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Corporate Yield Spreads and Bond Liquidity

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ABSTRACT

We find that liquidity is priced in corporate yield spreads. Using a battery of liquidity measures covering over 4,000 corporate bonds and spanning both investment grade and speculative categories, we find that more illiquid bonds earn higher yield spreads, and an improvement in liquidity causes a significant reduction in yield spreads. These results hold after controlling for common bond-specific, firm-specific, and macroeconomic variables, and are robust to issuers' fixed effect and potential endogeneity bias. Our findings justify the concern in the default risk literature that neither the level nor the dynamic of yield spreads can be fully explained by default risk determinants.

A NUMBER OF RECENT STUDIES (Collin-Dufresne, Goldstein, and Martin (2001) and Huang and Huang (2003)) indicate that neither levels nor changes in the yield spread of corporate bonds over Treasury bonds can be fully explained by credit risk determinants proposed by structural form models. Longstaff, Mithal, and Neis (2005) suggest that illiquidity may be a possible explanation for the failure of these models to more properly capture the yield spread variation. Yet much of the current literature abstracts from liquidity's influence (Elton et al. (2001), focuses on aggregate liquidity proxies (Grinblatt (1995), Duffie and Singleton (1997), Collin-Dufresne et al. (2001), and Campbell and Taksler (2003) or assumes that simply the unexplained portion of the yield spread is liquidity based (Duffee (1999)). This paper comprehensively assesses bond-specific liquidity for a broad spectrum of corporate investment grade and speculative grade bonds and examines the association between bond-specific liquidity estimates and corporate bond yield spreads.

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The notion that investors demand a liquidity premium for illiquid securities originates with Amihud and Mendelson (1986). Building on that work, Lo, Mamaysky, and Wang (2004) further argue that liquidity costs inhibit the frequency of trading. Because investors cannot continuously hedge their risk, they demand an ex ante risk premium by lowering security prices. Therefore, for the same promised cash flows, less liquid bonds will trade less frequently, realize lower prices, and exhibit higher yield spreads. Given this rationale, the theoretical prior is that liquidity is expected to be priced in yield spreads. We investigate bond-specific liquidity effects on the yield spread using three separate liquidity measures, namely, these include the bid–ask spread, the liquidity proxy of zero returns, and a liquidity estimator based on a model variant of Lesmond, Ogden, and Trzcinka (1999). We find that liquidity is indeed priced in both levels and changes of the yield spread.

Contemporaneous studies by Longstaff et al. (2005) and Ericsson and Renault (2002) also relate corporate bond liquidity to yield spreads. However, Longstaff et al. (2005) focus only on 68 issuers that have liquid default-swap trading data, leaving some doubt as to the generality of the results for the larger universe of corporate bonds. Ericsson and Renault (2002) develop a theoretical model in which they use a new issue dummy as their empirical bond-specific liquidity measure. However, this liquidity proxy does not shed light on the liquidity difference spanning corporate bonds, nor does it provide liquidity measures for more mature bonds. We provide extensive bond-specific liquidity measures for over 4,000 corporate bonds that span both investment and speculative grade categories over a 9-year period, allowing for a more comprehensive assessment of the relation between liquidity and yield spreads.

Historically, the lack of credible information on spread prices[1] or bond quotes has been a major impediment in the analysis of liquidity (Goodhart and O'Hara (1997)) and liquidity's impact on yield spreads. We employ Bloomberg and Datastream to provide our three liquidity estimates. Among them, the bid–ask spread is arguably the most utilized measure of liquidity costs. However, the percentage of zero returns is increasingly being used as a liquidity proxy in a host of empirical studies.[2] Despite the clear intuition surrounding the zero

[1] Liquidity's importance is well recognized by academics, regulators, and bond traders. Arthur Levitt, as the Chairman of the Securities and Exchange Commission, notes that "the sad truth is that investors in the corporate bond market do not enjoy the same access to information as a car buyer or a home buyer or, I dare say, a fruit buyer. Improving transparency is a top priority for us" (*Wall Street Journal*, 9/10/1998 and http://www.sec.gov/news/speech/speecharchive/1998/spch218.htm). Greg Ip of the *Wall Street Journal* notes that "the bond market's biggest worry these days isn't default or interest rates. It's illiquidity that is crippling the very workings of the market" (*Wall Street Journal*, 10/19/1998 C1). Reflecting on bond liquidity concerns, the NASD (National Association of Security Dealers) has recently instituted TRACE (Trade Reporting and Compliance Engine), which provides real-time quote estimates for 4,200 corporate bond issues (*Wall Street Journal*, 3/14/2003).

[2] Theoretically, it is well known that in the presence of transaction costs, investors will trade infrequently (Constantinides (1986)), and thus the magnitude of the proportion of zero returns is representative of illiquidity. Empirically, this measure has been found to be an effective liquidity measure in the U.S. equity market (e.g., Lesmond, Schill, and Zhou (2004)) and in the emerging market for equities, where the lack of liquidity-related information remains a challenge (e.g., Bekaert, Campbell, and Lundblad (2003)).

return proxy, it is a noisy measure of liquidity since it is the combination of a zero return and the simultaneous movement of bond price determinants that more properly estimate liquidity costs than the lack of price changes per se.

To more properly capture this notion, we employ the limited dependent variable model proposed by Lesmond et al. (1999) (hereafter, LOT) to obtain an alternative liquidity estimate.[3] The premise of the LOT model is that, while the true value of the bond is driven by many stochastic factors, measured prices will reflect new information only if the information value of the marginal trader exceeds the total liquidity costs. This implies that a liquidity cost threshold exists for each bond, which is equivalent to the minimum information value for a trade. The probability of observing a zero return is higher within the liquidity cost threshold than outside the liquidity cost threshold. We use a maximum likelihood method to jointly estimate the risk factors related to market-wide information and the upper and lower liquidity thresholds that, taken as a whole, represent round-trip liquidity costs.

We find a significant association between corporate bond liquidity and the yield spread with each of the three liquidity measures. Depending on the liquidity measure, liquidity alone can explain as much as 7% of the cross-sectional variation in bond yields for investment grade bonds, and as much as 22% of the cross-sectional variation in bond yields for speculative grade bonds. Using the bid–ask spread as the measure, we find that a one basis point increase in bid–ask spread is related to a 0.42 basis point increase in the yield spread for investment grade bonds, and a 2.30 basis point increase for speculative grade bonds. Using either the bid–ask spread or the LOT estimate, the liquidity effect remains significant even after controlling for general yield spread factors such as credit rating, maturity, and the amount outstanding, the tax effect (Elton et al. (2001)), the equity volatility (Merton (1974), and Campbell and Taksler (2003)), the accounting variables of Campbell and Taksler (2003), and the macroeconomic variables of Collin-Dufresne et al. (2001). The results are robust to issuer fixed effects and potential endogeneity in yield spreads, liquidity, and credit ratings. The results extend to the zero return liquidity proxy, but are most robust for investment grade bonds.

Extending the study to changes in yield spreads, we again find a liquidity influence. For all three liquidity measures, an increase in illiquidity is significantly and positively associated with an increase in yield spreads regardless of controlling for changes in credit rating, macroeconomic influences, or firm-specific factors. Specifically, we find that liquidity changes explain more of the variation in yield spread changes than do changes in the credit rating. The explanatory power of liquidity persists for both investment grade and speculative grade bonds, but is more pronounced for speculative grade bonds.

[3] Lesmond et al. (1999) and Lesmond et al. (2004) find that this method works well for equity markets, as evidenced by an 80% correlation between the LOT liquidity estimate and the bid–ask spread plus commissions. The proposed LOT model does not rely on the use of bid–ask spread prices; instead, it uses only daily closing returns to estimate liquidity costs. This method is also a natural extension of Glosten and Milgrom (1985), who illustrate that trades will occur when the information value exceeds the transaction costs defined by the bid–ask spread.

This paper contributes to the growing debate over bond market liquidity and corporate yields. It is commonly assumed that the yield spread, as a whole, represents default risk. Practitioners frequently draw conclusions regarding default probabilities from yield spreads. Our findings imply that this approach is inappropriate, as the liquidity component in the yield spread is not directly related to default risk. Second, consistent with Longstaff et al. (2005), our results more comprehensively justify the notion that the nondefault portion of the yield spread is due to liquidity, over and above tax effects (e.g., Elton et al. (2001), and Huang and Huang (2003) or equity volatility effects (Campbell and Taksler (2003)). Finally, the high consistency between the bid–ask spread and the LOT liquidity estimate suggests that return data can be effectively used in bond liquidity studies. This is particularly meaningful for thinly traded bonds, for which the lack of liquidity-related information is common. This extends to both U.S. domestic-listed bonds and $US-denominated bonds traded in international markets,

The rest of our paper is organized as follows. Section I introduces the liquidity measures and their summary statistics. Section II presents model validation tests, the consistency among the liquidity measures, and initial tests on the relation between liquidity and the yield spread. Section III studies the relation between liquidity levels and yield spread levels, and Section IV presents test results of changes in liquidity and changes in the yield spread. Finally, Section V concludes.

I. Liquidity Measures

A. Discussion

The literature provides a menu of measures for estimating liquidity. While the most utilized measure is the bid–ask spread, the spread is not always available for all bonds or for all time periods. This is especially true for thinly traded bonds or more mature bonds. Additionally, because our data are hand-collected, our quote information is gathered only on a quarterly basis, resulting in a less precise measure of liquidity. The least precise liquidity estimate results when only a single quarterly quote is available for the bond over an annual trading period.

Lesmond et al. (1999) introduce an alternative indirect method for estimating liquidity based on the occurrence of zero returns. Bekaert et al. (2003) show that zero returns themselves are a reasonable liquidity proxy. The LOT measure is a comprehensive estimate of liquidity by including the spread and other costs that may impinge on informed trade, such as commission costs, opportunity costs, and price impact costs. The maintained hypothesis is that the marginal trader will trade only if the value of the information exceeds the marginal costs. If trading costs are sizeable, Lesmond et al. (1999) argue that zero return days will occur more frequently because new information must accumulate longer, on average, before informed trade affects price. They show that the LOT estimate is a more accurate measure of the underlying liquidity costs than is the percentage of zero returns because the LOT measure extracts more information from the return generating process. An additional benefit of the LOT measure is that this liquidity estimate is available for more thinly traded bonds than is the bid–ask spread.

A potential theoretical drawback of the LOT model is that it requires a return generating model for bonds that the literature has yet to definitively define. A practical limitation is that the LOT model requires some zero returns to estimate liquidity's effect on price. For newly issued bonds or bonds offered mid-year, the sequence of prices may not reveal any zero returns and thereby invalidate the LOT estimate. Conversely, too many zero returns (i.e., where more than 85% of the daily returns over the year are zero) also renders this measure inestimable. However, both the zero return liquidity proxy and the LOT liquidity measure are presumed to be positively related to the bid–ask spread.

Because of the strengths and weaknesses of each measure, we employ all three estimators to determine the relation between corporate bond yield spreads and liquidity. This not only increases robustness, but also sheds light on the relative power of each liquidity measure. If we find that all three liquidity measures lead to consistent inferences, then we can take comfort in using the other two measures in situations in which the bid–ask spread is not available. Bekaert et al.'s (2003) study of the pricing implications of equity liquidity in emerging markets, is a case in point.

