Trading Costs in Three U.S. Bond Markets

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The corporate, municipal, and Treasury bond markets constitute about two-thirds of the average daily trade size in the U.S. debt markets. The total value of bonds outstanding was over $14 trillion in 1999, according to Bond Market Association (BMA) estimates.

Most bond transactions occur in over-the-counter dealer markets where there are varying degrees of pre- and post-trade transparency. In the Treasury market, there is a centralized location reporting pre-trade quotes and post-trade price and quantity for inter-dealer trades, while no such reporting system exists for corporate and municipal bond markets. For corporate and municipal bonds, an institution must call dealers or broadcast requests for quotations through an electronic dealer system; alternatively, dealers may broadcast indicative quotes for bonds in their inventory. A Securities and Exchange Commission (SEC) study concludes that the Treasury market is the most transparent, and the corporate market the least, with poor but improving transparency in the municipal market (SEC press release 98-81).

We use newly available data on secondary bond market transactions to compare trading costs in the corporate, municipal, and Treasury bond markets, after controlling for interest rate risk, credit risk, trading activity, and issuer-specific characteristics.[1] We estimate that the mean daily bid-ask spread per $100 par value is 23 cents for municipal bonds, 21 cents for corporate bonds, and 8 cents for Treasury bonds. We study the determinants of the bid-ask spread, and find that, in all markets, the time to maturity, the trading activity, and credit ratings are the main drivers of the bid-ask spread.

A topical issue in bond markets is the relation of transparency and liquidity. Should the greater transparency in the Treasury market with respect to pre-trade quote dissemination and post-trade publication (relative to other bond markets) result in lower trading costs?[2] We compare the bid-ask spread of Treasury bonds with spreads of corporate and municipal bonds, and find that, after controlling for credit risk, there is no significant difference in the bid-ask spread of Treasury and corporate bonds. Municipal bond spreads, however, are higher than those of Treasury bonds by 11 cents per $100 par value. Our findings imply that differences in trading cost between corporate and Treasury bonds reflect mainly differences in credit risk, rather than differences in the level of transparency.[3]

In related work, Hong and Warga [2000] and Schultz [2001] use the same data set we do, but they do not study municipal bonds or compare trading costs across markets.[4] Hong and Warga [2000] use a methodology similar to ours to estimate the bid-ask spread and its determinants, and compare dealer and exchange market transactions. They find that dealer and exchange market bid-ask spreads are similar in magnitude. The corporate bid-ask spread increases with age, maturity, and squared returns, but is not related to trade size.

Schultz [2001] estimates effective bid-ask spreads for corporate bonds by inferring daily bid quotes from a different data set with month-end quotes. His procedure allows for a much larger sample of less active bonds but also results in noisier estimates of trading costs.

I. DATA

The data, obtained from Capital Access International (CAI), include individual bond transactions by insurance companies. Since 1995, the National Association of Insurance Commissioners (NAIC) has provided transaction data based on Schedule D filings by all its member insurance companies, which are required to report information on the total cost of a transaction, the par amount, and the date of the transaction. CAI obtains the data from A.M. Best, and further verifies bond transactions by cross-referencing against other information in its files.[5]

The sample covers the period from January 1, 1995, through December 31, 1997. Each record indicates the transaction date, a bond identifier, the total dollar value of the transaction, the number of bonds traded, an indication as to whether the transaction is a sale or a purchase, and the identities of the dealers and the customers. We also obtain from CAI the Moody's and S&P credit ratings for each bond, the credit sector of issuer (e.g., whether the bond was issued by an industrial company), the bond issue date, and its maturity date. Finally, we obtain data on the amount outstanding of a bond from Bloomberg.

To purge the data of errors, we apply several filters:

1. We exclude bonds of non-U.S. issuers, Rule 144A or private bonds, and bonds without rating information. Commercial paper and municipal notes are also omitted.
2. A small number of corporate and municipal bonds are mistakenly categorized as government bonds. We use the credit sector information to correctly classify these bonds. For example, if the credit sector is "finance," "industry," or "service," we classify the bonds as corporate.
3. An unusually large number of observations occurring on June 30, 1995, June 30, 1996, and December 31, 1997, are removed. According to CAI, insurance companies may have used these days to record trades that actually occurred on other dates.
4. We delete transaction dates falling on a Saturday or a Sunday and observations for which the transaction date is an estimate.
5. To eliminate outliers, we delete all observations whose transaction price is in the upper or lower first percentile of its distribution.

The final sample has 151,012 trades in corporate bonds, 81,862 trades in municipal bonds, and 21,125 trades in Treasury bonds for the sample period. We exclude days a bond does not have both a buy and a sell transaction, since our liquidity measure is not defined for these days. This leaves us with 7,168 corporate bond trades, 3,168 municipal bond trades, and 3,912 Treasury bond trades.

