Essay 1: The Value of Bond Listing

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Abstract

We study the impact of bond exchange listing in the US publicly traded corporate bond market. Overall, we find that listed corporate bonds have lower bid-ask spreads than unlisted corporate bonds. We specifically show that listed bond spreads are $0.14 lower than unlisted bond spreads. We find that execution venue matters for listed bonds, and that listed bond trades that execute on the NYSE have higher trading costs than listed bond trades that execute off-NYSE. Lastly, we show listed bonds are more volatile than unlisted bonds.

I: Introduction

In the United States bond market, firms can list publicly traded bonds on the New York Stock Exchange or publicly traded bonds can be unlisted with no exchange affiliation. The trades that bond dealers report to the Trade Reporting and Compliance Engine (TRACE) execute on trading platforms across the United States, but do not include trades in listed bonds that execute on the New York Stock Exchange. The NYSE Automated Bond System operates as an electronic limit order book that executes trades in listed bonds on a price-time priority basis. Listed bond trades can execute on the NYSE or any of the TRACE bond trading platforms, while unlisted bonds can trade only on TRACE bond trading platforms.

Previous research documents two main advantages for securities listing on a national exchange: investor recognition and improved liquidity. Merton (1987) uses the capital asset pricing model to show theoretically that listing on an exchange is one way the firm can increase investor recognition, and Kadlec and McConnell (1994) show empirically that listing on the NYSE leads to a 27% increase in institutional shareholders for the firm. Research also documents a market quality advantage for NYSE stocks and for NYSE trades. For example, Huang and Stoll (1996) and Bessembinder and Kaufman (1997) compare NYSE and NASDAQ listed stocks using data from the early 1990s, when markets were more consolidated and listing potentially had a different value than it may in today's fragmented trading environment. Both Huang and Stoll and Bessembinder and Kaufman find that a sample of NYSE stocks has lower trading costs than a matched sample of NASDAQ stocks. Bennett and Wei (2006) find that lower trading costs occur for firms that switch their listing exchange from NASDAQ to the NYSE. The above mentioned research focuses only on equity markets. Analyzing the benefits of listing using bonds provides valuable research contributions for multiple reasons.

First, most of the research on listing focuses on highly liquid assets. Bonds are illiquid, with the average corporate bond trading just over two times per day (Edwards, Harris, and Piwowar, 2007). Bennet and Wei (2006) show that listing on the NYSE is particularly valuable for illiquid stocks. However, even the most liquid bonds will likely be less liquid than illiquid stocks, thus leaving

unanswered questions about the importance of listing for illiquid assets. Bonds are more expensive to trade than equities, both for institutions and individual traders, so documenting differences in trading costs between listed and unlisted bonds could be beneficial for bond traders. Determining what market quality advantages, if any, listing provides to bond traders sheds light on why firms choose to list their publicly traded debt.

Second, it is possible that listing a bond serves as a signal or stamp of approval to investors, much like paying dividends and beating earnings expectations can serve as a signal to stakeholders (Bhattacharya, 1979; Nissim and Ziv, 2001; and Fuller and Goldstein, 2011). Bonds may be listed on one venue – the NYSE— whereas firms can choose from multiple exchanges for equity listing (for example, the NYSE, NASDAQ, or AMEX). Choosing to list a bond may provide information to the market as to the quality of the bond. The bond market as a whole is less informationally efficient than the stock market (Kwan, 1996; Downing, Underwood, and Xing, 2009), and traders (both institutions and retail) may be able to better garner information based on a bond's listing status. Third, the bond market is economically large. According to Ederington and Yang (2013), US firms issued $6.6 trillion in corporate bonds from 2005 to 2011, compared to just $1.3 trillion in common stock offerings over the same time period.

II: Related Literature

Merton (1987) provides theoretical reasoning for the firm's decision to list on a national exchange. Merton utilizes the original capital asset pricing model in his theory of listing, but makes one change to the model's assumptions. Merton relaxes the assumption that all investors share equal information sets and develops a model in which expected returns decrease with the size of the firm's investor base. He shows an increase in the investor base (i.e., an increase in investor recognition) leads to lower expected returns and a higher market value for the firm. He goes on to detail that one way a firm increases its investor base is to list on a national exchange. Sanger and McConnell (1986) detail that listing provides a liquidity advantage, and also that an organized exchange can provide investors with a better quality of trading. Baruch and Saar (2009) propose that, in addition to investor recognition and

liquidity, firm commonality plays a role in the firm's decision to list on an exchange. Specifically, Baruch and Saar show that a stock is more liquid when it is listed on a market along with similar securities; the liquidity advantage arises because market makers are able to ascertain information about the firm using the order flow of other stocks listed on the exchange, thus improving the efficiency of prices.

Many of the studies that show a market quality or liquidity improvement looked at a time when the majority of the trades in exchange listed equities were executed on the listing exchange. For example, Huang and Stoll (1996) compare trading costs of large capitalization NASDAQ stocks to the trading costs of a matched sample of NYSE stocks using trade data from 1991, a time when markets were consolidated. The authors find that NYSE stocks have lower trading costs than the matched sample of NASDAQ stocks. Bessembinder and Kaufman (1997) expand the work by Huang and Stoll and compare the execution costs of NASDAQ and NYSE listed stocks using small, medium, and large capitalization stocks and find similar results. However, the study again uses a time period from the early 1990s (1994) when markets were more consolidated, and the advantages of the listing exchange were perhaps more different.

After markets began to experience increased fragmentation in trading, listing continued to have value. Bessembinder (2003) studies a sample of NYSE stocks using trade data from June 2000 and makes comparison among seven markets that compete for order flow volume in large capitalization NYSE stocks. Bessembinder finds the NYSE is the most competitive market for NYSE listed stocks, despite the fragmented trading opportunities. Bennett and Wei (2006) examine a sample of 39 firms that switch from NASDAQ to the NYSE in 2002 and 2003. Stocks have lower quoted spreads, effective spreads, and price volatility following the switch to the NYSE. In addition, the stocks that switch to the NYSE have more efficient prices. Bennet and Wei use Dash-5 data to show the improvement in market quality is driven by a reduction in order flow fragmentation. Empirically, there is strong support for NYSE equity listing and NYSE equity trades providing investors with better market quality.

The majority of research that relates to the advantages of listing on a national exchange focuses on equities and does not reach a definitive conclusion as to whether an exchange environment or a dealer environment is better. Now that trading in many securities markets is fragmented and listing bonds means simply that bonds can trade on the NYSE as well as other venues, is listing valuable? If so, is it valuable because only listed bonds can trade on the NYSE? We seek to determine the value of listing for bonds.

III: Hypotheses

First, we study the characteristics of listed bonds. Listed bond trades may execute either on the NYSE or through another TRACE-reporting bond trading venue. Alexander, Edwards, and Ferri (2000) show several factors that influence bond trading, including issue size, bond age, and return volatility. If listing on an exchange provides improved liquidity (Sanger and McConnell, 1986; and Merton, 1987), we expect listed bonds to have smaller bid-ask spreads than unlisted bonds. Additionally, we expect listed bonds to have lower volatility if exchange listing leads to better efficiency (Baruch and Saar, 2009). We estimate logistic regression models to determine the characteristics of listed bonds.

Second, we focus on the differences in listed and unlisted bonds. Previous work shows that bonds are more expensive to trade than equities.[1] It is not clear, however, if listed bonds offer better execution costs than unlisted bonds. Empirically, Huang and Stoll (1996) and Bennet and Wei (2006) show trading costs are lower for NYSE listed stocks. In addition, Bessembinder and Kaufman (1997) detail that trading costs are higher for off-NYSE stock trades in NYSE stocks. We form the following two hypotheses:

H1: Listed bonds have lower spreads than unlisted bonds.

H2: Listed bond transactions that execute on the NYSE have lower trading costs than listed bond trades that execute off the NYSE.

[1] See Goldstein, Hotchkiss, and Sirri (2007), Bessembinder, Maxwell, and Venkataraman (2006), Harris and Piwowar (2006), and Edwards, Harris, and Piwowar (2007) for further evidence.

Listing also affects price efficiency, as is indicated in Heidle and Huang (2002) and Baruch and Saar (2009). Three measures of price efficiency include return volatility, the variance ratio (O'Hara and Ye, 2011), and price volatility (Downing and Zhang, 2004). Bennet and Wei (2006) show empirically that volatility falls for stocks that switch their listing to the NYSE, and Baruch and Saar (2009) detail that a firm's choice to list on an exchange with similar firms can lead to more efficient information processing by market makers. We present the following hypothesis:

H3: Price efficiency is positively related to a bond being listed.