B. The Bid–Ask Spread

Data on the quarterly bid–ask quotes are hand-collected from the Bloomberg Terminals. Most quotes are available only from 2000 to 2003. For each quarter, we calculate the proportional spread as the ask minus the bid divided by the average bid and ask price. The bond-year's proportional bid–ask spread is then calculated as the average of the quarterly proportional spreads. To include as many bonds as possible, we compute the annual proportional spread as long as there is at least one quarterly quote for the year. The bid–ask quotes recorded are from the Bloomberg Generic Quote, which reflects the consensus quotes among market participants.

C. The Percentage Zeros and the LOT Model

The LOT measure of informed trading utilizes only daily bond returns to estimate bond-level liquidity costs. The effect of liquidity is observable through the incidence of zero returns. We obtain prices from Datastream, which, in turn, uses Merrill Lynch as the data source for the price. The stated price is an average price across all market makers for the bond. Given the probability of observing a zero return is decreasing with increasing numbers of market makers, we underestimate the number of zero returns for each bond issue. Moreover, given our model is predicated on days with no price changes, we are likely to understate our estimate of bond-specific liquidity costs, biasing against our liquidity hypothesis. We choose the start date of 1995 since daily prices are more regularly available through Datastream only after 1995. The data span a 9-year period ending in 2003.

We record the clean price of each bond on a daily basis, deleting prices that deviate more than 50% from the prior day's price. We separate the data into bond-years; that is, using daily data for each bond within each year, we jointly estimate the bond's return generating function and liquidity costs applicable to that year. This procedure allows time-series variations in the bond liquidity estimates to be adequately represented.

To price corporate bonds, we extend the Lesmond et al. (1999) methodology to a two-factor model. (The Appendix shows the theoretical basis for this approach.) The two factors are the interest rate and the equity market return, reflecting the fact that a corporate bond is a hybrid between a risk-free bond and equity. Following Jarrow (1978), we scale all risk coefficients by duration to obtain stable estimation coefficients. The return generating process is then given as

$$R^*_{j,t} = \beta_{j1}\text{Duration}_{j,t} * \Delta R_{ft} + \beta_{j2}\text{Duration}_{j,t} * \Delta\text{S\&P Index}_t + \epsilon_{j,t}, \quad (1)$$

where the term $R^*_{j,t}$ represents the unobserved "true" bond return for bond j and day t that investors would bid given zero liquidity costs, ΔR_{ft} is the daily change in the 10-year risk-free interest rate, and following Cornell and Green (1991), Δ*S&P Index* is the daily return on the Standard & Poor's 500 index.[4]

Amihud and Mendelson (1986, 1987) develop a framework in which the intrinsic value of a firm differs from its observed value. Amihud and Mendelson (1986) attribute this difference to a liquidity premium that requires higher cost assets to be priced lower to compensate investors for liquidity costs. Extending Amihud and Mendelson (1986) to fixed income securities, liquidity effects on bond returns can be stated as:

$$R_{j,t} = R^*_{j,t} - \alpha_{i,j}, \quad (2)$$

where $R_{j,t}$ is the measured return, $\alpha_{2,j}$ is the effective buy-side cost, and $\alpha_{1,j}$ is the effective sell-side cost for bond j. Thus, the desired return and the measured return are related, but only after taking liquidity costs into account. The effect of liquidity on bond prices is then modeled by combining the objective function with the liquidity constraint, that is

$$R^*_{j,t} = \beta_{j1}\text{Duration}_{j,t} * \Delta R_{ft} + \beta_{j2}\text{Duration}_{j,t} * \Delta\text{S\&P Index}_t + \epsilon_{j,t}. \quad (3)$$

where

$$\begin{array}{llll} R_{j,t} = R^*_{j,t} - \alpha_{1,j} & \text{if } R^*_{j,t} < \alpha_{1,j} & \text{and} & \alpha_{1,j} < 0 \\ R_{j,t} = 0 & \text{if } \alpha_{1,j} \le R^*_{j,t} \le \alpha_{2,j} & & \\ R_{j,t} = R^*_{j,t} - \alpha_{2j} & \text{if } R^*_{j,t} > \alpha_{2,j} & \text{and} & \alpha_{2,j} > 0. \end{array}$$

[4] We also estimate the model using the Fama–French (1993) bond factors in the objective function. The results are largely invariant to this specification.

The resulting log-likelihood function can be specified as:

$$LnL = \sum_1 \text{Ln}\frac{1}{\left(2\pi\sigma_j^2\right)^{1/2}} - \sum_1 \frac{1}{2\sigma_j^2}(R_j + \alpha_{1,j} - \beta_{j1}\text{Duration}_{j,t} * \Delta R_{ft} - \beta_{j2}\text{Duration}_{j,t} * \Delta\text{S\&P Index}_t)^2 + \sum_2 \text{Ln}\frac{1}{\left(2\pi\sigma_j^2\right)^{1/2}} - \sum_2 \frac{1}{2\sigma_j^2}(R_j + \alpha_{2,j} - \beta_{j1}\text{Duration}_{j,t} * \Delta R_{ft} - \beta_{j2}\text{Duration}_{j,t} * \Delta\text{S\&P Index}_t)^2 + \sum_0 \text{Ln}(\Phi_{2,j} - \Phi_{1,j}), \tag{4}$$

where $\Phi_{i,j}$ represents the cumulative distribution function for each bond-year evaluated at $(\alpha_{i,j} - \beta_{j1}\text{Duration}_{j,t} * \Delta R_{ft} - \beta_{j2}\text{Duration}_{j,t} * \Delta\text{S\&P Index}_t)/\sigma_j$. $\sum_1$ (region 1) represents the negative nonzero measured returns, $\sum_2$ (region 2) represents the positive nonzero measured returns, and $\sum_0$ (region 0) represents the zero measured returns. Maddala (1983) and Lesmond et al. (1999) outline the estimation procedure.

For purposes of liquidity estimation, we focus only on the $\alpha_{2,j}$ and $\alpha_{1,j}$ estimates. Differencing the buy-side and sell-side cost estimates, $\alpha_{2,j} - \alpha_{1,j}$, represents the round-trip transaction costs.

Implicitly, our model assumes that information motivates trade in bonds and that information is efficiently impounded into bond prices. This assumption finds support from Hotchkiss and Ronen (2002), who conclude that the informational efficiency of bond prices is similar to that of the underlying equity. The marginal trader is assumed to assess the value of information before deciding to trade relative to the expected liquidity costs. The marginal trader with the highest net difference between the value of information and transaction costs will drive price movements.[5] We do not impose any particular assumptions on whether the marginal investor possesses public or private information; rather, we assume that prices should rationally reflect the costs of trade relative to the information value of the trade. Unanticipated public information, noise trades, or trades of an idiosyncratic nature will not be priced in a rational asset pricing framework and are only captured, on average, in the error term.

D. Yield Spreads and Corporate Information

We examine over 4,000 U.S. corporate bonds. We obtain yield spreads and bond characteristics from Datastream. Up-to-date credit ratings for each bond come from the Fixed Income Securities Database, and when unavailable we use

[5] The LOT model is consistent with the Kyle (1985) model. Specifically, Kyle assumes that the market maker is risk neutral and allows for the market being composed of three trader types: informed, uninformed, and the market maker. The LOT model is predicated on trades made by the marginal trader who could be informed, uninformed, or even the market maker.

Standard and Poor's rating on Datastream. We delete bonds not rated by either S&P or the Fixed Income Securities Database. Finally, we use the Compustat Annual Industrial Database to collect all firm-level data for both active and inactive firms to minimize any survivorship bias in the liquidity determinant and yield spread regressions.[6] Each variable is collected in the year prior to the yield spread measurement. The equity volatility is estimated using 252 daily returns (from the Center for Research in Security Prices, or the CRSP file) for the year prior to the bond liquidity estimate. The bond volatility is estimated similarly using bond prices.

II. Preliminary Findings

A. Summary Statistics

Table I contains the summary statistics classified by maturity levels and credit ratings. Within each panel there are two sets. The first set relates all the bond information for a matching sample of zero returns and the LOT estimate, while the second presents information for a matching sample of zero returns, the LOT estimate, and the bid–ask spread. Several observations are apparent. First, liquidity costs are demonstrably higher for speculative grade bonds than for investment grade bonds. In particular, we observe a significant increase in the percentage of zero returns and the size of the LOT estimate of liquidity while moving from investment grade to speculative grade bonds. This is matched with a similar increase in the bid–ask spread.[7] Not surprisingly, yield spreads also increase markedly across these bond categories. For the matched sample of all three liquidity measures, the trend of each liquidity measure appears to match the underlying credit rating. That is, for investment grade bonds, we observe increasing liquidity costs when moving from AA bonds to BBB bonds. However, for speculative grade bonds, the trend of increasing liquidity costs with decreasing credit worthiness, is only apparent for the LOT measure and the bid–ask spread. The percentage of zero returns appears to be a weaker proxy for liquidity.

Second, liquidity costs increase as we move from short- to long-maturity bonds, consistent with the investment horizon argument offered by Amihud and Mendelson (1991) or the return volatility arguments of Chakravarty and Sarkar (1999).

[6] We collect operating income after depreciation (item 178) and interest expense (item 15) to determine the pre-tax interest coverage. For operating income to sales, we collect the firm's operating income before depreciation (item 13) divided by net sales (item 12). We use two definitions for debt: total long-term debt (item 9) divided by total assets (item 6), and total long-term debt plus debt in current liabilities (item 34) plus short-term borrowings (item 104) divided by total liabilities (item 181) plus market capitalization (item 60).

[7] We emphasize that while the general trends are similar, the LOT liquidity costs do not necessarily need to agree with the bid–ask spread in magnitude. The LOT estimates are derived from the investors' trading decision, which incorporates all relevant liquidity related costs. The marginal traders' reservation price will then reflect all these relevant costs, which could include commission costs, credit spread costs, and search costs, in addition to the bid–ask spread.

Table I

Corporate Bond Summary Statistics

We present liquidity and yield spread statistics for noncallable corporate bonds from 1995 to 2003 by three maturity categories. % Zeros is the percentage of zero returns for a given year adjusted for missing prices. LOT refers to the modified Lesmond et al. (1999) model's liquidity estimate. The bid–ask is the proportional spread derived from quarterly quotes from Bloomberg. To assign bond ratings, we use the Fixed Income Securities Database, and, when unavailable, the Standard & Poor's credit rating from Datastream. The yield spread is the difference between the bond yield and the yield of a comparable maturity treasury bond as determined from Datastream. Two separate samples for each maturity classification are presented. The first sample is restricted to only those bonds with available LOT estimates, while the second sample is restricted to only those bonds with available bid–ask spreads. bp stands for basis points and *N* stands for the sample size.