The number of bond days (the number of bonds times the number of days each bond is traded) is 2,600 for the corporate market, 1,227 for the municipal market, and 1,246 for the Treasury market, for a total of 5,073 bond days in the three markets.

Exhibit 1 provides the sample distributions of bond characteristics in the original sample and the sample used in the analysis. The daily volume is higher for the bonds we use than for the original sample bonds, suggesting that our analysis may pertain mostly to relatively active bonds likely to have lower bid-ask spreads.

In other respects, the bonds in our study are representative of the original sample bonds. The yield, maturity, age, and coupon rate are similar in the two samples. In both samples, the time to maturity, duration, and convexity are highest for municipal bonds, and about the same in the other two markets. The mean time to maturity is intermediate in all three sectors, consistent with the recent emphasis of insurance companies on shorter-term term life policies, rather than more traditional whole-life policies. The volume is lowest for municipal bonds and highest for Treasury bonds. The mean bond age is highest for Treasury bonds, indicating that these are mostly off-the-run bonds.

Hong and Warga [2000] suggest that insurance company transactions represent about 25% of the non-investment-grade market and a significantly greater share of the investment-grade market. For the aggregate bond market, the Merrill Lynch Domestic Master Bond Index reports daily values of bond characteristics for U.S. Treasuries and investment-grade corporate and municipal bonds.[6] For 1995-1997, bond characteristics from the Merrill Lynch Index are reported in the last column of Exhibit 1. A comparison shows that bonds in our sample are similar to bonds in the overall market as represented in the Merrill Lynch Index.

Insurance companies may trade the same bonds differently from other bond investors. They may buy and

EXHIBIT 1

Bond Characteristics in Corporate, Municipal, and Treasury Sectors

	Whole Sample			Sample Used			ML Bond Index	
	Number of Bond Days	Mean	Standard Deviation	Number of Bond Days	Mean	Standard Deviation	Mean	Standard Deviation
Panel A. Corporate Bond Market								
Annual Yield	93,161	7.47	1.71	2,560	7.37	1.50	6.78	0.28
Macaulay's Duration	93,161	6.54	2.72	2,560	6.11	2.57	6.82	0.10
Convexity	93,161	66.00	65.41	2,560	56.59	57.36	---	---
Time to Maturity	94,752	10.31	8.89	2,584	9.12	7.31	---	---
Bond Age	86,995	3.12	4.91	2,437	3.70	5.09	---	---
Coupon Rate	93,866	7.67	1.53	2,572	7.77	1.53	7.68	0.15
Buy Volume	60,583	4.84	9.36	2,559	4.28	6.93	---	---
Sell Volume	37,849	3.97	5.21	2,600	4.32	5.39	---	---
Trade Size	95,873	4.63	8.20	2,600	8.54	10.09	---	---
Panel B. Municipal Bond Market								
Annual Yield	60,540	5.62	1.46	1,224	5.53	1.40	5.48	0.30
Macaulay's Duration	60,540	8.77	2.96	1,224	8.11	2.84	12.05	0.47
Convexity	60,540	108.50	72.90	1,224	91.64	62.64	---	---
Time to Maturity	61,039	12.88	6.61	1,227	11.34	5.79	---	---
Bond Age	57,545	2.57	3.77	1,226	3.52	3.67	---	---
Coupon Rate	60,540	5.75	0.93	1,224	5.78	0.91	5.82	0.23
Buy Volume	43,232	2.63	3.65	1,227	2.95	3.44	---	---
Sell Volume	19,025	2.43	3.44	1,218	3.36	3.90	---	---
Trade Size	61,039	2.62	3.72	1,227	6.29	7.03	---	---
Panel C. Treasury Bond Market								
Annual Yield	12,502	6.41	0.60	1,237	6.37	0.58	5.88	0.35
Macaulay's Duration	12,502	6.02	3.19	1,237	6.10	2.71	5.21	0.18
Convexity	12,502	61.05	70.29	1,237	56.92	62.34	---	---
Time to Maturity	12,668	8.90	7.64	1,246	8.54	6.67	---	---
Bond Age	12,631	4.21	3.73	1,245	3.46	2.66	---	---
Coupon Rate	12,502	7.19	1.41	1,237	6.83	1.05	7.12	0.11
Buy Volume	7,290	6.07	19.49	1,236	5.19	13.32	---	---
Sell Volume	6,610	6.44	19.31	1,242	6.14	16.84	---	---
Trade Size	12,668	6.85	20.44	1,246	11.27	21.99	---	---

Source: Capital Access International, January 1995–December 1997. Merrill Lynch Bond Index includes daily values of bond characteristics for U.S. Treasuries and investment-grade corporate bonds. Number of bond days is number of bonds times number of days each bond traded. Annual yield (in percent) is annualized yield to maturity calculated on the basis of the market convention for accrued interest. Time to maturity is the difference between the trade date and the bond's maturity date (in years). Bond age is the difference between a bond's issue date and the trade date (in years). Volume is in millions of dollars.