Theoretical work by Merton (1987) and empirical work by Kadlec and McConnell (1994) indicate that listing serves as a way to expand a firm's investor base. Specifically, Kadlec and McConnell (1994) show that NYSE listing leads to a 27% increase in the number of institutional shareholders a firm has on record. However, the question of whether or not listing leads to more institutional trading in bonds remains. Bessembinder, Kahle, Maxwell, and Xu (2009) details that institutions account for 97% of bond transactions, showing that institutions have a prevalent role in the bond market. Ronen and Zhou (2013) detail that trade size is a reliable way to measure institutional trading in bonds and show that trades greater than $500,000 in size are institutional trades.[2] We question bond listing matters for institutional trading activity and form the following hypothesis:

H4: Listed bonds have a larger amount of institutional trading than unlisted bonds.

Third, we focus on price discovery in the bond market. Ronen and Zhou (2013) theorize that the bond market is a viable outlet for informed traders to share and capitalize upon information. If traders naturally gravitate towards a trading venue where it is easier to share their information, then it follows that trades in some markets will carry more information than trades in others. Listed bonds can be traded on the NYSE or via any of the bond trading platforms in the United States. One way that trade

[2] We follow Ronen and Zhou (2013) and classify bond trades as institutional if the trade value exceeds $500,000. Earlier bond papers, such as Edwards, Harris, and Piwowar (2007) classify trades as institutional if the trade size is greater than $100,000. In preliminary work, we use both trade sizes, $100,000 and $500,000, in all tests, to label institutional trades. We find that the results are qualitatively similar, and therefore we follow the more recent Ronen and Zhou paper.

information is measured is weighted price contribution (Barclay and Hendershott, 2003). Jiang, Likitapiwat, and McInish (2012) study the effect of earnings announcements on equity prices and illustrate that weighted price contribution differs among exchanges, especially for after-market earnings announcements. Ronen and Zhou show that each family of bonds has a 'top' bond and define the top bond as the bond with the most institutional trades following earnings announcements. This top bond contributes 54.79% of the price discovery in the bond market. If traders can choose to trade listed bonds on either the automated bond system or through a bond trading platform, it is possible that one market may attract more of specific types of traders than the other market. It also follows that bond traders will choose to distribute their trades in a way that allows them to best exploit their information, and as such, price contribution may differ among bond trades, depending on the execution location. We present the following hypothesis:

H5: Trades in listed bonds that execute on the NYSE have different weighted price contribution than trades in listed bonds that execute on other bond trading platforms.

IV: Sample and Data

We use bond transaction level data for the year 2013. Our bond trade data is from two sources: TRACE and the NYSE. We follow Bessembinder, Maxwell, and Venkataraman (2006) in making data deletions. We delete trades flagged as cancelled (135,437 observations), corrected (136,572 observations), reported after-market hours (48,170 observations), reported late (241,588 observations), and after-market trades reported late (8,132 observations). We delete 1,678,597 trades in bonds issued by private companies, and we also delete 754 trades with missing CUSIP identification. We delete any bond trading at less than 25% of par (15,662). We require the bond to trade at least ten times during our sample period (Edwards, Harris, and Piwowar, 2007). We obtain daily shares outstanding and daily stock prices from CRSP to calculate the firm's daily market capitalization.

In our study, we make comparisons between two types of bonds (listed and unlisted), and also between different trading venues (the NYSE and other bond trading platforms). One issue that arises when making comparisons between the trading venues is the time of operation. The NYSE bond market

and TRACE have different trading hours. The NYSE offers three bond trading sessions during the day: 4:00 am - 9:30 am EST (Early Trading); 9:30 am – 4:00 pm EST (Core Trading); and 4:00 pm – 8:00 pm EST (Late Trading). TRACE reporting is allowed from 8:00 am – 6:30 pm EST. To provide a clean comparison, we use an overlapping time between TRACE reporting hours and NYSE trading hours. As a result, we use trades that execute between 8:00 am to 6:30 pm EST. Following all data deletions, we have 6,841,030 bond trades in 12,633 bonds for the 2013 calendar year (our full sample period).

Table 1 provides a general overview of our sample. For the sample of trades, 79.30% involve an investment grade bond. 80.55% of trades involve a bond with less than ten years to maturity. Top bonds make up the majority of trades, accounting for 52.12% of all transactions. In regards to trade size, trades greater than $25,000 account for 47.36% of trades, while trades greater than $500,000 (institutional trades) account for only 13.44% of trades. Substantially more trades occur in bonds priced above par value (76.23%) than bonds priced below par value (23.13%).

Table 1 also shows summary statistics for listed and unlisted bonds. Unlisted bond trades are split fairly evenly between investment grade and high yield bonds, while listed bond trades are dominated by investment grade bonds. Investment grade bonds account for 81.07% of listed bond trades, while high yield bonds account for just 18.93% of listed bond trades. Roughly 40% of bond trading in both listed and unlisted bonds occurs in bonds with less than five years to maturity, while over 80% of trades in both listed and unlisted bonds occur in bonds with less than ten years to maturity. The percentage of institutional trades (trades greater than $500,000) is 16.22% for unlisted bonds, while 12.30% for listed bonds. Trades greater than $1,000,000 make up similar portions of listed and unlisted bonds (6.54% compared to 5.08%). For both listed and unlisted bond trades, over 70% of trades involve a bond priced above its par value.

Table 2 provides summary statistics for the full sample of bonds. Panel A includes all bonds in the sample. The sample includes 12,633 bonds that trade during the 2013 calendar year. On average, the bonds in the sample trade at 105.49% of par. The average bid-ask spread for the full sample of bonds is $1.34. The average bond trades 4.73 times each day and transacts over $1,500,000 in daily dollar volume

with an average trade size of roughly $380,000. Panel B details the summary statistics for listed bonds, and Panel C details the summary statistics for unlisted bonds. The average listed bond trades at 109.44% of par, while the average unlisted bond trades at 102.73% of par. Overall, listed bonds appear to trade more times than unlisted bonds. The average listed bond trades nearly six times each day, while the average unlisted bond trades about four times each day. Listed bonds have an average daily dollar volume of over $2,000,000, while unlisted bonds execute an average of $1,000,000 in daily dollar volume. Listed bonds appear to have lower spreads than unlisted bonds. Listed bonds have an average spread of $1.17, while unlisted bonds have an average spread of $1.45. Volatility appears similar between the listed and unlisted bonds. However, we do not test for differences between listed and unlisted bonds in Table 2. We test for differences between listed and unlisted bonds using the matched sample later in the paper.

We also provide summary statistics for the top bonds in the sample. A bond is designated as the firm's top bond if the bond has the most institutional trading out of all the firm's bonds on a given day. We classify a trade as institutional if it is greater than $500,000 (Ronen and Zhou, 2013). Throughout the sample period, 8,375 bonds are classified as the firm's top bond. Panel A details all top bonds in our sample. Top bonds trade, on average, at 107% of par and transact nearly $4,500,000 in average daily volume. Top bonds trade an average of nearly 7 times per day and have an average trade size of over $1,100,000 each day. The average top bond trade has a bid-ask spread of $0.87.

In Panel B and C, we split the top bonds into listed and unlisted bonds. Overall, listed top bonds trade at 109% of par and transact almost $5,000,000 in daily volume. Listed top bonds trade about seven times each day, on average, and have an average trade size of over $1,200,000. The average spread for listed top bonds is $0.90. Unlisted top bonds trade above par as well, trading at 104% of par. Unlisted top bonds appear to conduct slightly less average daily volume than listed top bonds, but not by much. Unlisted top bonds have an average daily dollar volume of over $4,000,000 and an average trade size of over $1,000,000. The average spread for unlisted top bonds is $0.83.

We further explore our sample by highlighting aspects of the bond market's intraday trading activity.[3] We show the number of average bond trades during thirty minute increments from 8:00 am to 6:30 pm in Graph 1. We utilize this time period because it is the overlapping time between TRACE reporting hours and the NYSE bond market's hours. The average number of bond trades increases gradually during the day, and spike around 4:00 pm, which is when the NYSE core trading ends. In Graph 1, we also show the average number of trades by listed versus unlisted bonds. Listed bonds seem to trade, on average, more often than unlisted bonds trade during the trading day. Both types of bonds appear to have a trading spike around 4:00 pm, but the increase seems more drastic for unlisted bonds. It is interesting to note that unlisted bonds, which do not trade on the NYSE platform, experience a spike in trading at the close of NYSE core trading. The average number of trades drops after 4:30 pm, almost reaching zero as TRACE reporting concludes at 6:30 pm.

