***	0.7398***
			(3.12)			(6.80)	(6.53)	(7.10)	(4.13)	(7.04)	(4.28)
Maturity				0.0915***		-0.2337***	-0.1534***	-0.2070***	0.0236	-0.1563***	0.0779***
				(4.41)		(-8.90)	(-5.61)	(-7.84)	(1.10)	(-6.34)	(3.70)
Roll					0.2499***	0.5575***	0.3369***	0.5360***	0.4217***	0.4883***	0.2497***
					(6.03)	(10.05)	(5.54)	(9.80)	(10.68)	(9.69)	(5.93)
Coupon	0.2243***	0.2222***	0.2247***	0.2471***	0.1613***		0.2431***				0.1826***
	(11.05)	(10.92)	(11.16)	(11.98)	(7.24)		(7.37)				(7.97)
Equity Volatility	-0.0030	-0.0016	-0.00004	0.0011	-0.0064			0.0659***			0.0001
	(-0.28)	(-0.16)	(0.00)	(0.11)	(-0.63)			(4.63)			(0.01)
Rating	0.3369***	0.3334***	0.3230***	0.3629***	0.3390***				0.3934***		0.3448***
	(20.4)	(19.92)	(19.02)	(21.0)	(21.2)				(23.69)		(19.49)
Distance-to-Default	-0.1162***	-0.1149***	-0.1208***	-0.1153***	-0.1085***					-0.3437***	-0.1145***
	(-4.41)	(-4.36)	(-4.62)	(-4.45)	(-4.24)					(-11.29)	(-4.58)
Adj.-R Square	0.7133	0.7137	0.7178	0.7226	0.7306	0.4051	0.4574	0.4263	0.7047	0.5159	0.7436

Table 6-1

Quadratic Terms with Amihud Measure (Before the Crisis)

The table shows the regression results for specifications that include quadratic terms of "Equity Volatility" from March 1, 2007 to December 31, 2008, represented as "Equity Volatility Sq" The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are: "Financial," a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; "Amihud," the average of absolute returns divided by the trade size; "Cash over Asset," the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; "Maturity," the years to maturity of the bonds; "Roll," the two times the square root of absolute value of the covariance between consecutive returns; "Coupon," the annual coupon interest; "Equity Volatility," the volatility of the firm's daily equity returns during which a specific issue is outstanding; "Rating," the credit rating assigned to each security, coded so that AAA=1; and "Distance-to-Default," the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and '*,' '**,' and '***' indicate significance at the 10%, 5%, and 1% levels, respectively.

	Model			
	1	2	3	4
Intercept	0.0453	-0.5599**	-0.9314***	0.3309
	(0.47)	(-2.52)	(-5.88)	(1.17)
Financial	-0.0511	-0.0239	0.0609	0.0611
	(-0.87)	(-0.24)	(0.99)	(1.05)
Amihud	0.5952***		-0.0832	-0.0046
	(3.83)		(-0.70)	(-0.04)
Cash over Asset	0.7551***		0.5526***	0.4422***
	(5.58)		(5.19)	(4.26)
Maturity	-0.1151***		-0.0224*	-0.0336***
	(-8.80)		(-1.86)	(-2.88)
Roll	0.9547***		0.7655***	0.7780***
	(21.11)		(21.37)	(22.70)
Coupon		0.1891***	0.1532***	0.1367***
		(6.26)	(8.56)	(7.87)
Equity Volatility		0.0235***	-0.0060	-0.1421***
		(2.75)	(-1.15)	(-5.40)
Equity Volatility Sq				0.0040***
				(5.27)
Rating		0.0906***	0.0800***	0.0813***
		(6.39)	(8.13)	(8.66)
Distance-to-Default		-0.0198	-0.0490***	-0.0603***
		(-0.78)	(-3.07)	(-3.91)
Adj.-R Square	0.6905	0.5220	0.8421	0.8561

Table 6-2

Quadratic Terms with Amihud Measure (After the Crisis)

The table shows the regression results for specifications that include quadratic terms of “Equity Volatility” from January 1, 2009 to December 31, 2011, represented as “Equity Volatility Sq” The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are: “Financial,” a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; “Amihud,” the average of absolute returns divided by the trade size; “Cash over Asset,” the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; “Maturity,” the years to maturity of the bonds; “Roll,” the two times the square root of absolute value of the covariance between consecutive returns; “Coupon,” the annual coupon interest; “Equity Volatility,” the volatility of the firm’s daily equity returns during which a specific issue is outstanding; “Rating,” the credit rating assigned to each security, coded so that AAA=1; and “Distance-to-Default,” the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and ‘*,’ ‘**,’ and ‘***’ indicate significance at the 10%, 5%, and 1% levels, respectively.