hold bonds until maturity, for example. Pension funds and hedge funds, in contrast, are reputed to trade more frequently. We indirectly address this issue by comparing the trade size of Treasury bond transactions in our sample with those from GovPX, a Treasury bond transaction database covering most of the major interdealer brokers.[7]

In our sample, the mean trade size (in millions of dollars) for Treasury bonds with an average time to maturity of 8.9 is $6.85 (*see Exhibit 1*). We infer from GovPX data the mean trade size for a Treasury bond of similar maturity by interpolating between the trade sizes in 1997 for the ten-year Treasury note (about $6.5 million) and the five-year Treasury note (about $8.3 million). We obtain a mean trade size of about $7.9 million for a GovPX bond with 8.9 years to maturity, comparable to bond trades of insurance companies.

II. ESTIMATES OF THE BID-ASK SPREAD IN BOND MARKETS

For a bond with at least one buy and one sell transaction in a day, the traded bid-ask spread per day is the difference between its mean daily selling price and its mean daily buying price. We eliminate observations with unusually high traded spreads (exceeding $10 in absolute value), leaving us with 4,923 (bond day) observations on the bid-ask spread in the three markets.

Panel A of Exhibit 2 reports the distribution of the traded bid-ask spread for the three markets per $100 par value. The mean bid-ask spread is 21 cents for corporate bonds, 8 cents for Treasury bonds, and 23 cents for municipal bonds.

As the bid-ask spread estimates are obtained from

EXHIBIT 2
Traded Bid-Ask Spreads

	Corporate Market				Treasury Market				Municipal Market			
	No. of Bonds	No. of Bond Days	Mean Bid-Ask Spread	Standard Deviation of Spread	No. of Bonds	No. of Bond Days	Mean Bid-Ask Spread	Standard Deviation of Spread	No. of Bonds	No. of Bond Days	Mean Bid-Ask Spread	Standard Deviation of Spread
Panel A. Traded Bid-Ask Spread for 1-Day Window												
1995-1997	1819	2,542	0.21	0.88	82	1,163	0.08	1.11	1,167	1,218	0.23	0.43
AAA Bonds	---	---	---	---	---	---	---	---	604	623	0.23	0.42
AA Bonds	198	263	0.14	1.54	---	---	---	---	400	430	0.22	0.40
A Bonds	762	1,085	0.20	0.64	---	---	---	---	133	139	0.20	0.46
BAA Bonds	514	739	0.21	0.67	---	---	---	---	---	---	---	---
Below BAA Bonds	285	378	0.28	1.17	---	---	---	---	---	---	---	---
Below A3 Bonds	---	---	---	---	---	---	---	---	17	17	0.24	0.29
Industrial Co. Bonds	550	781	0.18	0.83								
Finance Co. Bonds	582	794	0.17	0.60	---	---	---	---	---	---	---	---
Utility Bonds	255	333	0.27	1.01	---	---	---	---	225	240	0.21	0.29
Education Bonds	---	---	---	---	---	---	---	---	233	243	0.22	0.41
Panel B. Traded Bid-Ask Spread for 2-Day Window												
1995-1997	4,292	15,129	0.35	2.59	100	3,317	0.09	1.44	1,241	1,851	0.24	2.37
AAA Bonds	---	---	---	---	---	---	---	---	626	899	0.26	2.32
AA Bonds	495	1,845	0.16	2.48	---	---	---	---	416	670	0.18	2.30
A Bonds	1,814	6,751	0.25	2.35	---	---	---	---	167	243	0.37	2.78
BAA Bonds	1,078	3,956	0.23	2.54	---	---	---	---	---	---	---	---
Below BAA Bonds	727	2,064	1.07	3.11	---	---	---	---	---	---	---	---
Below A3 Bonds	---	---	---	---	---	---	---	---	27	33	0.17	2.24
Industrial Co. Bonds	1,193	4,313	0.30	2.87								
Finance Co. Bonds	1,428	5,261	0.23	2.12	---	---	---	---	---	---	---	---
Utility Bonds	681	2,017	0.44	2.55	---	---	---	---	285	432	0.36	2.43
Education Bonds	---	---	---	---	---	---	---	---	155	207	0.03	2.42
Panel C. Traded Bid-Ask Spread for 5-Day Window												
1995-1997	4,513	13,219	0.27	2.72	102	2,281	0.07	1.38	1,428	1,977	0.37	2.27
AAA Bonds	---	---	---	---	---	---	---	---	724	982	0.37	2.21
AA Bonds	522	1,588	0.13	2.68	---	---	---	---	466	672	0.38	2.33
A Bonds	1,903	5,834	0.11	2.39	---	---	---	---	197	269	0.34	2.22
BAA Bonds	1,123	3,430	0.14	2.78	---	---	---	---	---	---	---	---
Below BAA Bonds	768	1,884	1.16	3.20	---	---	---	---	---	---	---	---
Below A3 Bonds	---	---	---	---	---	---	---	---	34	44	0.11	2.77
Industrial Co. Bonds	1,238	3,692	0.19	3.11								
Finance Co. Bonds	1,510	4,610	0.10	2.08	---	---	---	---	---	---	---	---
Utility Bonds	720	1,797	0.46	2.57	---	---	---	---	329	489	0.45	2.27
Education Bonds	---	---	---	---	---	---	---	---	173	219	0.24	2.06