Liquidity & Yield spreads	S&P Credit Ranking						
	AAA	AA	A	BBB	BB	B	CCC to D
Panel A: Short Maturity (1–7 years)							
Zeros (%)	5.93	4.10	3.88	8.43	40.63	44.71	46.31
LOT (bp)	7.88	9.63	10.51	34.99	201.45	458.86	933.06
Yield Spread (bp)	84.06	96.91	129.34	252.09	575.58	1213.43	3949.55
N	87	336	1162	1234	333	167	119
Zeros (%)	3.20	3.35	3.33	7.80	42.77	44.00	51.09
LOT (bp)	5.83	8.18	9.82	34.40	191.23	335.63	868.59
Bid–ask (bp)	24.51	26.02	25.82	31.01	54.26	58.76	77.00
Yield spread (bp)	71.43	95.05	118.92	235.41	549.88	1247.23	3559.09
N	56	285	972	775	178	72	22
Panel B: Medium Maturity (7–15 years)							
Zeros (%)	9.79	12.59	10.61	11.94	36.99	38.71	34.96
LOT (bp)	24.28	47.26	57.74	70.29	259.34	342.50	941.84
Yield spread (bp)	82.44	146.24	177.68	277.45	566.53	947.14	2887.47
N	49	120	539	730	152	78	44
Zeros (%)	10.36	8.34	6.62	8.91	42.40	38.96	18.04
LOT (bp)	25.00	36.17	36.82	51.45	266.11	272.96	282.84
Bid–ask (bp)	49.52	36.57	38.20	44.22	54.65	60.44	180.35
Yield spread (bp)	70.65	129.02	154.19	251.68	497.45	863.71	1619.04
N	37	67	386	394	76	32	9
Panel C: Long Maturity (15–40 years)							
Zeros (%)	7.53	9.75	10.39	8.68	29.13	31.67	41.00
LOT (bp)	59.34	83.65	79.40	66.57	252.14	284.81	1023.18
Yield spread (bp)	133.81	152.25	183.76	242.16	437.69	681.44	2047.11
N	49	189	674	929	112	48	48
Zeros (%)	7.28	8.27	7.79	8.00	32.36	37.25	35.14
LOT (bp)	76.81	75.60	56.97	58.57	281.56	245.78	328.25
Bid–ask (bp)	51.65	52.68	54.76	58.62	73.56	82.47	86.75
Yield spread (bp)	113.65	142.83	172.21	236.89	457.97	623.45	2192.41
N	27	110	410	494	62	14	8

Finally, yield spreads generally increase (decrease) with maturity for investment (speculative) grade bonds. Merton (1974) shows that corporate yield spreads can either increase or decrease with maturity, depending on the risk of the firm. Investment grade issuers face upward-sloping yield spreads while speculative grade issuers face flat or downward-sloping yield spreads. Helwege and Turner (1999) find that within the same speculative credit rating category, the safer firms tend to issue longer-term bonds, which causes the average yield spread to decline with maturity.

B. Model Validation

Even though the proportion of zero returns and the LOT estimate both stem from the premise that liquidity costs inhibit trade, the LOT estimate is a less noisy measure because it incorporates the covariation between the zero returns and the market movement of the bond price determinants. To verify this point, we first perform a model specification check by investigating whether the LOT model helps to recover intuitive beta coefficients on the systematic risk factors. We then compare these coefficients to a naive asset pricing model without liquidity cost considerations.

If the model is correctly specified, we should expect several patterns to appear. First, the interest rate coefficient should be negative. However, moving from high-grade to low-grade bonds, this relationship is expected to become weaker (Schultz (2001)). Second, the equity return coefficient should be positive for low-grade bonds (Cornell and Green (1991)). Intuitively, a positive equity return, signaling an improvement in the firm's business operation, will have a positive effect on the bond return. However, the effect of the equity return on high grade bonds is not clear. On the one hand, a positive equity return might increase bond prices, as in the low-grade bond case. On the other hand, the positive equity return might be caused by capital flows from the corporate bond market into the equity market, in which case a negative return on corporate bonds is expected.[8]

The estimation results are summarized in Panel A of Table II. A comparison of the LOT results with those of the naive ordinary least squares (hereafter, OLS) model provides a clear indication of the influence that zero returns have on the estimation results. The LOT model's interest rate estimates are mostly negative and significant, while the interest rate influence is decreasing with decreasing bond ratings, all as expected. In sharp contrast, the naive OLS model produces interest rate estimates that are largely insignificant from zero. In addition, the interest rate effect has no apparent trend with bond ratings, contrary to common beliefs.

The falloff in interest rate influence for the LOT model is offset by a concomitant increase in the S&P 500 equity return influence, especially for speculative grade bonds. Also evident is the switch in the sign for the S&P 500 coefficient

[8] Kwan (1996) finds a positive equity return coefficient for investment grade bonds. Cornell and Green (1991) find that, when both the interest rate and the S&P 500 equity return are considered, the sign of equity return coefficient changes from positive to negative for the period 1977 to 1989.

Table II

Liquidity Measure Tests

Panel A reports coefficients on the risk-free rate factor, β_{T-Bond}, and the equity market return factor, β_{Equity}, from, respectively, a naive OLS model and the modified Lesmond et al. (1999) model (LOT). The interest rate factor is expected to be negative for all bonds while the equity factor can be either positive or negative for investment grade bonds but positive for speculative grade bonds. N is the sample size for each bond rating category. % Zeros are the percentage of zero returns for a given year adjusted for missing prices. LOT is the liquidity estimate from the modified Lesmond et al. (1999) model. Panel B reports the regression of the bid–ask spread on the percentage of zero returns and the LOT estimate as well as controls for other liquidity determinants. Age and maturity are in years referenced from the year the bond was issued or its maturity date relative to the year being analyzed. The amount outstanding is the dollar amount of the bond that has not been redeemed and is log scaled. The bond volatility is log scaled. The bond ratings are numbered from 1 to 10 for investment grade bonds (S&P ratings, AAA to BBB−) and from 1 to 12 for speculative grade bonds (S&P ratings, BB+ to D). Panel C reports an OLS regression of the yield spread on each liquidity measure for a matched sample using the bid–ask as a basis. White's (1980) t-statistics are in parentheses. Liquidity results are in boldfaced type.

Panel A: Modified Lesmond et al. Model and the Naive Model Coefficient Estimates

				Modified Lesmond et al. Model			Naive Model	
	S&P Rating	N	% Zeros	LOT	β_{T-Bond}	β_{Equity}	β_{T-Bond}	β_{Equity}
Investment Grade	AAA	185	7.37*	0.0026*	−0.9077*	−0.0072*	−0.0515	−0.0055*
	AA	645	7.34*	0.0038*	−0.9127*	−0.0084*	0.0068*	−0.0064*
	A	2395	7.29*	0.0041*	−0.9395*	−0.0090*	−0.0223	−0.0068*
	BBB	2893	9.40*	0.0054*	−0.9047*	−0.0069*	−0.0487	−0.0040†
Speculative Grade	BB	597	37.55*	0.0225*	−0.5332*	−0.0001	−0.0450	−0.0019
	B	293	40.97*	0.0399*	0.4424	0.0171†	−0.1261	0.0127*
	CCC to D	211	42.74*	0.0955*	−0.1976	0.0885*	−0.0662	0.0341†

Panel B: Regression of the Bid–Ask Spread on Liquidity Measures

Variable	Investment Grade Bonds				Speculative Grade Bonds			
Intercept	0.0112*	0.0059*	0.0032*	0.0051*	0.0049*	0.0043	0.0054*	0.0069
	(103.18)	(5.31)	(129.10)	(6.50)	(26.06)	(0.99)	(26.96)	(1.74)
LOT	**0.0442***	**0.0233***			**0.0440***	**0.0297***		
	(9.81)	(5.65)			(5.16)	(3.50)		
% Zeros			**0.0037***	**0.0027***			0.0007	**0.0017***
			(15.03)	(11.73)			(1.81)	(3.80)
Maturity		0.0001*		0.0001*		0.0001*		0.0001*
		(10.59)		(12.92)		(4.02)		(5.46)
Age		−0.0000		0.0000		0.0001		0.0001
		(0.34)		(1.25)		(1.67)		(0.89)
Ln (Amount outstanding)		0.0001		0.0001†		−0.0000		−0.0001
		(0.60)		(2.34)		(0.14)		(0.16)
Ln (Bond volatility)		0.0004*		0.0003*		0.0001		0.0002*
		(12.15)		(14.61)		(1.47)		(3.05)
Bond rating		0.0001		0.0001		0.0002†		0.0003*
		(1.38)		(1.49)		(2.30)		(2.81)
Sample size	3,970		6,040		421		525	
% Adjusted R^2	6.39	25.34	6.82	25.23	6.45	15.02	0.35	15.03

Panel C: Regression of the Yield Spread on Liquidity Measures

	Investment Grade Bonds			Speculative Grade Bonds		
Variable	Bid–Ask	LOT	% Zero	Bid–Ask	LOT	% Zero
Coefficient	**1.8246***	**0.3181***	**0.0239***	**1.7396**†	**0.7804***	0.0014
	(17.70)	(17.65)	(15.76)	(2.16)	(5.88)	(1.87)
N		3970			421	
% Adjusted R^2	7.29	7.26	5.87	0.86	7.39	1.72

An *denotes significance at the 1% level, while a † denotes significance at the 5% level.

from investment grade to speculative grade bonds. This indicates that signaling effects prevail in the case of speculative grade bonds, while substitution effects prevail for investment grade bonds. Similar but more muted patterns are apparent for the naive OLS model's estimates.

C. Bid–Ask Spread Tests

We provide further evidence on the consistency of the three liquidity measures. In particular, we regress the bid–ask spread separately on the other two liquidity measures controlling for other liquidity determinants as follows:

$$\begin{aligned}\text{Bid–Ask}_{it} = {} & \eta_0 + \eta_1\text{Liquidity}_{it} + \eta_2\text{Maturity}_{it} + \eta_3\text{Age}_{it} \\ & + \eta_4\text{Amount Outstanding}_{it} + \eta_5\text{Bond Volatility}_{it} \\ & + \eta_6\text{Bond Rating}_{it} + \epsilon_t.\end{aligned}$$

The subscript "*it*" refers to bond i and year t. The liquidity variable refers to either the proportion of zero returns or the LOT estimate. The liquidity determinants are chosen according to Garbade and Silber (1979), Sarig and Warga (1989), Chakravarty and Sarkar (1999), Stoll (2000), Schultz (2001), and Brandt and Kavajecz (2004). The *Bond Rating* variable proxies for default risk. For the overall regressions, bond ratings are assigned a cardinal scale ranging from one for AAA rated bonds to seven for CCC to D rated bonds. Panel B of Table II presents the results.

For investment grade bonds, the LOT liquidity estimate alone explains 6.39% of the cross-sectional variation in the bid–ask spread, while the percentage of zero returns explains 6.82% of the cross-sectional variation in the bid–ask spread. In comparison, Schultz (2001) reports an R^2 of 3.43% in regressions on all microstructure trading cost determinants for investment grade bonds. Both the LOT estimate and the percentage of zero returns remain positively and significantly related to the bid–ask spread when other variables are included.[9] Similar results are obtained for speculative bonds, but only for the LOT model estimate. In particular, the proportion of zeros is insignificant without the control variables, but becomes significant after including them in the regression. The percentage of zero returns appears to suffer more from specification error bias than does the LOT measure. This is to be expected given that the LOT measure extracts more information than is provided by the percentage of zero returns.