We continue our analysis of the bond trading day in Graph 2. Graph 2 details the average intraday bond trade size. We again focus on 8:00 am to 6:30 pm because of the overlapping hours between TRACE and the NYSE. Graph 2 shows that the average trade size is fairly consistent during the trading day, but increases leading up to 5:00 pm. The average trade size for listed and unlisted bonds begins to increase between 3:01 pm and 3:30 pm. Prior to the increase, the average trade size for listed bonds is just under $500,000, and the average trade size for unlisted bonds is just under $300,000. After 5:00 pm, the average trade size declines. From 4:31 pm to 5:00 pm, listed bonds have an average trade size of $800,000, whereas unlisted bonds have an average trade size of $500,000 during the same period. In Graph 3, we focus on the average intraday dollar volume. Throughout the course of the day, the average dollar volume appears to stay at consistent levels before spiking between 4:01 pm to 4:30 pm for listed and unlisted bonds. Following the spike in volume, the average volume level falls to nearly zero as TRACE reporting concludes.

[3] Reference Chan, Christie, and Schultz (1995), Chung, Van Ness, and Van Ness (1999), Lee, Mucklow, and Ready (1993), and Wood, McInish, and Ord (1985) for more information on intraday market behavior in the equities market.

V: Results

Listing

Not all bonds list on the NSYE. Therefore, we seek to determine the qualities of a listed bond, and to also determine if listing leads to a liquidity advantage for bonds. To do so, we use a logistic regression with the dependent variable equal to one if a bond is listed:

$$\text{Listed} = \beta_1 \text{Bid Ask Spread} + \beta_2 \text{Dollar Volume} + \beta_3 \text{Number of Trades} + \beta_4 \text{Trade Size} + \beta_5 \text{Volatility}$$
$$+ \beta_6 \text{Top Bond} + \beta_7 \text{Years to Maturity} + \beta_8 \text{Firm Size} + \beta_9 \text{Investment Grade} + \beta_{10} \text{Listed}$$

We present our findings in Table 3. The negative coefficient on *Bid-Ask Spread* indicates that listed bonds have lower spreads than unlisted bonds, indicating that listed bonds have a market quality advantage over unlisted bonds. We find that listed bonds are characterized not only by a greater number of trades, but also by larger levels of volatility. The positive relation between bond listing and volatility is puzzling given that listing is predicted to increase price efficiency. While the above mentioned focuses on trading activity variables, we also focus on bond specific variables. We show that listed bonds in our sample have longer time to maturity and higher credit ratings than unlisted bonds. Additionally, listed bonds are more likely to be the top bond for the firm.

Listed bonds can trade on the NYSE or through the various bond trading platforms that report trades to TRACE. However, there is potential for execution quality and liquidity differences to exist among the trading venues. Previous research on equities documents substantial differences between trading venues. For example, Huang and Stoll (1996) find that execution costs are larger for a sample of NASDAQ stocks than for a sample of NYSE stocks; Bessembinder (1999, 2003) shows that NASDAQ stocks have higher trading costs than NYSE stocks following both tick size reductions and changes in order handling rules. We compare a sample of listed bonds that trade on both the NYSE and TRACE venues during our time period.

Table 4 Panel A provides statistics on the sample of listed bonds. Overall, there is a slight statistical difference in the prices of listed bond trades on the NYSE and listed bond trades on the TRACE

venues. However, the difference is minimal ($0.32), which is not overly surprising; any difference in price between the trading venues indicates an arbitrage opportunity for listed bonds. On average, listed bond trades on the NYSE are less frequent, have a lower trade size, and hence, have a lower daily dollar volume than TRACE venue trades. NYSE trades are also more volatile than TRACE trades, but the difference in volatility is small (0.18) and significant only at the ten percent level. Listed bond trades on a TRACE venue have lower spreads than listed bond trades on the NYSE. NYSE trades have an average spread of $1.23, while TRACE trades have an average spread of $1.04. The difference in the spreads is significant at the one percent level. The spread differential could be driven by many factors. For one, TRACE may offer better execution quality and liquidity for bond traders. Or, the differential in spread could simply be driven by the fact that larger trades execute via TRACE, and there is an inverse relation between bond trade size and trading cost. Edwards, Harris, and Piwowar (2007), Harris and Piwowar (2006), and Goldstein, Hotchkiss, and Sirri (2007) document an inverse relation between trade size and trading cost in the bond market.

Table 4 Panel B provides statistics on the listed top bonds. The top bonds are the bonds with the most institutional trading for each firm (Ronen and Zhou, 2013). There is no difference in the price of top bond trades on the NYSE and TRACE venues. Top bonds trade more times each day, have higher daily dollar volume, and have larger average trade sizes on the TRACE venues than top bond trades on the NYSE. TRACE trades in top bonds have lower spreads than NYSE trades in top bonds. NYSE top bond trades have an average bid-ask spread of $1.13, while TRACE top bond trades have an average spread of $0.92. The $0.21 difference is significant at the one percent level.

Bid-Ask Spread

An important aspect of market quality is the bid-ask spread. In this section, we focus on the spread. We noted in the last section that listed bond trades have lower spreads and that TRACE spreads are lower for listed bonds than NYSE spreads. Model 1 utilizes the full sample of bond trades, whereas Model 2 (Model 3) utilizes listed (unlisted) bond trades. We estimate the following spread regression model:

$$\text{Bid Ask Spread} = \beta_0 + \beta_1 \text{Dollar Volume} + \beta_2 \text{Number of Trades} + \beta_3 \text{Trade Size} + \beta_4 \text{Volatility} + \beta_5 \text{Top Bond} + \beta_6 \text{Years to Maturity} + \beta_7 \text{Firm Size} + \beta_8 \text{Investment Grade} + \beta_9 \text{TRACE Execution} + \beta_{10} \text{Listed} + \varepsilon$$

Table 5 provides bid-ask spread regression results. Our main variable of interest in the bid-ask spread regressions is the *Listed* variable. The *Listed* variable is equal to one if a bond is listed. We find a negative relation between bond listing and the bid-ask spread. Economically, the magnitude of the coefficient indicates that listed bond spreads are $0.14 lower than unlisted bond spreads. The negative relation between bond listing and spread provides evidence that bond listing provides some value (in the form of reduced trading costs) to bond traders and is consistent with our previous findings in Table 3.

In addition to bond listing variable, we are also interested in the *Top Bond* variable in Models 1, 2, and 3. Focusing on the *Top Bond* variable allows us to see the relation between institutional trading activity and the bond bid-ask spread, given that top bonds are the bonds with the most institutional trading activity. We follow Ronen and Zhou (2013) in designating the top bond as the bond with the most institutional trading for each firm, with institutional trading measured as trades exceeding $500,000. The *Top Bond* variable is equal to one if the bond has the most institutional trading for each firm's bonds on a given day. The *Top Bond* coefficient is negative in all three regression models. For the full sample of bonds, top bonds spreads are $0.42 lower than the spreads of other bonds. For listed bonds (Model 2), top bonds have spreads that are $0.33 lower than other bonds, and unlisted top bonds (Model 3) have spreads that are $0.59 lower than other bonds. Although we do not test for differences in the coefficients here, it appears that being the firm's top bond has more value for unlisted bonds, given the large magnitude of the coefficient. The control variables in the regression conform to general expectations. Similar to Edwards, Harris, and Piwowar (2007), the regression models show that bonds with more time to maturity have larger spreads. The larger spread for bonds with longer maturities is likely driven by potential interest rate risk. Additionally, we find that investment grade bonds have lower bid-ask spreads. Edwards, Harris, and Piwowar (2007) also document a negative relation between bond spread and credit quality.

We estimate the bid-ask spread regressions for the top bonds in our sample to shed further light on the relation between institutional trading and spread since top bonds, by design, are the bonds with the most institutional trading. While we document a negative relation between bond listing and the bid-ask spread in the full sample of bonds, we find the opposite in the top bond sample. Listed top bond trades have spreads that are $0.08 larger than unlisted top bond trades. Otherwise, the control variables in the top bond regressions yield coefficients similar to the full sample bid-ask spread regressions. We find that volatility and time to maturity have a positive relation with the bid-ask spread, and that investment grade has a negative relation with the spread.

We are also interested in the intraday pattern of the bond bid-ask spread. The U-shaped intraday spread pattern in equities is well documented (see McInish and Wood, 1992), but less is known about the intraday pattern of bond spreads. In Graph 4, we show the average bond spread throughout the trading day. Like previous graphs, we utilize 8:00 am to 6:30 pm because it is the overlapping time between the NYSE trading hours and TRACE reporting hours. The graph shows that spreads steadily increase during the morning trading hours, before leveling off between 10:01 am to 10:30 am. Spreads appear to increase between 3:31 pm to 4:00 pm before peaking in the following half hour. The spike in spreads seems the most drastic for unlisted bonds. However, following the increase, spreads fall sharply leading up to the end of TRACE reporting at 6:30 pm.