Traded bid-ask spread (per $100 par value) of a bond is the difference between its mean sell price and its mean buy price. Bond ratings are from Moody's.

trade data, it is not surprising that they are noisy. For example, the standard deviation of the corporate bond bid-ask spread is 88 cents, about four times the mean spread. In spite of this imprecision, the mean spread estimates appear to be reasonable.

For example, in all markets, the mean bid-ask spread is generally higher for lower credit ratings. In the corporate market, the mean bid-ask spread is about 14 cents for AA-rated bonds and 28 cents for below-investment-grade bonds.[8]

As we have said, our spread estimates may be applicable mainly to relatively active bonds. To check the sensitivity of the bid-ask spread estimates to the requirement of one buy and one sell trade for a bond each day, we calculate the realized spread over non-overlapping two- and five-day windows.

For example, for the non-overlapping two-day window, we select bonds with at least one buy and one sell transaction over two consecutive trading days, say, day t and day $t-1$. The two-day bid-ask spread is the differ-

ence between the two-day means of the selling and buying prices. The calculation is then repeated for day $t + 1$ and day $t + 2$.

Panel B of Exhibit 2 reports the distribution of traded spreads calculated over a two-day window. The number of bond days in all markets increases from 4,923 for the one-day window to 20,297 for the two-day window, a more than fourfold increase. The mean and standard deviation of the bid-ask spread are generally higher, especially for the corporate market, consistent with the inclusion of less active bonds. The relative distribution of the spread, however, is robust to the change in the window. For example, the mean corporate bond spread remains lowest for AA-rated bonds and highest for utility sector bonds.

Similar observations apply to the bid-ask spreads estimated for the five-day window (Panel C of Exhibit 2). Compared to the one-day window, there is a more than threefold increase in the number of bond days, and the means and standard deviations of the spreads are higher.[9]

In the remainder of our analysis, we focus on the daily traded bid-ask spread reported in Panel A of Exhibit 2.

III. DETERMINANTS OF THE BOND BID-ASK SPREAD: METHODOLOGY

We consider variables as follows as determinants of the bid-ask spread. *Time to maturity* is the difference between the trading date and the maturity date (in years).[10] The *square of maturity* is the square of the time to maturity, for the corporate bond regression only. *Bond age* is the difference between the issue date and the trade date (in years).

Trade size is the level of daily volume (in millions of dollars). We interpret volume as a proxy for trade size since the data do not capture the entire market. Since the volume level is much higher for the Treasury market, we use the log of volume in that market. *Price* is the average daily price level of the bond.

Macroeconomic announcement dummies are dummy variables that are equal to one on days with a particular macroeconomic announcement. We use three dummies, one each for announcements of the Employment Report (*Employment ann*), the GDP announcement (*GDP ann*), and the Industrial Production (*Ind. Production ann*) announcement.

Credit rating dummies are dummy variables that are based on Moody's credit ratings. For corporate and municipal bonds, we define three dummy variables for rating categories *A1*, *A2*, and *A3*. For example, the dummy *A1* is one for bonds rated *A1* by Moody's, and zero otherwise. For the corporate market only, we define the dummy variable *AAA/AA* for bonds rated either *AAA* or *AA* and the dummy *BAA* for bonds with ratings *BAA1*, *BAA2*, or *BAA3*. The omitted rating category in the corporate market is the below-investment-grade or junk category, bonds rated *Ba* or below. For the municipal market alone, we include one dummy variable for *AAA*-rated bonds and another dummy variable for *AA*-rated bonds. The omitted rating category in the municipal market is the below-investment grade category (i.e., bonds rated *BAA1* or below).

Amt outstanding is the market value of the amount of the bond that remains outstanding (in millions of dollars) as of October 2001. Since most of our bonds are not callable, the amount outstanding is the same as the amount issued of the bond. Thus, for the most part, the lack of *historical* data on the amount outstanding makes little difference to the results. We also regress the spread on the amount issued, and find that the amount issued is not significant (results not reported, but available from the authors).