D. Initial Yield Spread and Liquidity Tests

We now test the relation between the yield spread and the three liquidity estimates. To provide a consistent comparison we match the bid–ask spread

[9] Although not reported, we also include the log scaled equity volatility in the regression and find that it is insignificantly associated with the bid–ask spread.

sample to the available liquidity estimates. As Panel C of Table II shows, for investment grade bonds all three liquidity estimates are positively and significantly associated with the underlying yield spread. The LOT measure and the bid–ask spread provide almost identical power in explaining the cross-sectional variation in the yield spread, with a reported R^2 of approximately 7.3%. The percentage of zero returns explains almost 6% of the cross-sectional variation in the yield spread.

For speculative bonds, only the bid–ask spread and the LOT measure are significantly associated with the underlying yield spread. The LOT measure explains 7.39% of the cross-sectional variation in the yield spread, while the bid–ask spread explains only 0.86% of the cross-sectional variation in the yield spread.

III. Liquidity Effects on Yield Spread Levels

Many theoretical models (e.g., Amihud and Mendelson (1986)) predict that investors demand higher expected returns for less liquid assets to compensate for the liquidity risk. This implies that, for the same cash flows in the future, less liquid assets will have lower prices. Because bond yield is a promised yield given known cash flows, the lower prices of less liquid bonds lead to higher bond yields and higher yield spreads, ceteris paribus. We test this theoretical prediction by investigating whether various liquidity proxies can explain yield spread levels.

A. Regression Tests of Liquidity Estimates and Other Yield Spread Determinants

The following regression is specified with the yield spread as the dependent variable and the various yield spread determinants as independent variables:

$$\begin{aligned}
&\text{Yield Spread}_{it} \\
&\quad = \eta_0 + \eta_1 \text{Liquidity}_{it} + \eta_2 \text{Maturity}_{it} + \eta_3 \text{Amount Outstanding}_{it} \\
&\qquad + \eta_4 \text{Coupon}_{it} + \eta_5 \text{Treasury Rate}_t + \eta_6 \text{10Yr-2Yr Treasury Rate}_t \\
&\qquad + \eta_7 \text{EuroDollar}_t + \eta_8 \text{Volatility}_{it} + \eta_9 \text{Bond Rating}_{it} \\
&\qquad + \eta_{10} \text{PreTax Coverage Dummy}_{it} + \eta_{11} \text{Operating Income/Sales}_{it} \\
&\qquad + \eta_{12} \text{Debt/Assets}_{it} + \eta_{13} \text{Debt/Capitalization}_{it} + \epsilon_t,
\end{aligned}$$

where the subscript "*it*" refers to bond i and year t and *Liquidity* refers to the bid–ask spread, the proportion of zero returns, or the LOT estimate. The choice of yield spread determinants is largely based on Elton et al. (2001) and Campbell and Taksler (2003).[10] We measure the incremental influence of the

[10] We exclude the additional equity market index considered by Campbell and Taksler (2003) because of potential endogeneity problems given that the LOT estimate includes the market return from the S&P 500 index.

pre-tax coverage using the procedure outlined in Blume, Lim, and MacKinlay (1998). In addition, we include three macroeconomic variables associated with the yield spread. These are the 1-year Treasury rate, the difference between the 10-year and 2-year Treasury rates that describes the slope of the yield curve, and the difference between the 30-day Eurodollar and 3-month Treasury bill rate that controls for other potential liquidity effects on corporate bonds relative to Treasury bonds.

We present two separate regressions for each liquidity estimate. The first uses only the bond-specific information and yields a larger sample, while the second incorporates the corporate and market information and yields a smaller sample. The sample for each liquidity measure differs due to the estimation limitations of each measure. The percentage of zero returns is the most comprehensive sample because it only requires the daily bond prices. As a practical matter, the LOT sample comprises more older bonds than does the bid–ask spread sample, but the bid–ask spread sample comprises more newly issued bonds than does the LOT sample. The results are presented in Table III.

The most telling finding is the consistent significance of the liquidity variable regardless of the specification used to define liquidity, the specification used for the yield spread determinants, or the investment versus speculative grade category tested. All these liquidity measures are positively related to the yield spread in all scenarios, for both investment grade and speculative grade bonds, even after we control for extensive bond-specific, firm-specific, and macroeconomic variables. The liquidity coefficients are highly significant (at 1%) in every scenario, supporting our theoretical prior that liquidity is priced in the yield spreads.

The interpretation of the magnitude of the liquidity influence varies depending on the liquidity measure. For investment grade bonds, the LOT measure predicts an incremental 0.21 basis point increase in the yield spread for a one basis point increase in liquidity costs, while the bid–ask spread predicts an incremental 0.42 basis point increase in the yield spread for a one basis point increase in the bid–ask spread. The coefficient for bond rating is 20 basis points, regardless of the LOT measure or the bid–ask spread liquidity measure, which means that for each grade drop in bond rating (e.g., from BBB+ to BBB), the yield spread will increase by 20 basis points. The incremental effect of maturity on the yield spread is significant, but only one basis point.

For speculative grade bonds, focusing on the full accounting variable regressions, the LOT measure predicts an incremental 0.82 basis point increase in the yield spread for a one basis point increase in liquidity costs, while the bid–ask spread predicts an incremental 2.29 basis point increase in the yield spread for a one basis point increase in the bid–ask spread.

It may be noted that the maturity coefficient is generally positive for investment grade bonds and negative for speculative grade bonds. For investment grade bonds, longer maturities are often noted to be associated with increased yield spreads (Campbell and Taksler (2003)), consistent with the positive sign for maturity. For speculative grade bonds, Helwege and Turner (1999) argue that better quality firms are able to issue bonds with longer maturity,

Table III

Yield Spread Determinants and Liquidity Tests

The yield spread determinants are based on bond-specific effects (bond rating, amount outstanding, coupon, and maturity in years), macroeconomic variables (1-year Treasury note rate (T-Note), the difference between the 10-year and 2-year Treasury rates (Term Slope), and the 30-day Eurodollar rate minus the 3-month T-Bill Rate (Eurodollar)), and firm-specific characteristics (pre-tax interest coverage, operating income to sales, long-term debt to assets, and total debt to capitalization). The pre-tax interest coverage is further grouped into one of four categories according to Blume et al. (1998). σ_E is the equity volatility for each issuer. Investment grade bonds are numbered from one (AAA rated bonds) to 10 (BBB− rated bonds). Speculative grade bonds are numbered from one (BB+ rated bonds) to 12 (D rated bonds). The liquidity cost estimates are based on the modified LOT model, the percent zero returns, and the bid–ask spread. White's (1980) t-statistics are presented in parentheses. The last partition is a univariate regression of the yield spread on each liquidity measure or credit rating using the larger sample for each liquidity measure. Liquidity results are in boldfaced type.

Variable	Investment Grade Bonds						Speculative Grade Bonds					
Intercept	0.1573*	0.1251	0.0696*	0.0902*	0.1737*	0.1408†	0.5696†	0.5397†	0.3232*	0.2784*	0.9056*	0.8242*
	(15.03)	(11.52)	(9.97)	(8.76)	(12.25)	(14.08)	(2.00)	(1.98)	(2.81)	(3.23)	(2.99)	(2.88)
LOT	**0.5122***	**0.2166***					**1.6757***	**0.8213***				
	(10.71)	(10.03)					(7.82)	(2.95)				
Bid–Ask			**0.4362***	**0.4200***					**2.7266***	**2.2957***		
			(5.65)	(5.20)					(4.99)	(4.69)		
% Zeros					**0.0255***	**0.0138***					**0.0600***	**0.0521***
					(12.94)	(8.84)					(5.25)	(3.10)
Maturity	0.0001	0.0001*	0.0001*	0.0001*	0.0001*	0.0001*	−0.0024*	−0.0021*	−0.0009*	−0.0106*	−0.0027*	−0.0032*
	(1.57)	(5.28)	(5.40)	(5.89)	(7.25)	(7.44)	(4.62)	(3.92)	(5.75)	(4.03)	(5.61)	(4.93)
Amount	0.0001	−0.0005	0.0003	−0.0008†	−0.0001	−0.0007*	−0.0071*	0.0005	−0.0004	0.0011	−0.0064†	0.0023
	(0.34)	(1.33)	(0.92)	(2.48)	(0.75)	(2.66)	(3.08)	(0.34)	(0.17)	(0.28)	(2.25)	(0.78)
Coupon	0.2074*	0.1141*	0.0013*	0.0009*	0.1828*	0.1078*	0.4895	0.4441†	0.0034*	0.0027*	1.3981*	1.2975†
	(10.30)	(6.28)	(11.09)	(5.48)	(12.45)	(7.36)	(1.52)	(2.13)	(3.69)	(3.67)	(3.42)	(2.24)
T-note	−2.4595*	−1.5603*	−1.1035*	−0.9273*	−2.5467*	−1.7185*	−9.5597†	−9.4014†	−4.0206*	−3.3823*	−14.0365*	−13.771*
	(17.84)	(15.68)	(13.09)	(9.83)	(22.00)	(15.20)	(2.40)	(2.43)	(2.72)	(4.26)	(3.18)	(4.43)
Term slope	−5.5080*	−3.8658*	−2.9417*	−2.6337*	−5.9552*	−4.3546*	−14.0822	−19.6601†	−10.0332*	−10.7150*	−28.8487*	−34.342*
	(18.01)	(15.71)	(14.92)	(11.25)	(23.43)	(16.71)	(1.58)	(2.21)	(2.99)	(5.25)	(2.97)	(3.69)
Eurodollar	−0.0774*	−0.0677*	−0.0560*	−0.0541*	−0.0889*	−0.0751*	0.0328	−0.1369	−0.2440*	−0.3370*	−0.4291*	−0.3924†
	(16.42)	(15.31)	(14.02)	(13.92)	(23.61)	(19.13)	(0.25)	(0.98)	(4.11)	(5.15)	(3.01)	(2.45)

(*continued*)

Table III—*Continued*

Variable	Investment Grade Bonds						Speculative Grade Bonds					
Credit rating	0.0021*	0.0020*	0.0023*	0.0023*	0.0021*	0.0021*	0.0247*	0.0249*	0.0092*	0.0091*	0.0372*	0.0366*
	(26.96)	(20.14)	(32.54)	(24.35)	(34.62)	(22.55)	(9.61)	(6.45)	(8.67)	(6.85)	(13.25)	(9.29)
σ_E		3.4437*		5.2107*		4.1768*		4.2847		2.8546†		16.8334*
		(4.99)		(6.85)		(5.32)		(1.92)		(2.27)		(3.86)
Pre-Tax D1		−0.0012*		−0.0015*		−0.0010*		0.0091*		−0.0014		0.0037
		(5.93)		(6.85)		(5.32)		(2.79)		(0.93)		(0.73)
Pre-Tax D2		0.0005*		0.0006*		0.0005*		−0.0103		0.0043†		−0.0051
		(3.56)		(4.83)		(4.33)		(1.46)		(2.12)		(0.85)
Pre-Tax D3		0.0001		0.0002†		0.0001		0.0060		0.0047		0.0138*
		(1.21)		(2.24)		(1.59)		(0.75)		(1.78)		(2.66)
Pre-Tax D4		−0.0001*		−0.0001*		−0.0001		0.0014		−0.0067†		0.0273
		(2.57)		(4.52)		(1.65)		(0.12)		(2.52)		(1.16)
Income to Sales		−0.0069*		−0.0080*		−0.0079*		−0.0185		−0.0277*		−0.0900
		(4.80)		(6.34)		(5.29)		(1.38)		(2.81)		(1.10)
LT Debt to Assets		−0.0057*		−0.0061*		−0.0047†		0.0165		−0.0147		−0.0295
		(3.22)		(3.83)		(2.56)		(0.48)		(0.90)		(0.32)
Total Debt to Capital		0.0049†		0.0036†		0.0073*		0.0519		0.0748*		0.0185*
		(2.53)		(2.19)		(4.29)		(0.78)		(4.24)		(4.29)
N	5,838	2,176	6,035	2,374	8,802	3,257	1,041	461	583	288	1,413	606
% Adj. R^2	29.19	41.84	25.44	47.91	25.47	46.02	37.04	44.30	32.04	58.36	33.40	44.09
	LOT	Rating	Bid–Ask	Rating	% Zeros	Rating	LOT	Rating	Bid–Ask	Rating	% Zeros	Rating
Coefficient	0.4233*	0.0028*	0.5536*	0.0025*	0.0183*	0.0026*	2.4233*	0.0318*	3.3941*	0.0106*	0.1158*	0.0379*
	(9.67)	(29.82)	(6.36)	(32.67)	(10.96)	(35.00)	(9.07)	(9.89)	(4.77)	(10.17)	(7.14)	(12.35)
% Adj. R^2	7.57	15.20	2.12	20.12	3.95	15.08	21.83	24.00	7.49	25.12	3.02	28.21

An *or a † signifies significance at the 1% or 5% level, respectively.

causing a negative relation between the yield spread and maturity for these bonds.