Previous research documents an inverse relation between bond trade size and bond spread (Edwards, Harris, and Piwowar, 2007). We see if this relation holds for both listed and unlisted bonds in Table 6. In Panel A, we detail the average spread by trade size for the full sample of bonds, for listed bonds, and for unlisted bonds. Our findings are similar to previous work by Goldstein, Hotchkiss, and Sirri (2007).[4] We find a consistent negative relation between trade size and bond spread for the full sample of bonds, for listed bonds, and for unlisted bonds. While we test for differences between listed and unlisted bonds using the matched sample later in the paper, it appears in Table 6 that listed bonds

[4] Other research documents the inverse relation between bond trade size and bid-ask spread, including Edwards, Harris, and Piwowar (2007) and Harris and Piwowar (2006).

have lower spreads than unlisted bonds, on average, for the full sample, small sized trades, and medium trades. In Panel B, Quartile 1 includes the most active bonds in our sample, and Quartile 4 includes the least active bonds in our sample. Panel B shows that bond spread and trading activity have an inverse relation. The most active bonds appear to have lower spreads ($0.99) than the least active bonds ($1.56). The same relation holds for listed and unlisted bonds. The most active listed bonds have an average spread of $0.95, and the least active listed bonds have an average spread of $1.80. The range of spread from the most active to the least active is not as drastic for unlisted bonds, however. The most active listed bonds have an average spread of $1.07, and the least active unlisted bonds have an average spread of $1.51.

Bond Volatility

We also examine whether listing influences the price efficiency of bonds. O'Hara and Ye (2011) utilize volatility as a measure of price efficiency in equities, and Bennet and Wei (2006) show that volatility decreases for stocks that change their listing venue from NASDAQ to the NYSE. We measure volatility following Downing and Zhang (2004) using the following equation:

$$\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$$

We use the following regression model to estimate volatility:

$$\text{Volatility} = \beta_0 + \beta_1 \text{Dollar Volume} + \beta_2 \text{Number of Trades} + \beta_3 \text{Trade Size} + \beta_4 \text{Top Bond} + \beta_5 \text{Years to Maturity} + \beta_6 \text{Firm Size} + \beta_7 \text{Investment Grade} + \beta_8 \text{TRACE Execution} + \beta_9 \text{Listed} + \varepsilon$$

We present our bond volatility regression results in Table 7. Our main variable of interest is the *Listed* variable. The *Listed* variable is equal to one if a bond is listed. We find that listed bonds are more volatile than unlisted bonds and document a positive relation between bond listing and volatility in Model 1. The *Listed* coefficient is significant at the one percent level. The positive relation between bond listing and volatility conflicts with our expectations, given the predictions that exchange listing positively influences price efficiency.

The top bond variable is equal to one if a bond has the most institutional trading for each firm on a given trading day; following Ronen and Zhou (2013), a trade is classified as institutional if it is greater than $500,000. The *Top Bond* indicator variable is also of interest because it helps detail the relation between bond volatility and institutional trading activity since the top bond is the bond with the most institutional trading activity. We find (weak) evidence that top bonds are more volatile than non-top bonds. We document a weak positive relation between top bond status and volatility for the full sample of bonds and the sample of unlisted bonds. However, we find no relation between top bond status and volatility for the sample of listed bonds. The control variables in the volatility regressions conform to expectations. We find that bonds with more time to maturity have higher levels of volatility than bonds with less time to maturity, and bonds with investment grade ratings have lower levels of volatility that non-investment grade bonds.

Next, we study volatility for top bonds to further understand the relation between institutional trading and volatility. In Model 4, we find evidence that listed top bonds are more volatile than unlisted top bonds. The positive relation between bond listing and volatility for top bonds is somewhat puzzling, given that we find no relation between top bond status and volatility for listed bonds in Model 2.

In Graph 5, we further detail intraday bond volatility. We utilize trades that occur between 8:00 am and 6:30 pm. Generally, the graph shows that volatility increases gradually between 8:01 am and 10:00 am before leveling off to a consistent level during the majority of the trading day. Volatility spikes between 4:01 pm and 4:30 pm, and then continues to decrease during the remainder of trading.

VI: Matched Sample

We repeat the previous analysis for a matched sample of listed and unlisted bonds. Our matching procedure closely follows Boehmer (2005)[5]. We match each listed bond to an unlisted bond using four bond specific characteristics and one firm specific characteristic. We use the following bond

[5] We match on a one-to-one basis like Boehmer (2005). However, our matching procedure does differ slightly from his. He matches the sample used the time period preceding his analysis, while we match our sample based on the bond average price, daily dollar volume, investment quality, years to maturity, and firm market capitalization during our 2013 time period. For an in-depth description of the propensity score matching procedure, see Boehmer (2005).

characteristics to match the sample: price, daily dollar volume, investment quality, and years to maturity. The firm specific characteristic is daily market capitalization. We then calculate a propensity score based on the matching characteristics, and we delete matches with propensity score differences greater than 0.01[6]. The final results of the match yield 2,086 pairs of bonds with 2,706,274 bond trades. Table 8 provides summary statistics on the matching properties of the sample. Panel A shows summary statistics of the matched sample. Overall, bonds in the matched sample trade at 106% of par and transact nearly $2,000,000 each day in average dollar volume. The bonds in the matched sample have, on average, eight and a half years to maturity. Panel B provides differences between the listed bond sample and the unlisted bond sample. Overall, we find no significant differences between the listed sample and the unlisted sample, and interpret the lack of difference as evidence of a well-matched sample.

Listing

We further explore the value of bond listing using the matched sample. In Table 9, we focus on the characteristics of listed bonds using a logistic regression. Similar to the full sample, we expect to find liquidity advantages for listed bonds. The dependent variable is equal to one if a bond is listed. Our findings are similar to those in the full sample. The regression shows that listed bonds have not only lower bid-ask spreads, but also greater levels of volatility.

To compare NYSE and TRACE trades in listed bonds, we utilize the listed bond portion of our matched sample. The results are presented in Table 10. Panel A provides differences for the full matched sample, and Panel B provides differences for the sample of top bonds. A bond is the firm's top bond if it has the most institutional trading (measured as the number of trades greater than $500,000) for the firm on a given trading day. For the matched sample, there is little price difference between trades on the NYSE and TRACE. We document differences in the average daily dollar volume, the average number of trades, the average trade size, the average volatility, and the average bid-ask spread, however, for trades that

[6] Boehmer (2005) refers to matching differences as "matching errors." Pairwise propensity score differences are calculated using the following equation: $D_{xy} = \left|\frac{\text{Price}_x}{\text{Price}_y}\right| + \left|\frac{\text{DollVol}_x}{\text{DollVol}_y}\right| + \left|\frac{\text{Grade}_x}{\text{Grade}_y}\right| + \left|\frac{\text{Mat}_x}{\text{Mat}_y}\right| + \left|\frac{\text{MktCap}_x}{\text{MktCap}_y}\right|$.

execute on the NYSE and trades that)execute on the TRACE reporting venues. We find that TRACE trades typically have a larger average trade size, a larger number of trades, and larger average daily dollar volume than NYSE trades. We also find that listed bond trades that execute on the NYSE have larger spreads than listed bond trades that execute via TRACE ($1.43 compared to $1.18). Lastly, we find that NYSE trades have greater volatility than TRACE trades.

In Panel B, we focus on top bonds. Similar to the results in Panel A, we find no difference in bond price for trades that execute on the NYSE and trades that execute via TRACE. However, we document differences in the average daily dollar volume, the average number of trades, the average trade size, the average volatility, and the average bid-ask spread. Specifically, top bond trades that execute via the NYSE have lower daily dollar volume, fewer daily trades, and smaller trade size than top bond trades that execute via TRACE venues. We also find that NYSE trades in top bonds are more volatile than TRACE trades in top bonds, and that NYSE top bond trades have larger spreads ($1.36) than TRACE top bond trades ($1.07).

Spread

We replicate the bond bid-ask spread analysis for the matched sample. Table 11 provides spread regression results. Model 1 includes the matched sample, and Model 2 (Model 3) breaks the matched sample into listed and unlisted bonds. The p-value is for the difference in the listed and unlisted coefficients. Similar to the full sample, our main variable of interest is the *Listed* variable. The *Listed* variable is equal to one if the bond is listed. In Model 1, we document a negative relation between bond listing and the bid-ask spread (we also document a negative relation between bond listing and spread in the full sample). Consistent with the full sample of bonds, we find that top bonds have lower spreads than non-top bonds in the matched sample. The negative relation holds for the full matched sample, and for both listed and unlisted bonds. The control variables are as expected (and similar to our findings in the full sample and also to Edwards, Harris, and Piwowar, (2007)). Specifically, we find that investment grade bonds have lower spreads than non-investment grade bonds, and bonds with more time to maturity have higher spreads than bonds that are closer to maturity. Next, we focus on the bid-ask spread for top

bonds in the matched sample. Model 4 provides results for the top bonds included in the matched sample, and Models 5 and 6 are for listed and unlisted bonds. Our main variable of interest is the *Listed* variable in Model 4. We find a positive relation between bond listing and the top bond bid-ask spread. Specifically, listed top bond spreads are $0.11 more than unlisted top bond spreads.