Since the traded bid-ask spread represents dealers' average daily revenues for a bond, it should be related to dealers' costs of adjusting inventory. Inventory models suggest that the bid-ask spread increases with the bond price and the risk of the security, and declines with trading activity (Amihud and Mendelsohn [1980], Garman [1976], Ho and Stoll [1981], and Stoll [1978]). Leland [1994] and Merton [1974] suggest that the bond price should depend on the risk-free rate, provisions in the bond indenture (such as maturity date, coupon rate, and call provisions), and the probability of default. For corporate bonds, Longstaff and Schwartz [1995] predict that the credit spread for risky debt initially increases with time to maturity and then declines, suggesting a non-linear relation between time to maturity and the spread.

Researchers have identified other factors important in explaining bond market liquidity. Alexander, Edwards, and Ferri [2000] and Sarig and Warga [1989] find that younger corporate bonds are more actively traded, and Babbel et al. [2001] show that on-the-run Treasury bonds are more liquid. So, the bond age may influence the spread.[11] Bollerslev, Cai, and Song [1999] and Fleming and Remolona [1999] find that macroeconomic announcements have a significant effect on the bid-ask spread. Finally, Fisher [1959] argues that the amount outstanding of a bond is an indicator of the marketability of the bond.[12]

We do not control for the coupon rate or the risk-

free rate in the regressions because these variables are highly correlated with our other explanatory variables. Time to maturity is highly correlated with duration and convexity, so we do not use duration and convexity in the regressions.[13] We initially included dummy variables for bonds of different issuer industries (e.g., industrial bonds), but later omitted them since they were not significant in the regressions.

In our first empirical model, we regress $Spread_{it}$, the daily traded bid-ask spread per $100 par value for bond i on day t, on all explanatory variables except *Amt Outstanding* and *Price*:

$$\begin{aligned} Spread_{it} = {} & a_0 + a_1\, Maturity_{it} + a_2\, Square\ of\ Maturity_{it} + \\ & a_3\, Age_{it} + a_4\, Trade\ Size_{it} + \\ & Announcement\ Dummies_t + \\ & Credit\ Rating\ Dummies_i + e_{it} \end{aligned} \quad (1)$$

In our second model, we average $Spread_{it}$ and all the explanatory variables (except the announcement dummies) across trading days for each bond and estimate a pure *cross-sectional* regression. We also include *Amt Outstanding*, which has one observation per bond and so does not need to be averaged over days, and *Price*. Thus, the bid-ask spread for bond i, $Spread_i$, is regressed on the variables:

$$\begin{aligned} Spread_i = {} & a_0 + a_1\, Maturity_i + a_2\, Square\ of\ Maturity_i + \\ & a_3\, Age_i + a_4\, Trade\ Size_i + a_5\, Price_i + \\ & a_6\, Amt\ Outstanding_i + Credit\ Rating\ Dummies_i + e_i \end{aligned} \quad (2)$$

IV. EMPIRICAL DETERMINANTS OF BID-ASK SPREAD AND COMPARISON ACROSS MARKETS

For all three markets, Durbin-Watson test statistics indicate significant serial correlation in the error terms when the bid-ask spread regressions (1) or (2) are estimated with ordinary least squares (OLS). Lagrange multiplier and White's [1980] tests also detect the presence of heteroscedasticity in the OLS error terms. Accordingly, the t-statistics are adjusted for autocorrelation and heteroscedasticity using the Newey-West [1987] procedure with the generalized method of moments (GMM) technique.

GMM estimation results for regression (1) and regression (2) for the three markets are reported in Exhibit 3.

Considering the corporate market and results for regression (1) first, we find that the bid-ask spread is concave in *Maturity*, increasing at a declining rate with the bond's remaining time to maturity. The bid-ask spread increases by 1 cent when the bond ages by another year. The bid-ask spread is negatively related to the trade size, indicating that active bonds have lower bid-ask spreads.

The credit rating variables are highly significant and indicate that lower-rated bonds have higher spreads. Specifically, bonds rated *AAA*, *AA*, *A1*, *A2*, *A3*, and *BAA* have significantly lower spreads relative to below-investment-grade or junk bonds. In particular, *AAA*- and *AA*-rated bonds have substantially lower spreads than junk bonds. Within the *A1*, *A2*, *A3*, and *BAA* categories, on the other hand, the variation in the bid-ask spread appears to be smaller. The macroeconomic announcement day dummy is positive and significant, indicating an increase in the spread on these days.

The results from regression (2) show that, in addition, the bid-ask spread is lower for higher-priced bonds, but the amount outstanding is not significant.

Results for the municipal market are similar to those for the corporate market. Time to maturity, volume, and credit ratings are all significant and of the same sign as in the corporate market. With respect to the credit ratings, investment-grade bonds have substantially lower bid-ask spreads than junk bonds, but the spread shows little variation within different categories of investment-grade bonds. The bond age, price, and amount outstanding are not significant. For Treasury bonds, volume, price, and the announcement day dummy are significant and of the same signs as in the other markets. Time to maturity is significant in model (2) but not in model (1).