At the bottom of Table III we report the regression of yield spread on each liquidity measure separately using the full sample whenever the measure is available. For each measure, we also regress the yield spread on the bond rating alone for the same sample as a comparison. For investment grade bonds, liquidity alone explains from 2.12% (for the bid–ask spread) to 7.57% (for the LOT estimate) of the cross-sectional variation in the yield spread. In comparison, for the same sample, bond rating alone explains 15.20% of the cross-sectional variation of yield spread for the LOT sample and 20.12% for the bid–ask spread sample. For speculative bonds, the bid–ask spread alone explains 7.49% of the yield spread variation while the LOT liquidity measure explains 21.83% of the yield spread variation.

B. Issuer Fixed-Effects Regressions

We perform an issuer fixed effects regression to control for issuer influences on yields because a small set of companies may dominate the bond market. For instance, Ford Motor Company's bonds comprise almost 10% of the entire bond market. As in the levels regression tests, we use separate samples for each liquidity measure to allow for different bond characteristics. This results in approximately 1,100 issuers for investment grade bonds and 220 issuers for speculative grade bonds. However, approximately only 300 issuers have complete accounting information for investment grade bonds and approximately only 90 issuers have complete accounting information for speculative grade bonds. Table IV presents the results.

We observe the same consistent result using either the bid–ask spread or the LOT liquidity estimate. Liquidity is positively and significantly associated with the yield spread regardless of bond grade, even after controlling for bond-specific, firm-specific, and macroeconomic variables. The coefficients are highly significant at the 1% level. Note that the proportion of zero returns is significantly positive (at 1%) for both investment grade bonds and speculative grade bonds when the accounting variables are not included, but is only significant at 10% when the firm-level variables are included. In other words, while all liquidity measures lead to the same conclusion, the case for the proportion of zero returns is slightly weaker, consistent with the notion that the proportion of zero returns is a relatively noisy measure of liquidity.

C. Simultaneous Equation Model Tests

Every liquidity measure, whether based on observable bid–ask spreads or new estimable measures, could contain information about the credit quality of a bond, and thus may affect the yield through the credit risk channel. This would make it difficult to interpret the main results purely in terms of liquidity costs. Under the assumption that much of the liquidity costs are due to adverse selection under asymmetric information, for a typical corporate bond we would

Table IV

Fixed Effects: Yield Spread Determinant Tests

The yield spread determinants are based on bond-specific effects (bond rating, amount outstanding, coupon, and maturity in years), macroeconomic variables (1-year Treasury note rate (T-Note), the difference between the 10-year and 2-year Treasury rates (Term Slope), and the 30-day Eurodollar rate minus the 3-month T-Bill Rate (Eurodollar)), and firm-specific characteristics (pre-tax interest coverage, operating income to sales, long-term debt to assets, and total debt to capitalization). The pre-tax interest coverage is further grouped into one of four categories according to Blume et al. (1998). σ_E is the equity volatility for each issuer. Investment grade bonds are numbered from 1 (AAA rated bonds) to 10 (BBB− rated bonds). Speculative grade bonds are numbered from 1 (BB+ rated bonds) to 12 (D rated bonds). The liquidity cost estimates include the LOT estimate, the percentage of zero returns, and the bid–ask spread. The issuer is the fixed effect. The significance of the issuer fixed effect is reported by the F-test. Liquidity results are in boldfaced type.

Variable	Investment Grade Bonds						Speculative Grade Bonds					
Intercept	0.1111*	0.1194*	0.1086*	0.0932*	0.1219*	0.1053*	0.7743†	0.2208	0.3588*	0.4188*	1.0571*	0.0360
	(12.15)	(14.11)	(14.93)	(10.25)	(10.98)	(13.78)	(2.55)	(0.61)	(2.87)	(3.78)	(3.47)	(0.85)
LOT	**0.2118***	**0.1078***					**2.2897***	**0.8764***				
	(13.12)	(9.73)					(13.80)	(4.31)				
Bid–Ask			**0.1703***	**0.2019***					**1.4963***	**1.5890***		
			(5.72)	(5.15)					(4.75)	(4.17)		
% Zeros					**0.0119***	**0.0044***					**0.0981***	0.0482
					(13.01)	(5.75)					(5.01)	(1.72)
Maturity	0.0001*	0.0001*	0.0002*	0.0001*	0.0001*	0.0002*	−0.0029*	−0.0029*	−0.0011*	−0.0011*	−0.0022*	−0.0028*
	(5.60)	(12.15)	(12.51)	(12.45)	(9.98)	(14.75)	(4.84)	(4.22)	(7.85)	(7.18)	(3.94)	(3.73)
Amount	−0.0006†	−0.0004	−0.0001	−0.0002	−0.0005*	−0.0003	−0.0058	−0.0026	−0.0064*	−0.0041†	0.0038	0.0087†
	(2.26)	(1.86)	(0.60)	(0.84)	(2.72)	(1.63)	(1.48)	(0.79)	(2.93)	(1.95)	(1.00)	(2.20)
Coupon	0.0658*	0.0705*	0.0005*	0.0005*	0.0629*	0.0667*	0.6891	1.6274*	0.0013	0.0002	0.6689	1.5849*
	(3.84)	(5.32)	(5.10)	(3.84)	(4.83)	(6.03)	(1.28)	(3.09)	(1.00)	(0.17)	(1.31)	(2.62)
T-Note Rate	−1.5298*	−1.2470*	−1.1839*	−0.9141*	−1.6169*	−1.1972*	−13.6442*	−5.8177	−2.4538	−5.3023*	−19.0025*	−10.352
	(17.02)	(18.48)	(15.85)	(10.96)	(19.69)	(17.02)	(3.48)	(1.18)	(1.35)	(3.29)	(4.24)	(1.78)
Term Slope	−3.6526*	−3.3459*	−3.2950*	−2.6766*	−3.9435*	−3.2680*	−20.8069†	−13.1133	−7.5091†	−13.7416*	−39.3252*	−24.667
	(17.60)	(21.05)	(19.81)	(14.15)	(21.16)	(20.08)	(2.42)	(1.20)	(2.04)	(4.18)	(4.59)	(1.92)
Eurodollar	−0.0570*	−0.0602*	−0.0685*	−0.0545*	−0.0637*	−0.0591*	−0.2086	−0.2031	−0.2571*	−0.2533*	−0.6623*	−0.3158
	(15.95)	(20.94)	(25.95)	(17.22)	(21.74)	(21.90)	(1.57)	(1.20)	(7.64)	(6.39)	(5.37)	(1.62)

Credit	0.0035*	0.0008*	0.0009*	0.0008*	0.0031*	0.0012*	0.0048	0.0250*	0.0123*	0.0123*	0.0300*	0.0423*
rating	(16.98)	(3.87)	(5.92)	(3.75)	(19.03)	(6.28)	(1.25)	(6.52)	(10.37)	(9.80)	(8.36)	(9.67)
σ_E		1.1266*		2.2140*		1.8186*		−1.5774		−2.9956*		6.8704
		(3.89)		(5.40)		(6.80)		(0.44)		(3.21)		(1.72)
Pre-Tax D1		−0.0013*		−0.0010*		−0.0009*		0.0098		0.0035†		0.0007
		(7.67)		(5.42)		(5.82)		(1.52)		(2.34)		(0.10)
Pre-Tax D2		0.0003†		0.0005*		0.0004*		−0.0045		0.0007		0.0028
		(1.96)		(3.55)		(3.70)		(0.29)		(0.26)		(0.23)
Pre-Tax D3		0.0001		0.0000		0.0001		0.0336		0.0076		0.0057
		(0.47)		(0.27)		(1.11)		(0.66)		(1.26)		(0.30)
Pre-Tax D4		−0.0000		0.0000		−0.0000		−0.0578		−0.0077		−0.0099
		(0.15)		(0.42)		(0.37)		(0.62)		(1.26)		(0.36)
Income		−0.0022		−0.0068*		−0.0039		−0.0274		−0.0713*		0.0024
to Sales		(1.00)		(3.10)		(1.92)		(0.69)		(3.42)		(0.46)
LT Debt		−0.0004		−0.0047		0.0005		0.0618†		0.0812*		0.0037
to Assets		(0.15)		(1.42)		(0.19)		(2.02)		(2.73)		(0.09)
Total Debt		0.0187*		0.0182*		0.0186*		0.1041		0.0732*		−0.0094
to Capital		(6.79)		(6.33)		(7.60)		(1.25)		(2.79)		(0.12)
Sample Size	5,838	2,176	6,035	2,374	8,802	3,257	1,041	461	583	288	1,413	606
Issuers	1,124	336	1,019	306	1,235	367	263	96	179	76	294	106
F-Statistic	6.67*	14.01*	14.06*	14.12*	8.74*	15.80	3.06*	2.10*	11.11*	9.65*	3.67*	2.90*

An *or a † signifies significance at the 1% or 5% level, respectively.

hypothesize that asymmetric information on its credit quality (rather than on the interest rate) is the main reason for adverse selection costs. Intuitively, one expects that bonds with lower credit quality should have a more severe adverse selection problem, ceteris paribus. Thus, higher liquidity costs could mean lower credit quality, which could lead, in turn, to higher yield spreads. In addition, Campbell and Taksler (2003) note that bond ratings may be contemporaneously incorporating observed firm-level accounting characteristics. Rating agencies may also absorb market information through the observed yield spread as well as macroeconomic information when assigning a credit rating.