To further our study of the bond bid-ask spread, we also focus on the relation between spread and trade size. Edwards, Harris, and Piwowar (2007) find a negative relation between trade size and the bid-ask spread. To see if the inverse relation between spread and trade size holds in our sample, we break the sample into small, medium, and large sized trades in Table 12. Table 12 Panel A presents the results regarding bond trade size and the bid-ask spread. Consistent with prior literature, we document an inverse relation between trade size and bond bid-ask spread. Listed bonds have lower spreads than unlisted bonds for small and medium sized trades, while unlisted bonds have lower spreads for large trades. The difference between the listed and unlisted bond spread is significant for all trade categories.

In Panel B, we focus on the relation between trading activity and the bond bid-ask spread. Quartile 1 consists of the most active bonds over the course of the sample period, and Quartile 4 consists of the least active bonds over the course of the sample period. For listed bonds, we find that the most active bonds have the lowest bid-ask spread at $0.98 (Quartile 1) and $0.95 (Quartile 2), and the least active bonds have the largest bid-ask spread at $1.47. We find a direct relation between trading activity and bond spread for unlisted bonds, with the most active unlisted bonds having lower spreads than the least active unlisted bonds. We also compare the spreads of listed and unlisted bonds. Overall, we find a significant difference in listed and unlisted bond spreads in Quartile 2, but not for any of the other quartiles.

Volatility

Lastly, we follow O'Hara and Ye (2011) and focus on bond volatility as a measure of price efficiency. Table 13 provides results for bond volatility regressions for the matched sample of bonds. The p-value is for the difference between listed and unlisted bond regression coefficients. Our main variable of interest is the *Listed* variable, which is equal to one if the bond is listed. We find a positive

relation between bond listing and volatility, which is consistent with our findings in the full sample. We are also interested in the top bond variable. We find a significant and positive relation between top bond status and volatility for the full matched sample, and for the listed bonds in the matched sample. However, we do not find a significant relation between top bond status and volatility for the unlisted bonds. We further explore the relation between top bonds and volatility in regression Models 4, 5, and 6. In Model 4, we document a positive relation between bond listing and volatility for the top bonds included in the matched sample.

VII: Conclusion

We study the impact of bond listing in the corporate bond market. Previous theoretical research by Merton (1987) documents an advantage to exchange listing in the equities market; specifically, Merton details that exchange listing in the equities market can lead to an increase in investor recognition and improved liquidity for the firm. Kadlec and McConnell (1994) show empirically that listing leads to an increase in institutional shareholders for the firm, while much research documents improved liquidity for NYSE stocks and NYSE trades (Huang and Stoll, 1996; Bennet and Wei, 2006; and Bessembinder and Kaufman, 1997).

While the above mentioned research focuses on equities, we focus on the bond market in our research. Studying the impact of exchange listing in the bond market is valuable for several reasons. First, much of the research on listing focuses on stocks, which are highly liquid assets, especially when compared to the bond market. In our sample, the average corporate bond trades just 5 times, which is substantially less than the average stock in the equity market. Bonds are also costly to trade. Documenting a market quality or trading advantage for listed (or unlisted) bonds is beneficial for traders. It is also possible that bond listing serves a signal to bond traders, similar to the firm paying dividends or beating earnings. Given the well-documented informational inefficiencies in the bond market (Kwan, 1996; Downing, Underwood, and Xing, 2009), it could be important for investors to obtain information based on bond listing.

First, we document the qualities of listed bonds. Our findings show that listed bonds tend to have lower spreads and a greater number of trades than unlisted bonds. We also find that listed bonds have

greater volatility than unlisted bonds. Second, we focus on the bond bid-ask spread. We show that listed bonds have lower spreads than unlisted bonds. Listed bond spreads are $0.14 lower than unlisted bond spreads. Additionally, listed top bond spreads are $0.33 lower than the spreads of other bonds. However, we also find that NYSE bond trades in listed bonds have larger bid-ask spreads than TRACE trades in listed bonds. We find that listed top bond trades have larger spreads than unlisted top bond trades. Third, we focus on volatility and price efficiency for listed and unlisted bonds. We find that listed bonds are more volatile than unlisted bonds. Overall, there appears to be a market quality advantage to bond listing.

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Table 1
Trade Level Sample Statistics

The sample includes 6,841,030 bond trades during the year 2013. Bond trades in the sample occur from 8:00 am – 6:30 pm EST.

	% of Total Trades	% of Listed Bond Trades	% of Unlisted Bond Trades
% investment grade bond trades	73.30%	81.07%	54.32%
% high yield bond trades	26.70%	18.93%	45.68%
% trades in bonds with less than 1 year to maturity	5.19%	3.08%	10.35%
% trades in bonds with less than 5 years to maturity	44.09%	44.15%	43.94%
% trades in bonds with less than 10 years to maturity	81.53%	81.92%	80.57%
% top bond trades	52.12%	53.96%	47.62%
% trades greater than $25,000	47.36%	46.12%	50.38%
% trades greater than $50,000	34.71%	33.23%	38.30%
% trades greater than $100,000	26.23%	24.69%	29.99%
% trades greater than $500,000	13.44%	12.30%	16.22%
% trades greater than $1,000,000	6.11%	6.54%	5.08%
% trades of premium bonds	76.23%	77.90%	72.14%
% trades of discount bonds	0.64%	0.32%	1.41%
% trades at par	23.13%	21.77%	26.45%

Table 2
Sample Summary Statistics, Bond Level

The top bond is the bond with the most daily institutional trading using a $500,000 trade size (Ronen and Zhou, 2013). Price is the percentage of par. Dollar volume is the daily dollar volume for each bond, and the number of trades is the daily number of trades for each bond. Trade size is the average daily dollar trade size. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades.

	All Bonds				Top Bonds			
	N	Mean	Minimum	Maximum	N	Mean	Minimum	Maximum
Panel A: Full Sample								
Price	12,633	$105.49	$25.16	$276.92	8,375	$107.46	$25.00	$288.81
Dollar Volume	12,633	$1,559,216.10	$2,000.00	$82,374,604.17	8,375	$4,464,537.46	$502,000.00	$55,385,555.56
Number of Trades	12,633	4.73	1.09	80.00	8,375	6.93	1.00	241.00
Trade Size	12,633	$381,336.29	$1,000.00	$5,000,000.00	8,375	$1,176,863.39	$38,148.15	$5,000,000.00
Volatility	12,633	2.15	0.00	20.21	8,375	1.99	0.00	19.77
Bid-Ask Spread	12,633	$1.34	0.00	$9.66	8,375	$0.87	$0.00	$9.31
Panel B: Listed Bonds								
Price	5,199	$109.44	$47.83	$263.62	4,725	$109.37	$48.68	$263.62
Dollar Volume	5,199	$2,192,225.57	$8,400.00	$82,374,604.17	4,725	$4,819,489.08	$538,000.00	$84,113,106.38
Number of Trades	5,199	5.71	1.14	69.47	4,725	7.16	1.00	109.33
Trade Size	5,199	$488,023.17	$2,733.33	$4,666,666.67	4,725	$1,231,376.63	$47,727.37	$5,000,000.00
Volatility	5,199	2.17	0.01	20.21	4,725	2.08	0.04	31.32
Bid-Ask Spread	5,199	$1.17	$0.01	$9.66	4,725	$0.90	$0.00	$7.60
Panel C: Unlisted Bonds								
Price	7,434	$102.73	$25.16	$276.92	3,650	$104.98	$25.00	$288.81
Dollar Volume	7,434	$1,116,518.19	$2,000.00	$55,385,555.56	3,650	$4,005,045.29	$502,000.00	$55,385,555.56
Number of Trades	7,434	4.04	1.09	80.00	3,650	6.64	1.00	241.00
Trade Size	7,434	$306,724.36	$1,000.00	$5,000,000.00	3,650	$1,106,294.87	$38,148.15	$5,000,000.00
Volatility	7,434	2.14	0.00	15.22	3,650	1.88	0.00	19.77
Bid-Ask Spread	7,434	$1.45	0.00	$9.63	3,650	$0.83	$0.00	$9.31

Table 3
Regression Models of Bond Listing and Trade Execution Determinants

We model the determinants of bond listing using a logistic model. The top bond is the bond with the most daily institutional trading using a $500,000 trade size (Ronen and Zhou, 2013). Price is the percentage of par. Dollar volume is the daily dollar volume for each bond, and the number of trades is the daily number of trades for each bond. Trade size is the average daily dollar trade size. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. Listed is equal to one if the bond is listed. P-values are used to determine coefficient significance, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *.