In summary, the bond bid-ask spread increases with time to maturity, credit risk, and on announcement days, and declines with trade size. The corporate and Treasury bid-ask spread is lower for higher-priced bonds. The bid-ask spread is higher for older corporate bonds.

We pool observations across markets to test whether the bid-ask spread is different in the three bond markets. The univariate results suggest that the Treasury bonds have lower spreads than the other two markets, perhaps due to their larger volume and lower credit risk. In the first regression, we compare the bid-ask spread without controlling for credit risk.

In the second regression, we also control for credit risk. We define a dummy variable that is one for corporate bonds and zero otherwise, and another dummy variable that is one for municipal bonds and zero otherwise. A positive coefficient for the corporate or municipal dummy implies that the bid-ask spread is higher in these

EXHIBIT 3

Determinants of Bid-Ask Spreads

	Corporate Bonds		Municipal Bonds		Treasury Bonds	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)
Intercept	0.24	2.16	0.58	0.57	0.25	1.41
	(3.69)	(3.93)	(3.20)	(2.47)	(3.47)	(1.95)
Time to Maturity	**0.02**	**0.02**	**0.01**	**0.01**	-0.01	**0.02**
	(4.08)	(4.28)	(3.11)	(2.96)	(-0.65)	(2.07)
Square of Maturity	**-0.0002**	**-0.0002**	---	---	---	---
	(-2.57)	(-2.85)				
Bond Age	**0.01**	**0.01**	-0.00	-0.00	-0.01	-0.01
	(1.69)	(1.99)	(-1.06)	(-0.84)	(-0.78)	(-0.47)
Trade Size	**-0.0048**	**-0.0040**	**-0.0045**	**-0.0039**	**-0.05**	0.01
	(-3.05)	(-3.27)	(-2.94)	(-2.69)	(-2.17)	(0.92)
Price	---	**-0.02**	---	0.00	---	**-0.01**
		(-3.76)		(0.34)		(-1.99)
Employment Ann	**0.13**	---	0.03	---	-0.03	---
	(1.78)		(0.90)		(-0.13)	
GDP Ann	0.03	---	**0.38**	---	0.05	---
	(0.33)		(1.80)		(0.41)	
Ind. Production Ann	-0.11	---	0.04	---	**0.17**	---
	(-1.59)		(0.69)		(1.74)	
AAA/AA Dummy	**-0.29**	**-0.31**	---	---	---	---
	(-3.29)	(-3.22)				
AAA Dummy	---	---	**-0.42**	**-0.47**	---	---
			(-2.32)	(-2.44)		
AA Dummy	---	---	**-0.42**	**-0.46**	---	---
			(-2.31)	(-2.40)		
A1 Dummy	**-0.14**	**-0.15**	**-0.47**	**-0.52**	---	---
	(-1.80)	(-1.82)	(-2.57)	(-2.65)		
A2 Dummy	**-0.17**	**-0.17**	**-0.42**	**-0.44**	---	---
	(-2.36)	(-2.31)	(-2.17)	(-2.14)		
A3 Dummy	**-0.18**	**-0.21**	-0.31	-0.32	---	---
	(-2.44)	(-2.79)	(-1.40)	(-1.37)		
BAA Dummy	**-0.17**	**-0.16**	---	---	---	---
	(-2.39)	(-2.19)				
Amt Outstanding	---	-0.00	---	-0.00	---	-0.00
		-(0.75)		(-1.15)		-(0.11)
Adjusted R-Square	2.39	6.32	2.67	3.05	0.32	10.41
No. of Observations	2,393	1,696	1,217	1,108	1,224	82

Time to maturity is the difference between the trade date and the bond's maturity date (in years). Square of maturity is the square of the time to maturity, used in the corporate bond regression only. Bond age is the difference between a bond's issue date and the trade date (in years). Trade size is the level of daily volume (in million $) for the corporate and municipal markets, and the log of volume in the Treasury bond market. Price is the average daily price level of the bond. Employment ann is a dummy variable equal to one on days the Employment Report is announced. GDP Ann and Ind. Production Ann are dummy variables for the GDP and the Industrial Production announcements, respectively. The AAA/AA dummy is equal to one for bonds rated AAA or AA by Moody's and zero otherwise. AAA, AA, A1, A2, and A3 are dummy variables for bonds rated, respectively, AAA, AA, A1, A2, and A3 by Moody's. BAA is a dummy variable equal to one for bonds rated BAA1, BAA2, or BAA3 by Moody's. The omitted rating category is below-investment-grade (bonds rated Ba or below in the corporate sector and BAA1 or below in the municipal sector). Amt Outstanding is the market value of the amount of the bond that remains outstanding (in million $).

markets compared to the Treasury market, after controlling for other factors.