To control for the potential endogeneity problems arising from the contemporaneous measurement of the yield spread, liquidity costs, and the credit rating, we employ a simultaneous equation model using three equations that represent each of the potentially endogenous variables. The system of equations is as follows:

$$\begin{aligned}
&\text{Yield Spread}_{it}\\
&\quad = \eta_0 + \eta_1\text{Liquidity}_{it} + \eta_2\text{Maturity}_{it} + \eta_3\text{Coupon}_{it} + \eta_4\text{Treasury Rate}_t\\
&\qquad + \eta_5\text{10Yr} - \text{2Yr Treasury Rate}_t + \eta_6\text{EuroDollar}_t + \eta_7\text{Volatility}_{it}\\
&\qquad + \eta_8\text{Credit Rating}_{it} + \eta_9\text{PreTax Coverage Dummy}_{it}\\
&\qquad + \eta_{10}\text{Operating Income/Sales}_{it} + \eta_{11}\text{Debt/Assets}_{it}\\
&\qquad + \eta_{12}\text{Debt/Capitalization}_{it} + \epsilon_t
\end{aligned}$$

$$\begin{aligned}
\text{Liquidity}_{it} &= \eta_0 + \eta_1\text{Maturity}_{it} + \eta_2\text{Age}_{it} + \eta_3\text{Amount Outstanding}_{it}\\
&\quad + \eta_4\text{Credit Rating}_{it} + \eta_5\text{Bond Volatility}_{it} + \eta_6\text{Yield Spread}_{it} + \epsilon_t\\
\text{Credit Rating}_{it} &= \eta_0 + \eta_1\text{Treasury Rate}_{it} + \eta_2\text{10Yr} - \text{2Yr Treasury Rate}_t\\
&\quad + \eta_3\text{PreTax Coverage Dummy}_{it} + \eta_4\text{Operating Income/Sales}_{it}\\
&\quad + \eta_5\text{Debt/Assets}_{it} + \eta_6\text{Debt/Capitalization}_{it}\\
&\quad + \eta_7\text{Yield Spread}_{it} + \epsilon_t.
\end{aligned}$$

The parameters of the simultaneous equation model are estimated using the two-stage least squares method with the estimation results presented in Table V. As the table shows, the potential endogeneity bias does not affect the relation between liquidity and the yield spread for either investment grade or speculative grade bonds. The LOT liquidity estimate and the bid–ask spread liquidity measure remain significant at the 1% level for investment grade bonds, and they remain significant at the 5% level for speculative grade bonds. The percentage of zero returns is significant at the 5% level for investment grade bonds, but is insignificant for speculative grade bonds, illustrating the lack of power of this liquidity estimate. The negative coefficient for the yield spread in the liquidity equations indicates that as credit quality falls, a larger percentage of the increased yield spread is due to default risk. The regression results for

Table V

Two-Stage Least Squares Estimation: Yield Spread Determinants

The simultaneous equation model results are presented using three liquidity measures, the LOT estimate, the percentage of zero returns, and the bid–ask spread. The liquidity exogenous variables include the bond return volatility, the amount outstanding, the age and maturity in years, and bond rating. σ_B and σ_E refer to bond volatility and equity volatility, respectively. The amount outstanding and bond volatility are log scaled. The yield spread exogenous variables include bond-specific effects (bond rating, amount outstanding, coupon, and maturity in years), macroeconomic variables (1-year T-note rate, the difference between the 10-year and 2-year Treasury rates, and the 30-day Eurodollar rate over the 3-month T-bill rate), firm-specific accounting variables (pre-tax interest coverage, operating income to sales, long-term debt to assets, and total debt to capitalization), and equity market effects (equity volatility). The bond rating exogenous variables are bond age and firm-specific accounting variables. Liquidity results are in boldfaced type.

	Investment Grade								
Instrumental Variable	Yield Spread	Bid–Ask	Credit Rating	Yield Spread	LOT	Credit Rating	Yield Spread	%Zeros	Credit Rating
Intercept	0.1661*	0.0150*	8.4213*	0.2398*	0.1476*	8.1414*	0.7819	1.1697*	7.9553*
	(2.77)	(5.05)	(6.52)	(5.10)	(13.84)	(8.39)	(1.87)	(10.46)	(9.12)
Liquidity	**7.0442***			**0.9975***			**0.2126**†		
	(4.23)			(7.44)			(1.96)		
Maturity	−0.0003	0.0001†		0.0001	−0.0004*		0.0001	−0.0028*	
	(1.94)	(2.19)		(1.29)	(9.23)		(1.72)	(5.88)	
Coupon	−0.0009			−0.0504			−0.1899		
	(1.14)			(0.66)			(1.93)		
T-note	−2.5455*		−49.4529†	−3.9712*		−35.4179†	−11.8048†		−34.8361†
	(3.41)		(2.35)	(6.55)		(2.32)	(1.96)		(2.50)
Term slope	−6.7878*		−86.3815†	−8.6125*		−61.5634†	−26.2885†		−60.4370†
	(3.82)		(2.08)	(6.93)		(0.31)	(2.00)		(2.17)
Eurodollar	−0.1121*			−0.0810*			−0.2727†		
	(4.36)			(6.79)			(2.19)		
σ_E	2.0849			1.6004			−5.2688		
	(0.92)			(1.88)			(1.43)		
Credit rating	0.0057†	0.0003*		0.0056*	0.0018*		0.0038*	0.0396*	
	(2.34)	(3.18)		(2.65)	(4.90)		(3.94)	(9.54)	
Pre-Tax D1	−0.0001		0.0414	−0.0003		0.0140	0.0016		0.0382
	(1.44)		(1.15)	(0.81)		(0.39)	(1.10)		(1.29)

(*continued*)

Table V—*Continued*

Instrumental Variable	Investment Grade Yield Spread	Bid–Ask	Credit Rating	Yield Spread	LOT	Credit Rating	Yield Spread	%Zeros	Credit Rating
Pre-Tax D2	0.0015		−0.2862*	0.0015†		−0.2921*	0.0012		−0.2964*
	(1.66)		(9.67)	(2.19)		(9.52)	(1.03)		(11.98)
Pre-Tax D3	0.0005		−0.1152*	0.0004		−0.1012*	0.0001		−0.1031*
	(1.02)		(5.48)	(1.51)		(4.20)	(1.03)		(5.56)
Pre-Tax D4	−0.0002		0.0337*	−0.0001		0.0298*	0.0001		0.0226*
	(0.81)		(3.67)	(0.99)		(2.82)	(0.31)		(2.88)
Income to Sales	0.0002		−1.4810*	0.0051		−1.7060*	0.0079		−1.4883*
	(0.03)		(5.84)	(1.02)		(6.41)	(1.21)		(6.93)
Long-Term Debt to Assets	−0.0282†		3.9493*	−0.0189		4.0813	−0.0188		3.6651*
	(2.40)		(12.85)	(1.90)		(12.76)	(1.28)		(14.21)
Total Debt to Capital	0.0026		−0.1889	0.0077†		−0.4549	0.0202†		−0.4472
	(0.44)		(0.58)	(2.17)		(1.34)	(2.53)		(1.59)
Ln(σ_B)		0.0008*			0.0080*			0.0633*	
		(5.44)			(17.22)			(12.76)	
Ln(amount outstanding)		−0.0002			−0.0026*			−0.0250*	
		(1.80)			(5.79)			(5.53)	
Bond age		0.0001†			−0.0001			−0.0001	
		(2.45)			(0.58)			(0.04)	
Yield spread		−0.0784*	63.4919*		−0.7430*	50.2688*		−9.9378*	56.7310*
		(3.24)	(11.34)		(9.11)	(8.78)		(10.83)	(12.14)
Sample size		2374			2176			3257	
Adjusted R^2	5.23	5.48	40.05	17.77	13.80	36.88	3.45	5.88	36.45
Speculative Grade									
Intercept	0.0139	0.0077	4.9369	0.1265	0.0568*	−8.1870	0.4540*	−0.7170*	−2.8820
	(0.04)	(0.78)	(0.75)	(0.30)	(1.06)	(1.64)	(0.66)	(3.02)	(0.51)
Liquidity	**12.1308**†			**1.8432**†			−0.1944		
	(1.95)			(1.96)			(0.83)		
Maturity	−0.0027†	0.0001*		−0.0024*	0.0008		−0.0039*	0.0041†	
	(2.14)	(2.72)		(3.89)	(1.85)		(3.37)	(2.07)	

Coupon	0.0064†			0.2784			1.5665*		
	(2.35)			(1.24)			(2.76)		
T-note	0.4380		−49.1239	−4.5914		192.8104†	−4.3845		80.9381
	(0.08)		(0.45)	(0.82)		(2.35)	(0.58)		(0.87)
Term slope	−5.7854		−66.7110	−5.8488		375.1280†	−16.1279		165.3930
	(0.51)		(0.31)	(0.39)		(2.29)	(1.00)		(0.89)
Eurodollar	−0.5536†			0.0981			−0.5329†		
	(2.65)			(0.36)			(2.11)		
σ_E	5.9458			−0.4133			17.8417†		
	(1.32)			(0.17)			(1.97)		
Credit rating	0.0321*	0.0018*		0.0211†	−0.0024		0.0397*	0.0657*	
	(3.68)	(4.70)		(2.04)	(0.79)		(3.85)	(3.10)	
Pre-Tax D1	0.0090†		−0.3952*	0.0081		−0.3802*	−0.0017		−0.1887†
	(2.14)		(6.20)	(1.80)		(4.38)	(0.20)		(1.98)
Pre-Tax D2	0.0073		0.0611	0.0078		−0.0868*	−0.0170		−0.0784
	(1.06)		(0.49)	(0.73)		(0.36)	(0.85)		(0.41)
Pre-Tax D3	−0.0067		−0.1693	−0.0192		−0.0994	0.0194		−0.0460
	(0.64)		(0.92)	(0.81)		(0.21)	(0.97)		(0.17)
Pre-Tax D4	−0.0031		0.2538	0.0345		0.1380	−0.0190		0.1594
	(0.26)		(1.11)	(0.88)		(0.18)	(0.80)		(1.79)
Income	0.1101		−0.5159	−0.0045		−0.8189	0.0410		−1.3637
to Sales	(1.90)		(0.97)	(0.15)		(1.45)	(0.69)		(1.79)
Long-Term Debt	−0.1915*		2.4873*	0.0490		−0.1068	−0.2921*		3.2336*
to Assets	(2.84)		(3.17)	(1.50)		(0.20)	(3.81)		(2.89)
Total Debt	0.1994*		−3.1155*	−0.0372		−1.2718	0.1443†		−1.4239
to Capital	(3.77)		(4.00)	(0.59)		(1.47)	(1.96)		(1.45)
Ln(σ_B)		0.0004			0.0024			−0.0992*	
		(1.30)			(0.65)			(6.38)	
Ln(amount		−0.0001			−0.0012			−0.0006	
outstanding)		(0.11)			(1.06)			(0.09)	
Bond age		−0.0002†			−0.0004			−0.0057	
		(2.28)			(1.03)			(1.56)	
Yield spread		−0.0312	24.3250*		0.3014*	22.3214*		0.1582	15.5033*
		(1.59)	(9.38)		(3.45)	(16.65)		(0.56)	(14.32)
Sample size		288			461			606	
Adjusted R^2	28.81	22.17	58.57	46.46	22.84	47.82	35.31	6.08	36.87

An *denotes 1% significance while a † denotes 5% significance.

tax effects (coupon) are now insignificant, indicating that the prior significance in the tax effects may simply be capturing the fact that higher-coupon bonds are less liquid than other bonds, as noted by Longstaff et al. (2005). Finally, equity volatility is also insignificant, adding to the importance of liquidity, in addition to default risk, in explaining yield spreads.