	Bond Listing	P-Value
Intercept	-0.2839***	0.0000
Trading Activity Variables		
Bid-Ask Spread	-0.2655***	0.0000
Dollar Volume	-0.0000***	0.0000
Number of Trades	0.0045***	0.0000
Trade Size	-0.0000***	0.0000
Volatility	0.0876***	0.0000
Top Bond	0.2425***	0.0000
Firm/Bond Specific Variables		
Years to Maturity	0.0104***	0.0000
Firm Size	-0.0000***	0.0000
Investment Grade	1.4805***	0.0000
Wald's Pr > χ^2	0.0000***	

Table 4
A Comparison of NYSE and TRACE Trades

Table 4 compares the average summary statistics for listed bond trades that execute on the NYSE and listed bond trades that execute on TRACE. The top bond is the bond with the most institutional trading each day using a $500,000 trade size (Ronen and Zhou, 2013). Price is the percentage of par. Dollar volume is the daily dollar volume for each bond on each trading venue (TRACE and the NYSE), and the number of trades is the daily number of trades for each bond on each trading venue (TRACE and the NYSE). Trade size is the average daily dollar trade size on each venue (TRACE and the NYSE). Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Significance is indicated at the 1%, 5%, and 10% levels by ***, **, and *.

	NYSE	Trace	Difference	T-Stat
Panel A: All Bonds				
Price	$105.84	$105.52	$0.32*	1.87
Dollar Volume	$10,094.86	$4,090,728.88	-$4,080,634.02***	-17.87
Number of Trades	1.27	13.66	-12.40***	-22.21
Trade Size	$8,113.32	$386,042.66	-$377,929.34***	-25.50
Volatility	3.51	3.33	0.18*	1.85
Bid-Ask Spread	$1.23	$1.04	$0.19***	4.66
Panel B: Top Bonds				
Price	$105.08	$104.93	$0.16	0.73
Dollar Volume	$12,028.33	$7,106,201.08	-$7,094,172.76***	-21.91
Number of Trades	1.27	18.15	-16.88***	-20.14
Trade Size	$9,587.53	$611,423.91	-$601,836.38***	-25.83
Volatility	4.01	3.59	0.42***	3.05
Bid-Ask Spread	$1.13	$0.92	$0.21***	4.24

Table 5
Bond Spread Regressions

Models 1, 2, and 3 are estimated for all bonds. Models 4, 5, and 6 are estimated for top bonds. The top bond is designated as the bond with the most daily institutional trading using a $500,000 trade size (Ronen and Zhou, 2013). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. Volatility is calculated as $\frac{100}{\text{Price}_t}(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}})$ (Downing and Zhang, 2004). The Top Bond variable is equal to one for the bond with the most institutional trading each day. A trade is categorized as institutional if it is greater than $500,000. Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

	All Bonds			Top Bonds		
Model	All Bonds	Listed Bonds	Unlisted Bonds	All Top Bonds	Listed Top Bonds	Unlisted Top Bonds
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.8186***	0.8069***	0.7143***	0.5707***	0.7002***	0.5081***
	(13.88)	(12.83)	(14.24)	(9.68)	(10.69)	(12.98)
Dollar Volume	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-6.32)	(-4.58)	(-8.89)	(-7.11)	(-5.38)	(-8.75)
Number of Trades	0.0001	0.0003	0.0002	0.0010***	0.0012***	0.0009**
	(0.69)	(1.03)	(0.82)	(3.88)	(3.64)	(2.10)
Trade Size	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-12.43)	(-9.86)	(-10.09)	(-11.78)	(-9.58)	(-9.55)
Volatility	0.1243***	0.1063***	0.1597***	0.0814***	0.0745***	0.0948***
	(10.58)	(7.54)	(10.34)	(8.44)	(6.02)	(8.56)
Top Bond	-0.4164***	-0.3252***	-0.5878***			
	(-34.17)	(-23.31)	(-28.90)			
Years to Maturity	0.0399***	0.0386***	0.0397***	0.0299***	0.0312***	0.0255***
	(18.97)	(15.33)	(12.11)	(14.86)	(12.51)	(8.57)
Firm Size	-0.0000***	-0.0000***	0.0000	-0.0000***	-0.0000***	-0.0000***
	(-7.92)	(-11.78)	(0.77)	(-10.77)	(-9.50)	(-5.17)
Investment Grade	-0.1071***	-0.2183***	-0.0070	-0.1884***	-0.2482***	-0.0913***
	(-4.47)	(-6.83)	(-0.22)	(-7.40)	(-7.29)	(-2.74)
Trace Execution	0.0302	0.0463		-0.0155	-0.0142	
	(0.69)	(1.10)		(-0.35)	(-0.32)	
Listed	-0.1355***			0.0769***		
	(-7.32)			(3.91)		
R-Squared	40.62%	42.57%	41.16%	40.32%	43.38%	34.91%
F-Stat	614.94***	374.03***	394.66***	252.20***	210.13***	111.39***

Table 6
Bond Spread by Trade Size and Trading Activity

The most active bonds in the sample are in Quartile 1, and the least active bonds in the sample are in Quartile 4. The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades.

	All Bonds	Listed Bonds	Unlisted Bonds
Panel A: Dollar Spreads by Trade Size			
All Trade Sizes	$1.34	$1.17	$1.45
Less than $100,000	$1.42	$1.25	$1.54
$100,000 - $999,999	$1.17	$1.04	$1.31
Greater than $1,000,000	$0.82	$0.88	$0.76
Panel B: Dollar Spreads by Trading Activity			
Q1 (most active)	$0.99	$0.95	$1.07
Q2	$1.29	$1.12	$1.45
Q3	$1.52	$1.44	$1.54
Q4 (least active)	$1.56	$1.80	$1.51

Table 7
Bond Volatility Regressions

Table 7 presents bond volatility regressions. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). Models 1, 2, and 3 estimate volatility for the full sample of bonds, listed bonds, and TRACE bonds. Models 4, 5, and 6 estimate volatility for all top bonds, listed top bonds, and unlisted top bonds. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. The Top Bond is equal to one for the bond with the most institutional trading each day. A trade is categorized as institutional if it is greater than $500,000 (Ronen and Zhou 2013). Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

	All Bonds			Top Bonds		
Model	Full Sample	Listed Bonds	Unlisted Bonds	All Top Bonds	Listed Top Bonds	Unlisted Top Bonds
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	3.0355***	3.3894***	3.0082***	3.4985***	3.9290***	3.2946***
	(16.64)	(14.36)	(21.98)	(15.08)	(13.36)	(14.86)
Dollar Volume	0.0000*	0.0000	0.0000***	0.0000**	0.0000	0.0000***
	(1.95)	(1.28)	(3.29)	(2.38)	(1.52)	(3.82)
Number of Trades	0.0144***	0.0190***	0.0069***	0.0120***	0.0165***	0.0058**
	(6.50)	(6.69)	(2.82)	(5.82)	(6.27)	(2.36)
Trade Size	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-13.63)	(-9.94)	(-11.71)	(-14.20)	(-10.69)	(-12.70)
Top Bond	0.0908*	0.0616	0.1294*			
	(1.83)	(0.98)	(1.72)			
Years to Maturity	0.1208***	0.1191***	0.1210***	0.1190***	0.1194***	0.1168***
	(25.09)	(20.51)	(10.80)	(15.75)	(15.06)	(5.35)
Firm Size	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000*	-0.0000***
	(-4.31)	(-3.24)	(-4.04)	(-3.20)	(-1.82)	(-3.24)
Investment Grade	-1.5569***	-1.6970***	-1.3399***	-1.7403***	-1.8428***	-1.5319***
	(-11.85)	(-8.58)	(-10.37)	(-9.89)	(-7.24)	(-8.06)
Trace Execution	-0.0423	-0.0286		-0.3296*	-0.3529*	
	(-0.27)	(-0.18)		(-1.74)	(-1.87)	
Listed	0.3402***			0.4979***		
	(3.72)			(3.41)		
R-Squared	20.00%	23.00%	15.10%	18.76%	21.57%	14.31%
F-Stat	166.46***	169.44***	51.79***	129.20***	144.97***	39.50***

Table 8
Matched Sample Summary Statistics

We construct a matched sample using bond price, dollar volume, market capitalization, bond investment grade, and bond years to maturity as our matching criteria. The sample is matched at the bond level. The matched sample includes 2,706,274 trades. Summary statistics are calculated at the bond level. Price is the percentage of par. Dollar volume is the daily dollar volume for each bond. The investment grade variable is equal to one if a bond is investment grade quality. Market Capitalization is the daily stock price multiplied times daily shares outstanding. Significance is indicated at the 1%, 5%, and 10% levels with ***, **, and *.