To control for credit risk, we define dummy variables for every rating category except below-investment-grade bonds. To check the sensitivity of the results, we repeat our analysis for all *market pairs*.

Exhibit 4 reports the results of the GMM estimation with pooled data. Panel A of Exhibit 4 reports results when observations are pooled across all three markets. When we do not control for credit risk (regression 1), the market dummies are positive and significant, indicating that the bid-ask spreads in the municipal and corporate markets are higher by 11 cents and 13 cents, respectively, than spreads in the Treasury market. After

EXHIBIT 4

Comparison Determinants of Bid-Ask Spreads

	Intercept	Municipal Market	Corporate Market	Trade Size	Bond Age	Time to Maturity	Square of Maturity	AAA Dummy	AA Dummy	A1 Dummy	A2 Dummy	A3 Dummy	BAA Dummy
Panel A. All Bond Markets													
Coefficient	0.04	**0.11**	**0.13**	**-0.03**	0.00	**0.01**	**-0.0001**	---	---	---	---	---	---
(t-statistic)	(1.19)	(2.85)	(3.59)	(-2.89)	(0.16)	(3.04)	-(2.02)						
$N = 4834$ $R^2 = 0.94$													
Coefficient	0.31	**0.11**	0.05	**-0.03**	0.00	**0.01**	**-0.0001**	**-0.26**	**-0.29**	**-0.19**	**-0.21**	**-0.20**	**-0.18**
(t-statistic)	(3.56)	(2.74)	(0.88)	(-2.91)	(0.36)	(2.87)	-(1.72)	(-3.27)	(-3.65)	(-2.58)	(-2.88)	(-2.73)	(-2.59)
$N = 4834$ $R^2 = 1.30$													
Panel B. Corporate and Treasury Bond Markets													
Coefficient	0.05	---	**0.13**	**-0.03**	0.00	**0.01**	**-0.0001**	---	---	---	---	---	---
(t-statistic)	(1.29)		(3.59)	-(2.64)	(0.36)	(2.29)	-(1.71)						
$N = 3617$ $R^2 = 0.83$													
Coefficient	0.20	---	0.15	**-0.04**	0.00	**0.01**	-0.00	-0.14	**-0.32**	**-0.14**	**-0.18**	**-0.18**	**-0.16**
(t-statistic)	(1.34)		(1.13)	-(2.72)	(0.59)	(2.01)	-(1.20)	-(0.97)	-(3.51)	-(1.80)	-(2.52)	-(2.50)	-(2.29)
$N = 3617$ $R^2 = 1.20$													
Panel C. Municipal and Treasury Bond Markets													
Coefficient	**0.17**	**0.13**	---	**-0.04**	**-0.01**	0.00	---	---	---	---	---	---	---
(t-statistic)	(3.72)	(3.22)		-(2.49)	-(1.87)	(0.11)							
$N = 2441$ $R^2 = 0.94$													
Coefficient	**1.11**	**0.13**	---	**-0.04**	**-0.01**	0.00	---	**-0.94**	**-0.94**	**-1.00**	**-0.94**	**-0.82**	**-0.87**
(t-statistic)	(3.01)	(2.90)		-(2.39)	-(2.19)	(0.11)		-(2.57)	-(2.56)	-(2.71)	-(2.53)	-(2.12)	-(2.35)
$N = 2441$ $R^2 = 1.23$													

The dependent variable is the daily traded bid-ask spread (per $100 par value) of a bond, calculated as the difference between a bond's mean sell price and its mean buy price for the day. The municipal (corporate) market dummy is equal to one for municipal (corporate) bond trades and zero otherwise. Trade size is the log of daily volume. Bond age is the difference between a bond's issue date and the trade date (in years). Time to maturity is the difference between the trade date and the bond's maturity date (in years). Square of maturity is the square of the time to maturity, used in the corporate bond regression only. AAA, AA, A1, A2, and A3 are dummy variables for bonds rated AAA, AA, A1, A2, A3 by Moody's. BAA is a dummy variable equal to one for bonds rated and BAA1, BAA2 or BAA3 by Moody's. For regression (1), the daily traded bid-ask spread for a bond is regressed on all explanatory variables except the credit rating dummies. For regression (2), all explanatory variables are used. N is the number of observations. R^2 is the adjusted R-square. The t-statistics are adjusted for autocorrelation and heteroscedasticity using the Newey-West [1987] procedure with the generalized method of moments (GMM) technique. Coefficient estimates significant at the 10% level or better are in bold.

we control for credit risk (regression 2), the corporate dummy is no longer significant, but the municipal dummy continues to be positive and significant.