	Model			
	1	2	3	4
Intercept	0.4592***	-1.0479***	-1.3845***	-0.1748
	(3.57)	(-5.13)	(-6.70)	(-0.40)
Financial	-0.0824	0.3366***	0.5029***	0.5500***
	(-0.88)	(3.48)	(5.70)	(6.20)
Amihud	4.1892***		1.9268***	1.8227***
	(18.04)		(9.27)	(8.75)
Cash over Asset	1.0593***		0.6032***	0.5984***
	(5.04)		(3.74)	(3.74)
Maturity	-0.1015***		0.0687***	0.0596***
	(-4.62)		(3.62)	(3.14)
Roll	0.4911***		0.2650***	0.2839***
	(11.19)		(6.85)	(7.32)
Coupon		0.2243***	0.1345***	0.1276***
		(11.05)	(6.15)	(5.85)
Equity Volatility		-0.0030	0.0005	-0.1938***
		(-0.28)	(0.05)	(-3.23)
Equity Volatility Sq				0.0077***
				(3.28)
Rating		0.3369***	0.2818***	0.2888***
		(20.4)	(16.43)	(16.85)
Distance-to-Default		-0.1162***	-0.0830***	-0.0896***
		(-4.41)	(-3.54)	(-3.83)
Adj.-R Square	0.6098	0.7133	0.7781	0.7820

Table 7-1
Quadratic Terms with Turnover Measure (Before the Crisis)

The table shows the regression results for specifications that include quadratic terms of “Equity Volatility” from March 1, 2007 to December 31, 2008, represented as “Equity Volatility Sq” The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are: “Financial,” a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; “Turnover,” the total trading volume divided by the outstanding amount; “Cash over Asset,” the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; “Maturity,” the years to maturity of the bonds; “Roll,” the two times the square root of absolute value of the covariance between consecutive returns; “Coupon,” the annual coupon interest; “Equity Volatility,” the volatility of the firm’s daily equity returns during which a specific issue is outstanding; “Rating,” the credit rating assigned to each security, coded so that AAA=1; and “Distance-to-Default,” the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and ‘*,’ ‘**,’ and ‘***’ indicate significance at the 10%, 5%, and 1% levels, respectively.

	Model			
	1	2	3	4
Intercept	0.0644	-0.5600**	-0.9757***	0.1956
	(0.64)	(-2.52)	(-6.30)	(0.70)
Financial	-0.0840	-0.0239	0.0391	0.0441
	(-1.40)	(-0.24)	(0.65)	(0.77)
Turnover	121.82**		131.84***	111.91***
	(2.49)		(3.88)	(3.40)
Cash over Asset	0.8736***		0.5508***	0.4574***
	(6.53)		(5.37)	(4.56)
Maturity	-0.1062***		-0.0129	-0.0235**
	(-7.65)		(-1.09)	(-2.03)
Roll	0.9000***		0.7671***	0.7720***
	(20.21)		(23.46)	(24.60)
Coupon		0.1891***	0.1486***	0.1349***
		(6.26)	(8.55)	(7.98)
Equity Volatility		0.0235***	-0.0087*	-0.1340***
		(2.75)	(-1.70)	(-5.22)
Equity Volatility Sq				0.0037***
				(4.97)
Rating		0.0906***	0.0815***	0.0836***
		(6.39)	(8.69)	(9.28)
Distance-to-Default		-0.0198	-0.0517***	-0.0621***
		(-0.78)	(-3.31)	(-4.11)
Adj.-R Square	0.6812	0.5220	0.8500	0.8620

Table 7-2
Quadratic Terms with Turnover Measure (After the Crisis)

The table shows the regression results for specifications that include quadratic terms of "Equity Volatility" from January 1, 2009 to December 31, 2011, represented as "Equity Volatility Sq" The dependent variable is the difference between the yield-to-maturity on a corporate bond and the corresponding risk-free rate. The independent variables are: "Financial," a dummy variable indicating whether a firm is a financial institution, coded so that a financial firm=1; "Turnover," the total trading volume divided by the outstanding amount; "Cash over Asset," the ratio of the sum of cash and marketable securities such as trading securities to the amount of total assets; "Maturity," the years to maturity of the bonds; "Roll," the two times the square root of absolute value of the covariance between consecutive returns; "Coupon," the annual coupon interest; "Equity Volatility," the volatility of the firm's daily equity returns during which a specific issue is outstanding; "Rating," the credit rating assigned to each security, coded so that AAA=1; and "Distance-to-Default," the probability of default based on Merton (1974). The t-statistics are shown in parentheses below each coefficient estimate, and '*,' '**,' and '***' indicate significance at the 10%, 5%, and 1% levels, respectively.