IV. Liquidity Effects on the Yield Spread Changes

We conduct regression tests to study whether issue-specific liquidity changes are a determinant of yield spread changes. This test offers a glimpse into how the dynamics of liquidity are incorporated into yield spread changes. Econometrically, differencing the time series removes autocorrelative influences that may cause spurious results due to time-series trends.

A. Regression Tests of Changes in Liquidity and Yield Spread Determinants

We include a list of independent variables used in Collin-Dufresne et al. (2001) and Campbell and Taksler (2003). Unlike in the case of the levels specification, here we use the unscaled pre-tax coverage because of the differencing operation. In addition, unlike Collin-Dufresne et al. (2001), we directly control for the default probability by using the realized annual changes in the credit ratings for each bond. We believe this is a better control than using the change in the forward jump rate in the option market. Specifically, the regression is given as:

$$
\begin{aligned}
&\Delta(\text{Yield Spread})_i \\
&\quad = \gamma_0 + \gamma_1 \Delta(\text{Liquidity})_i + \gamma_2 \Delta(\text{S\&P Rating})_i + \gamma_3 \Delta(\sigma_E)_i \\
&\qquad + \gamma_4 \Delta(\text{Treasury Rate})_i + \gamma_5 \Delta(\text{10yr} - \text{2yr Treasure Rate})_i \\
&\qquad + \gamma_6 \Delta(\text{30 Day EuroDollar Rate})_i + \gamma_7 \Delta(\text{PreTax Interest Coverage})_i \\
&\qquad + \gamma_8 \Delta(\text{Operating Income/Sales})_i \\
&\qquad + \gamma_9 \Delta(\text{Debt/Assets})_i + \gamma_{10} \Delta(\text{Debt/Capitalization})_i + \epsilon,
\end{aligned}
$$

where Δ represents the first difference in each variable for each bond i. The results are presented in Table VI.

As expected, a deterioration of bond quality (rating) is related to a significant increase in the yield spread. Similarly, a rise in interest rates leads to a reduction in the yield spread, especially for investment grade bonds (Duffee (1998), and Longstaff and Schwartz (1995)). However, even after controlling for this and other factors, changes in liquidity are highly associated with changes in the yield spread, especially for the bid–ask spread and the LOT estimate. This is the case for both investment grade and speculative grade bond categories.

Adding the macroeconomic variables and firm-specific accounting variables increases the explanatory power, but not at the expense of the liquidity variable, which remains significant. The conclusive result in Table VI is the positive, significant coefficient for the liquidity change variable. Liquidity changes remain

Table VI

Yield Spread Change Determinants and Liquidity Tests

The yield spread change determinants are based on bond-specific effects, macroeconomic effects, and firm-specific operating characteristics. Annual changes in all variables are examined for the 1995–2003 period. The liquidity cost proxies include the LOT estimate, the percentage of zero returns, and the bid–ask spread. We use a cardinal scale for all bonds, regardless of whether they are investment grade or speculative grade bonds, ranging from 1 for AAA bonds to 22 for D rated bonds. The firm-specific characteristics are pre-tax interest coverage, operating income to sales, long-term debt to assets, and total debt to capitalization. σ_E is equity volatility. T-Note Rate is the 1-year Treasury rate. Term-Slope is the difference between the 10 year and 2-year Treasury rates. Eurodollar refers to the difference between the 30-day Eurodollar rate and the 3-month T-Bill rate. The last partition is a univariate regression of the change in the yield spread on either the change in each liquidity measure or the change in the credit rating using the larger sample for each liquidity measure. White's (1980) *t*-statistics are presented in parentheses. Liquidity results are in boldfaced type.

Variable	Investment Grade Bonds						Speculative Grade Bonds					
Intercept	−0.0001	−0.0004	−0.0005*	−0.0006*	−0.0014*	−0.0006	0.0327	0.0213	0.0003	0.0080	−0.0103*	−0.0006
	(0.49)	(1.34)	(2.81)	(2.80)	(5.49)	(1.83)	(2.55)	(1.31)	(0.08)	(1.06)	(10.21)	(0.39)
Δ(LOT)	**0.1885***	**0.1239***					**1.5153***	**0.6068***				
	(5.92)	(4.01)					(3.56)	(4.17)				
Δ(%Zero)			**0.0286***	**0.0134***					0.0172	**0.0369†**		
			(6.02)	(3.51)					(1.81)	(2.11)		
Δ(Bid–ask)					**0.1873†**	**0.2909†**					**2.1636†**	**2.4613†**
					(2.22)	(2.34)					(2.44)	(2.57)
Δ(Credit rating)	0.0015*	0.0011*	0.0018*	0.0015*	0.0007*	0.0014*	0.0123	0.0293*	0.0098*	0.0089*	0.0181*	0.0197*
	(2.64)	(2.91)	(4.48)	(5.10)	(4.25)	(4.33)	(1.90)	(4.99)	(5.75)	(3.03)	(6.72)	(6.17)
Δ(T-note)	−0.9791*	−0.7426*	−1.1166*	−0.6589*	−0.9203*	−0.4271*	−8.9819	−6.9540	−4.2911†	−2.6598	−0.2080	0.4007
	(13.04)	(9.69)	(11.04)	(7.48)	(12.31)	(4.18)	(2.29)	(1.65)	(2.43)	(0.56)	(0.46)	(0.56)
Δ(Term slope)	−2.6012*	−2.2579*	−2.7856*	−1.9930*	−2.5691*	−1.5795*	−18.153†	−20.057†	−10.728*	9.8818	−1.1486	−3.3099
	(15.60)	(13.90)	(13.24)	(11.41)	(16.15)	(7.72)	(2.22)	(2.40)	(3.12)	(0.99)	(1.17)	(1.69)
Δ(Eurodollar)	−0.0538*	−0.0473*	−0.0504*	−0.0397*	−0.0601*	−0.0385*	−0.2534	−0.2927†	−0.1999*	−0.2396*	−0.2001*	−0.2808*
	(16.93)	(12.62)	(9.40)	(15.28)	(23.95)	(11.13)	(2.41)	(2.30)	(7.18)	(3.37)	(3.96)	(4.87)
Δ(σ_E)		−0.3013		−0.5490		−1.7774		−3.0106		−2.1667†		2.2830
		(0.36)		(0.73)		(1.77)		(1.79)		(1.94)		(1.21)
Δ(Pre-Tax Interest)		0.0000		0.0001		0.0001		−0.0001		−0.0005		−0.0000
		(0.08)		(1.02)		(1.75)		(0.10)		(1.08)		(0.02)
Δ(Income to Sales)		−0.0107*		−0.0115*		−0.0181*		0.0044		−0.0192		−0.0393
		(2.57)		(4.01)		(3.12)		(0.16)		(1.55)		(0.75)
Δ(LT Debt to Assets)		0.0094		0.0037		0.0189*		0.0437		0.0027		0.0709
		(1.80)		(0.97)		(3.02)		(1.25)		(0.09)		(0.97)
Δ(Debt to Capital)		0.0083		0.0075†		−0.0057		0.0674		0.0407		0.0349
		(1.67)		(2.08)		(0.92)		(1.38)		(1.54)		(0.90)
Sample Size	2,646	985	5,170	1,842	2,914	1,164	451	198	477	195	188	103
Adj R^2 (%)	11.93	21.19	9.10	17.32	16.06	18.34	17.49	63.26	18.98	33.05	34.17	50.43
Liquidity alone	0.1847		0.0276*		0.2270*		1.7739*		0.0527*		0.9534†	
	(6.19)		(5.95)		(2.57)		(4.74)		(5.57)		(2.00)	
% Adj. R^2	2.80		2.32		0.19		16.89		5.97		0.75	
Credit risk alone	0.0018†		0.0023*		0.0007*		0.0250*		0.0095*		0.0178*	
	(2.53)		(4.36)		(3.13)		(3.56)		(4.67)		(6.84)	
% Adj. R^2	1.03		1.19		0.34		4.30		5.39		19.65	

An *denotes 1% significance while a † denotes 5% significance.

significantly associated with yield spread changes regardless of whether we include bond-specific, firm-specific, or macro-level variables.

Economically, for investment grade bonds, a one basis point increase in LOT liquidity costs over time results in a 0.12 basis point increase in the yield spread, while a one basis point increase in the bid–ask spread over time results in a 0.29 basis point increase in the yield spread. The corresponding impacts for speculative grade bonds are 0.61 basis points (LOT liquidity costs) and 2.46 basis points (bid–ask spread). Note that the coefficients for the liquidity variables are broadly consistent with those of Table III.

At the bottom of Table VI we report the regression of the change in the yield spread on the change in each liquidity measure separately using the full sample whenever the measure is available. For each measure, we also regress the change in the yield spread on the change in the bond rating alone as a comparison. For investment grade bonds, the changes in the percentage of zero returns and the LOT liquidity measure explain more than 2.0% of the cross-sectional variation in the change of yield spread. For speculative bonds, changes in the LOT liquidity measure alone explain 16.89% of the changes in the yield spread, while changes in the percentage zeros alone explain 5.97% of the changes in the yield spread. Changes in the bid–ask spread alone have relatively lower explanatory power for both categories of bonds.

B. Simultaneous Equation Model Tests

To control for potential endogeneity bias, we estimate a simultaneous equation model using two-stage least squares with the change in yield spread and the change in each of the liquidity measures (respectively) as the endogenous variable. Unlike the levels test, we do not endogenize bond rating changes because credit rating changes are infrequent within the sample period, causing a limited dependent variable problem in the simultaneous system regression. Additionally, the equations for the bid–ask spread sample for speculative grade bonds are unidentified because of linear dependence among the macroeconomic variables. We therefore remove the Eurodollar variable to allow for system identification. Moreover, changes in maturity, age, and coupon are also excluded. The resulting simultaneous regression for yield spread changes is specified as:

$$
\begin{aligned}
\Delta(\text{Yield Spread})_i &= \eta_0 + \eta_1\Delta(\text{Liquidity})_i + \eta_2\Delta(\text{Treasury Rate})_i \\
&\quad + \eta_3\Delta(\text{10Yr} - \text{2Yr Treasury Rate})_i + \eta_4\Delta(\text{EuroDollar})_i \\
&\quad + \eta_5\Delta(\text{Volatility})_i + \eta_6\Delta(\text{Credit Rating})_i \\
&\quad + \eta_7\Delta(\text{PreTax Coverage})_i + \eta_8\Delta(\text{Operating Income/Sales})_i \\
&\quad + \eta_9\Delta(\text{Debt/Assets}_i) + \eta_{10}\Delta(\text{Debt/Capitalization})_i + \epsilon \\
\Delta(\text{Liquidity})_{it} &= \eta_0 + \eta_1\Delta(\text{Credit Rating})_i + \eta_2\Delta(\text{Bond Volatility})_i \\
&\quad + \eta_3\Delta(\text{Yield Spread})_i + \epsilon.
\end{aligned}
$$

The results, presented in Table VII, can be summarized as follows. For the bid–ask spread or the LOT estimates, an increase in liquidity costs causes a significantly positive increase in yield spreads, for both the investment grade and the speculative grade bonds. For the proportion of zero returns, an increase in liquidity costs causes a significant increase in yield spreads for investment grade bonds, but not for speculative bonds. The results concerning the percentage of zero returns for the speculative grade bonds are consistent with the levels tests. On the whole, Table VII indicates that our tests on changes in liquidity are robust to potential endogeneity bias.