Panel A: All Bonds

	N	Mean	Standard Deviation	Minimum	Max
Price	4,172	$106.08	$11.71	$42.85	$272.60
Dollar Volume	4,172	$1,822,735.71	$2,962,901.53	$2,416.67	$82,357,435.86
Market Capitalization	4,172	$53,376,174.28	$72,256,984.34	$11,523.30	$438,712,329.00
Investment Grade	4,172	0.76	0.43	0.00	1.00
Years to Maturity	4,172	8.49	7.58	0.02	29.97

Panel B: Listed Bond vs. Unlisted Bond

	N	Listed Bond Mean	Unlisted Bond Mean	Difference	T Stat
Price	2,086	$106.72	$105.44	$1.28	0.47
Dollar Volume	2,086	$1,857,091.51	$1,788,379.90	$68,711.62	0.97
Market Capitalization	2,086	$54,837,257.40	$51,915,091.16	$2,922,166.24	1.32
Investment Grade	2,086	0.73	0.79	-0.06	0.98
Years to Maturity	2,086	8.47	8.50	-0.03	-0.15

Table 9
Matched Sample Regression Models of Bond Listing and Trade Execution Determinants

Table 9 provides regression estimates for the determinants of bond listing. The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). The Top Bond is equal to one for the bond with the most institutional trading each day. A trade is categorized as institutional if it is greater than $500,000 (Ronen and Zhou 2013). Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. Listed is equal to one if the bond is listed. P-values are provided, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *.

	Bond Listing (1)	P-Value
Intercept	1.1998***	0.0000
Trading Activity Variables		
Bid-Ask Spread	-0.1707***	0.0000
Dollar Volume	-0.0000***	0.0000
Number of Trades	0.0071***	0.0000
Trade Size	-0.0000***	0.0000
Volatility	0.0887***	0.0000
Top Bond	-0.1393***	0.0000
Firm/Bond Specific Variables		
Years to Maturity	-0.0048***	0.0000
Firm Size	0.0000***	0.0000
Investment Grade	-0.4837***	0.0000
Wald's Pr > χ^2	0.0000***	

Table 10
Matched Sample Comparison of NYSE and TRACE Trades

We compare listed bond trades that execute on the NYSE and listed bond trades that execute on TRACE using the matched sample. The bond with the most institutional trading each day is designated as the top bond for that firm. A trade is classified as institutional if the trade size is greater than $500,000 (Ronen and Zhou, 2013). Price is the percentage of par. Dollar volume is the daily dollar volume, and the number of trades is the average daily number of trades. Trade size is the average daily dollar trade size. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Significance is indicated at the 1%, 5%, and 10% levels by ***, **, and *.

	NYSE	TRACE	Difference	T-Stat
		Panel A: All Bonds		
Price	$102.95	$103.03	-$0.08	-0.31
Dollar Volume	$8,329.97	$3,276,823.39	-$3,268,493.42***	-9.51
Number of Trades	1.28	11.88	-10.60***	-14.84
Trade Size	$6,772.10	$335,195.87	-$328,423.77***	-16.89
Volatility	3.89	3.59	0.30**	2.14
Bid-Ask Spread	$1.43	$1.18	$0.25***	4.45
		Panel B: Top Bonds		
Price	$102.03	$102.22	-$0.19	-0.53
Dollar Volume	$9,400.49	$6,149,843.11	-$6,140,442.62***	-11.33
Number of Trades	1.31	16.50	-15.20***	-12.76
Trade Size	$7,400.29	$575,750.71	-$568,350.42***	-15.90
Volatility	4.54	4.05	0.49**	2.21
Bid-Ask Spread	$1.36	$1.07	$0.29***	3.91

Table 11
Matched Sample Bond Spread Regressions

Models 1, 2, and 3 are for matched sample bonds. Models 4, 5, and 6 are estimated for matched sample top bonds. The top bond has the most daily institutional trading using a $500,000 trade size (Ronen and Zhou, 2013). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. Volatility is calculated as $\frac{100}{\text{Price}_t}(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}})$ (Downing and Zhang, 2004). Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

	Matched Sample of Bonds				Matched Sample of Top Bonds			
Model	Matched	Listed	Unlisted	P Value	Matched	Listed	Unlisted	P Value
	(1)	(2)	(3)		(4)	(5)	(6)	
Intercept	0.9081***	0.9085***	0.6033***	0.2690	0.6224***	0.7745***	0.3787***	0.8397
	(9.53)	(9.91)	(10.26)		(6.32)	(7.94)	(7.05)	
Dollar Volume	-0.0000***	-0.0000***	-0.0000***	0.3773	-0.0000***	-0.0000***	-0.0000***	0.0823
	(-4.34)	(-2.66)	(-7.43)		(-4.60)	(-2.94)	(-5.57)	
Number of Trades	0.0000.	-0.0001	0.0013**	0.4173	0.0010**	0.0008*	0.0017*	0.2035
	(0.07)	(-0.27)	(1.97)		(2.47)	(1.87)	(1.81)	
Trade Size	-0.0000***	-0.0000***	-0.0000***	0.9637	-0.0000***	-0.0000***	-0.0000***	0.2249
	(-8.98)	(-7.41)	(-4.66)		(-8.43)	(-7.66)	(-4.34)	
Volatility	0.1084***	0.0931***	0.1956***	0.3819	0.0722***	0.0645***	0.1224***	0.2901
	(5.76)	(4.98)	(14.12)		(4.60)	(4.03)	(12.76)	
Top Bond	-0.3889***	-0.3179***	-0.5946***	0.1960				
	(-21.00)	(-15.29)	(-19.13)					
Years to Maturity	0.0401***	0.0404***	0.0334***	0.2911	0.0306***	0.0329***	0.0218***	0.7765
	(12.04)	(10.91)	(9.10)		(9.97)	(9.42)	(4.95)	
Firm Size	-0.0000***	-0.0000***	0.0000	0.2235	-0.0000***	-0.0000***	-0.0000***	0.3893
	(-5.60)	(-7.14)	(0.90)		(-6.70)	(-6.88)	(-4.75)	
Investment Grade	-0.1967***	-0.2460***	-0.0190	0.3159	-0.2064***	-0.2470***	-0.0452	0.3175
	(-5.43)	(-5.84)	(-0.40)		(-5.52)	(-5.56)	(-0.95)	
Trace Execution	0.0043	0.0160			-0.0258	-0.0178		
	(0.06)	(0.24)			(-0.35)	(-0.24)		
Listed	-0.0626**				0.1146***			
	(-2.21)				(3.95)			
R-Squared	41.47%	43.90%	43.81%		42.01%	44.48%	36.01%	
F Statistic	258.00***	190.29***	159.39***		145.99***	154.00***	44.14***	