	Model			
	1	2	3	4
Intercept	1.5598***	-1.0479***	-1.3209***	0.2632
	(7.62)	(-5.13)	(-5.06)	(0.57)
Financial	-0.3618***	0.3366***	0.4960***	0.5599***
	(-3.09)	(3.48)	(5.23)	(5.91)
Turnover	-246.73***		-141.47***	-126.24***
	(-3.76)		(-3.33)	(-3.00)
Cash over Asset	1.7090***		0.7039***	0.6912***
	(6.63)		(4.10)	(4.08)
Maturity	-0.2574***		0.0471**	0.0376*
	(-9.06)		(2.17)	(1.74)
Roll	0.5632***		0.2098***	0.2400***
	(9.92)		(4.94)	(5.65)
Coupon		0.2243***	0.1797***	0.1675***
		(11.05)	(7.91)	(7.42)
Equity Volatility		-0.0030	-0.00004	-0.2572***
		(-0.28)	(0.00)	(-4.07)
Equity Volatility Sq				0.0102***
				(4.12)
Rating		0.3369***	0.3381***	0.3435***
		(20.4)	(19.89)	(20.44)
Distance-to-Default		-0.1162***	-0.1129***	-0.1194***
		(-4.41)	(-4.55)	(-4.87)
Adj.-R Square	0.3946	0.7133	0.7481	0.7553

Appendix A. Estimation of Distance-to-Default

This appendix elaborates on the estimation of the distance-to-default provided by the Risk Management Institute at the National University of Singapore.[31] The distance-to-default computation begins with the framework of Merton (1974), which is a structural model that requires a number of assumptions. Among them, the two most important are as follows. The first is that the asset value of a firm follows a geometric Brownian motion:

$$dV = \mu V d\mathrm{t} + \sigma_V V d\mathrm{W}_t$$

where V is the asset value of the firm, μ is the drift based on V, σ_V is the volatility of the firm value, and W is a standard Wiener process.

The second assumption of the Merton model is that firms are financed by a single discount bond maturing in T, besides equity. Meanwhile, equity holders receive the firm value, which is less than the face value of the firm's debt, represented as L. Thus, the payoff of equity holders at maturity is

$$E_{\mathrm{T}} = \max\ (V_{\mathrm{T}} - L, 0)$$

that is the same as the call option payoff on the underlying value of the firm with a strike price equal to the face value of the firm's debt and a time-to-maturity of T. Thus, according to the Black–Scholes option pricing formula, the equity value of a firm satisfies

$$E = V\mathcal{N}(d_1) - \mathrm{e}^{-rT} F\mathcal{N}(d_2),$$

where E is the market value of the firm's equity, F is the face value of the firm's debt, r is the risk-free rate, $\mathcal{N}(\ )$ is standard cumulative normal distribution function, and

$$d_1 = \frac{\ln\left(\frac{V}{F}\right) + \left(r + 0.5\sigma_V^2\right)T}{\sigma_V\sqrt{T}} \ \&\ d_2 = d_1 - \sigma_V\sqrt{T}.$$

The Merton model uses one more important equation, expressing that the volatility of the

[31] For reference, the distance-to-default estimates offered by NUS–RMI include those for both non-financial and financial firms. We will briefly distinguish between those two.

firm's value is closely related to the volatility of its equity. Under the second assumption, we can derive the following relationship using Ito's lemma:

$$\sigma_E = \left(\frac{V}{E}\right) \mathcal{N}(d_1)\sigma_V.$$

In Merton's (1974) model, the distance-to-default can be calculated as follows. The first step is to estimate σ_E (the volatility of equity) from the market data such as historical return data. The second step is to choose a forecasting horizon and the face value of the firm's debt. Moody's KMV assumptions are to set the time to maturity at 1 year and the face value of the firm's debt to a value equal to the firm's current liabilities plus one half of its long-term debt.[32] The last step is to solve $E = V\mathcal{N}(d_1) - e^{-rT}F\mathcal{N}(d_2)$ numerically to infer V and σ_V.

After this numerical procedure, the distance-to-default can be obtained from the following formula:

$$\text{DtD} = \frac{\ln\left(\frac{V}{F}\right) + (\mu - 0.5\sigma_V^2)T}{\sigma_V\sqrt{T}}$$

However, financial firms usually have large amount of liabilities such as deposits that are categorized as neither current nor long-term liabilities. Thus, since the standard assumption of debt in traditional distance-to-default calculation, as described above, ignores a significant portion of a firm's liabilities, the standard distance-to-default calculation needs to be extended to give reasonable (acceptable) estimates for financial firms by accounting for debt other than current liabilities and long-term debt. For further details, see Duan and Wang (2012).

[32] NUS–RMI's technical report says that the current liabilities and long-term debt are taken from a firm's financial statements, compiled according to Generally Accepted Accounting Principles (GAAP) and not International Financial Reporting Standards (IFRS).