V. Conclusions

We examine the association between corporate bond liquidity and yield spreads. An important feature of our analysis is the use of a battery of liquidity measures and a comprehensive set of 4,000 corporate bonds spanning both investment grade and speculative grade bond categories. Specifically, we adopt two model-independent liquidity measures (the bid–ask spread and the proportion of zero returns) and a liquidity estimate from a model developed by Lesmond et al. (1999) to throughly test the relations between liquidity and yield spread levels and between liquidity changes and yield spread changes. We find that the percentage of zero returns and the modified Lesmond model are highly associated with the underlying bid–ask spread, with the modified Lesmond model the more strongly associated liquidity measure. In contrast to Longstaff et al. (2005), we find little evidence of the importance of the outstanding principal amount in explaining bond liquidity. However, consistent with Stoll's (2000) equity market results, we find strong evidence of the importance of bond volatility in explaining bond liquidity.

We find that liquidity is a key determinant in yield spreads, explaining as much as half of the cross-sectional variation in yield spread levels and as much as twice the cross-sectional variation in yield spread changes than is explained by credit rating effects alone. Echoing the general belief in the default risk literature, we document that liquidity is priced in yield spreads regardless of whether one controls for issuer fixed effects, potential simultaneity bias between credit ratings, liquidity, and yield spreads, or the commonly used yield spread determinants adopted by Campbell and Taksler (2003) or yield spread change determinants of Collin-Dufresne et al. (2001). Both investment grade and speculative grade bonds exhibit liquidity effects. We find inconsistent statistical evidence of a tax effect, in line with Longstaff et al. (2005), or an equity volatility effect for investment grade bonds, and little evidence of these effects for speculative grade bonds.

This paper contributes to the growing debate over liquidity's influence on asset pricing and corporate finance decisions, with implications for both domestic and international markets. Specifically, the issue of a liquidity premium on returns (Amihud and Mendelson (1986)) may now find common ground in both bond and equity markets (Bekaert et al. (2003)). A liquidity premium in bond yields may provide the impetus to examine liquidity's impact on balancing the

Table VII

Two-Stage Least Squares Estimation: Yield Spread Changes

Simultaneous regressions are presented using three liquidity measures: the LOT estimate, the percentage of zero returns, and the bid–ask spread. Annual changes in all variables are examined for the 1995–2003 period. The liquidity cost proxies include the LOT estimate, the percentage of zero returns, and the bid–ask spread. We use a cardinal scale for all bonds, regardless of whether they are investment grade or speculative grade bonds, ranging from 1 for AAA bonds to 22 for D rated bonds. The exogenous variables for liquidity are the bond return volatility and bond rating. σ_B and σ_E refer to bond volatility and equity volatility, respectively. The exogenous variables for the yield spread are bond rating, macroeconomic variables (1-year Treasury note rate, the difference between the 10-year and 2-year Treasury rates, and the 30-day Eurodollar rate over the 3-month T-bill rate), firm-specific accounting variables (pre-tax interest coverage, operating income to sales, long-term debt to assets, and total debt to capitalization), and equity market effects (equity volatility). Liquidity results are in boldfaced type.

	Investment Grade						Speculative Grade					
Instrumental Variable	Yield Spread	LOT	Yield Spread	%Zeros	Yield Spread	Bid–Ask	Yield Spread	LOT	Yield Spread	%Zeros	Yield Spread	Bid–Ask
Intercept	0.0006	−0.0005†	0.0001	−0.0080*	−0.0027	−0.0001†	0.0169	−0.0119*	0.1634	−0.0090	−0.2785†	0.0002
	(1.33)	(2.32)	(0.10)	(4.77)	(1.16)	(2.45)	(0.80)	(4.71)	(0.43)	(1.06)	(2.55)	(0.43)
Δ(LOT)	**0.7608***						**1.6039†**					
	(8.03)						(2.55)					
Δ(%Zero)			**0.2785***						2.2042			
			(5.20)						(0.44)			
Δ(Bid–Ask)					**19.0803†**						**12.4693***	
					(2.51)						(2.90)	
Δ(T-Note)	−0.5787*		−3.6513*		−241.617		−9.5024		71.448		1.1050	
	(3.97)		(5.48)		(1.90)		(1.24)		(0.42)		(1.74)	
Δ(Term Slope)	−1.8475*		−7.7999*		−2.3671		−16.522		131.721		−428.795	
	(5.92)		(5.95)		(1.44)		(1.08)		(0.39)		(1.68)	
Δ(Euro-Dollar)	−0.0299*		−0.0575*		0.0230		0.1190		1.3221			
	(5.76)		(6.99)		(0.71)		(0.59)		(0.36)			
Δ(σ_E)	−0.1831		0.2952		3.3901		−5.9277*		−39.873		−2.7684	
	(0.44)		(0.38)		(0.93)		(3.49)		(0.45)		(0.99)	
Δ(Credit Rating)	0.0013*	−0.0004	0.0021*	−0.0008	0.0005	−0.0000	−0.0022	0.0053†	−0.0231	0.0248†	0.0183*	0.0000
	(3.16)	(1.10)	(3.39)	(0.33)	(0.34)	(0.38)	(0.39)	(2.02)	(0.31)	(2.12)	(3.35)	(1.24)
Δ(Pre-Tax Interest)	0.0000		−0.0000		−0.0001		0.0033†		0.0042		−0.0015	
	(0.09)		(0.23)		(0.28)		(2.24)		(0.36)		(1.44)	
Δ(Income to Sales)	−0.0165*		−0.0102		−0.0068		0.1287†		0.1280		0.1304	
	(4.79)		(1.79)		(0.49)		(2.45)		(0.35)		(1.51)	
Δ(Debt to Assets)	0.0115†		−0.0107		0.0123		0.1187		0.1484		−0.0291	
	(2.34)		(1.29)		(0.54)		(1.91)		(0.36)		(0.30)	
Δ(Debt to Capital)	0.0050		0.0057		0.0029		−0.0067		−0.1256		0.0139	
	(1.06)		(0.77)		(0.14)		(0.11)		(0.28)		(0.22)	
Δ(Ln(σ_B))		27.3013*		138.250*		−0.0816		5.4303		−22.2797		2.1237
		(8.33)		(5.38)		(0.08)		(0.97)		(0.88)		(1.03)
Δ(Yield spread)		0.1109		−1.0143		0.0596*		0.1847		0.3965		−0.0205
		(1.35)		(1.65)		(3.06)		(1.28)		(0.55)		(0.68)
Sample size	985		1,842		1,164		198		195		103	
Adjusted R^2	18.92	12.20	3.63	1.83	0.60	1.46	20.36	11.33	−4.98	3.17	26.59	−0.22

An *denotes 1% significance while a † denotes 5% significance.

tax benefits of debt over and above agency costs or financial distress costs (Graham (2000)). Furthermore, the evidence of a liquidity effect on corporate yield spreads may shed light on sovereign debt yield spread determinants (Duffie, Pedersen, and Singleton (2004)).

Appendix: The Return Generating Function

By definition, the bond price, B_t is:

$$B_t = \sum_{n=T-t-k}^{T-t} Ce^{-rn} + Ae^{-r(T-t)},$$

where T is the maturity, $k+1$ is the number of coupon payments remaining, C is the half-year coupon payment rate, A is the face value of debt, and r is the yield to maturity for $k+1$ coupon payments remaining. We assume that r_t follows some unspecified stochastic process. By Ito's lemma we have:

$$dB_t = \frac{\partial B}{\partial r}dr + \frac{\partial B}{\partial t}dt + \frac{1}{2}\frac{\partial^2 B}{\partial r^2}\Lambda_t dt, \tag{A1}$$

where Λ_t is the square of the diffusion coefficients of r_t process. If r_t is a multivariate process, then Λ_t should also include the covariance terms. Therefore, from equation (A1):

$$\frac{\partial B}{\partial r} = -D_t B_t, \tag{A2}$$

where D_t is the bond's duration. We can rewrite equation (A2) as:

$$\frac{dB_t}{B_t} = -D_t dr + \frac{\left(\frac{\partial B}{\partial t} + \frac{1}{2}\frac{\partial^2 B}{\partial r^2}\Lambda_t\right)}{B_t}dt. \tag{A3}$$

Barring arbitrage, there exists some state price density process, Λ_t, such that:

$$d\Lambda_t = \mu_{\Lambda,t}dt + \sigma_{\Lambda_t}^T d\omega_t.$$

In equilibrium, the risky bond return should satisfy:

$$E_t\left[\frac{dB_t}{B_t}\right] - r_t dt = -\text{cov}_t\left(\frac{dB_t}{B_t}, \frac{d\Lambda_t}{\Lambda_t}\right) = D_t \text{cov}_t\left(r_t, \frac{d\Lambda_t}{\Lambda_t}\right), \tag{A4}$$

where $\text{cov}_t(dP_t/P_t, d\Lambda_t/\Lambda_t)$ is the instantaneous conditional covariance, and $r_t = -\mu_{\Lambda,t}/\Lambda_t$ is the risk-free rate. We obtain the second equality above by using equation (A3). Following the discrete-time empirical literature, we further assume that the state price density is a linear function of both the market equity return and the long-term risk-free bond return (e.g., Scruggs (1998)). This implies that:

$$E_t\left[\frac{dB_t}{B_t}\right] = r_t dt + D_t \times \gamma_1 \times \text{cov}_t\left(r_t, \frac{dB_{l,t}}{B_{l,t}}\right) + D_t \times \gamma_2 \times \text{cov}_t\left(r_t, \frac{dM_t}{M_t}\right), \quad \text{(A5)}$$

where, γ_i, $i = 1, 2$, is the price of risk associated with the respective state variable, $dB_{l,t}/B_{l,t}$ is the long-term bond return, and dM_t/M_t is the equity market return. In the empirical implementation, we will make the two adjustments. First, we only measure the proportional daily price change in dB_t/B_t. Second, we do not consider daily accrued interest. The latter condition means we consider only clean prices. In summary, bond price changes are only driven by long-term risk-free bond returns and equity returns. We also assume the conditional covariances are constant.[11] This leads to the following specification for equation (1) in the text:

$$R^*_{j,t} = \beta_{j1} \times \text{Duration}_{j,t} \times \Delta R_{l,t} + \beta_{j2} \times \text{Duration}_{j,t} \times \Delta\text{S\&P Index}_t + \epsilon_{j,t},$$

where $R_{j,t}$ is the daily return for bond j that investors would bid given zero transaction costs, $Duration_{j,t}$ is the bond's duration, and Δ S&P Index $_t$ is the daily S&P equity return. $\text{Duration}_{j,t} \times \Delta R_{l,t}$ is the proportional bond return of a long-term risk-free bond adjusted by the duration of the risky bond. The scaling of the market sensitivities by duration is consistent with Jarrow (1978).

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[11] This can be justified for two reasons. First, for each bond we split daily bond prices into separate years and estimate beta coefficients within the year. The coefficients can thus be treated as conditionally constant. Second, we assume that changes in duration for each bond within the year capture some of the variation in beta coefficients.

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