These results are confirmed when observations are pooled for pairs of markets. For the corporate and Treasury market pair (Panel B), the bid-ask spread is higher in the corporate market when unadjusted for credit risk, but not after controlling for credit risk. For the municipal and Treasury markets pair (Panel C), on the other hand, the municipal bond bid-ask spread is higher and remains so even after controlling for credit risk.

We conclude that, after adjusting for credit risk, the bid-ask spread is not statistically different in corporate or Treasury markets. Municipal bonds, though, have higher bid-ask spreads than Treasury bonds, even after adjusting for credit risk and other bond characteristics.

V. CONCLUSION

We compare the traded bid-ask spread in the U.S. corporate, municipal, and Treasury bond markets for 1995–1997, taking advantage of newly available transaction data. We estimate that the mean daily bid-ask spread per $100 par value is 23 cents for municipal bonds, 21 cents for corporate bonds, and 8 cents for Treasury bonds. The bond bid-ask spread increases with interest rate risk (longer time to maturity), credit risk (lower Moody's credit ratings), and on announcement days, and declines with more activity (trade size). The corporate and Treasury bid-ask spread is reduced with the price of a bond. The bid-ask spread is higher for older corporate bonds.

After controlling for credit risk, there is no significant difference in the bid-ask spread of corporate and Treasury bonds, but municipal bonds have higher spreads than Treasuries even after controlling for credit risk.

ENDNOTES

The authors thank for comments Greg Duffie, Mike Fleming, Jean Helwege, Andrew Jeffrey, Charles Jones, Frank Keane, Patricia Mosser, Frank Packer, Tony Rodrigues, Paul Schultz, Philip Strahan, Suresh Sundaresan, Robert Whitelaw, Arthur Warga, and participants at the 1999 Western Finance Association meetings; and Chung-Chiang Hsiao and Sarah Rahman

for excellent research assistance. The views here are those of the authors, and do not necessarily reflect the views of the Federal Reserve Bank of New York or the Federal Reserve System.

[1]While U.S. Treasury securities are virtually free of credit risk, corporate bonds may suffer from significant credit risk. Municipal bonds have intermediate credit risk due to the financial fragility of some municipalities and innovative issues with uncertain legal bondholder rights. The secondary market in U.S. Treasuries is highly active, with large trading volumes and narrow bid-ask spreads (Fleming and Sarkar [1999]). Corporate bonds tend to be active for the first two years after issuance, but relatively inactive thereafter.

[2]Naik, Neuberger, and Viswanathan [1999] show that, with interdealer trading, greater post-trade transparency may improve or worsen investor welfare since it improves risk-sharing among dealers but increases price revision risk. Evidence from experimental settings is also ambiguous. Bloomfield and O'Hara [1999] study post-trade transparency and find that opening spreads are higher but prices are more efficient. Flood et al. [1999] examine pre-trade transparency and come to the opposite conclusion.

[3]Hong and Warga [2000] find that the bid-ask spread in the corporate bond dealer market is similar in magnitude to the bid-ask spread for bonds trading in the more transparent exchange markets. Hotchkiss and Ronen [2002] show that market quality is similar for high-yield corporate bonds and the underlying (more transparent) stocks.

[4]Alexander, Edwards, and Ferri [2000] study trading volume. Sarig and Warga [1989], Blume, Keim, and Patel [1991], Warga [1992], and Crabbe and Turner [1995] use the yield or return spread as a measure of liquidity.

[5]CAI has a security master of over 7 million issues, which it uses to validate incoming security information. Mismatched records are compared to the security master and identified by a data specialist.

[6]To be included in the Merrill Lynch Index, bonds must have at least one year to maturity and satisfy a minimum par amount.

[7]Two caveats are in order. GovPX data relate to interdealer broker trades, while our data are for customer-to-dealer transactions. Further, even for the same trade size, the bid-ask spread for insurance company trades may be different from, say, hedge fund trades if the dealer knows who the customer is. Smaller insurance companies, however, typically go through a money manager, and so are likely to remain anonymous.

[8]Since we have only 48 observations in the sample for AAA-rated corporate bonds, we do not report the spread distribution for these bonds separately in Exhibit 1.

[9]Note that, when going from the two-day to the five-day window, the number of bond days actually drops. This is the effect of sampling every fifth observation, rather than every second observation.

[10]The effective time to maturity is shorter for callable bonds. We define a callability dummy but find that the dummy does not have any explanatory power for the bid-ask spread regressions.

[11]One explanation as to why bond age may influence the spread is that institutional buyers in the bond market are buy-and-hold investors. They buy large quantities of a bond as soon as it comes to the market and hold until maturity.

[12]We thank the referee for suggesting inclusion of the price and the amount outstanding variables.

[13]For example, the correlation of corporate bond maturity with duration is 0.90 and with convexity is 0.95. We calculate Macaulay duration and convexity on the basis of the estimated annual bond yield. We estimate the yield using the semiannual coupon payments and the accrued interest from the previous coupon interest date.

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