Table 12
Matched Sample Bond Spread by Trade Size and Trading Activity

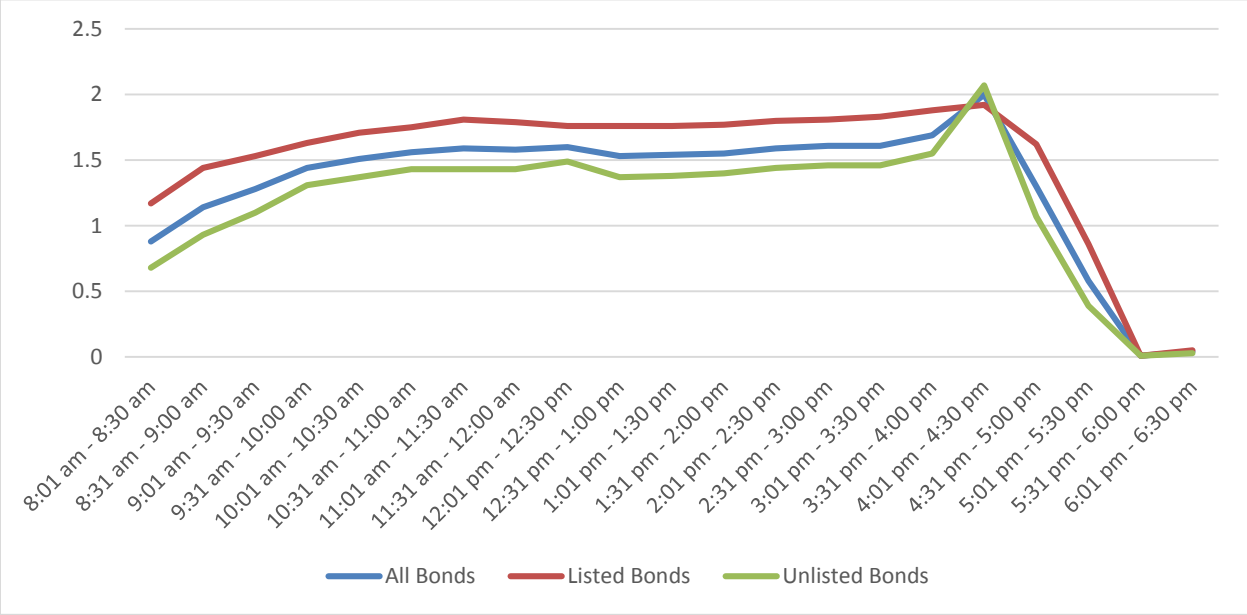
The most active bonds in the sample are in Quartile 1, and the least active bonds in the sample are in Quartile 4. The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. The difference column represents the difference between listed bond spread and unlisted bond spread. Significance is determined using t-stats. Significance is indicated at the 1%, 5%, and 10% levels using ***, **, and *.

	All Bonds	Listed Bonds	Unlisted Bonds	Difference	T Stat
Panel A: Dollar Spreads by Trade Size					
All Trade Sizes	$1.24	$1.12	$1.36	-$0.25***	-7.83
Less than $100,000	$1.33	$1.17	$1.49	-$0.32***	-9.52
$100,000 - $999,999	$1.10	$1.02	$1.22	-$0.20***	-5.76
Greater than $1,000,000	$0.81	$0.90	$0.74	$0.16***	5.11
Panel B: Dollar Spreads by Trading Activity					
Q1 (most active)	$1.01	$0.98	$0.95	$0.03	0.28
Q2	$1.10	$0.95	$1.36	-$0.42***	-3.60
Q3	$1.33	$1.20	$1.40	-$0.20	-1.41
Q4 (least active)	$1.51	$1.43	$1.56	-$0.13	-0.59

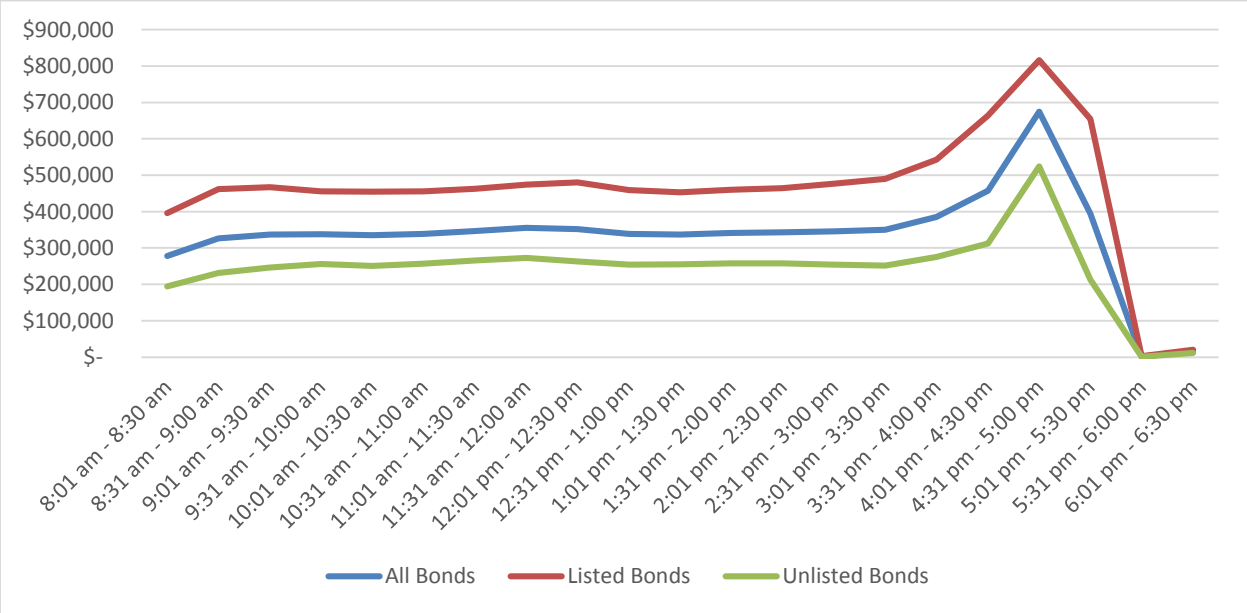
Table 13
Matched Sample Bond Volatility Regressions

Volatility is calculated as $\frac{100}{\text{Price}_t}(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}})$ (Downing and Zhang, 2004). Models 1, 2, and 3 estimate volatility for the full sample of matched bonds, listed bonds, and TRACE bonds. Models 4, 5, and 6 estimate volatility for all top bonds, listed top bonds, and unlisted top bonds. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. The Top Bond is equal to one for the bond with the most institutional trading each day. A trade is categorized as institutional if it is greater than $500,000 (Ronen and Zhou, 2013). Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

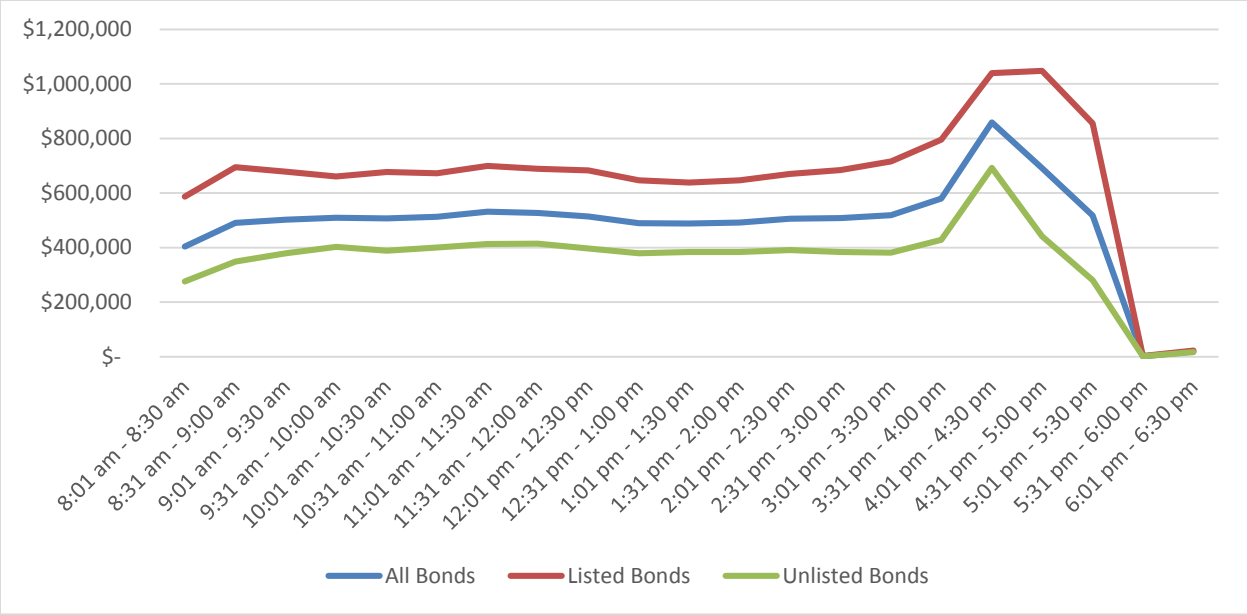
	Matched Sample of Bonds				Matched Sample of Top Bonds			
Model	Matched	Listed	Unlisted	P Value	Matched	Listed	Unlisted	P Value
	(1)	(2)	(3)		(4)	(5)	(6)	
Intercept	3.1464***	3.4480***	3.1068***	0.3113	3.7922***	4.2791***	3.3987***	0.8435
	(10.22)	(9.92)	(19.91)		(9.77)	(9.29)	(18.38)	
Dollar Volume	0.0000	0.0000	0.0000***	0.3713	0.0000	0.0000	0.0000***	0.4306
	(0.32)	(0.59)	(3.03)		(0.72)	(0.68)	(3.82)	
Number of Trades	0.0185***	0.0224***	0.0029	0.4004	0.0164***	0.0212***	0.0013	0.9683
	(4.14)	(4.13)	(1.52)		(3.79)	(3.86)	(0.98)	
Trade Size	-0.0000***	-0.0000***	-0.0000***	0.4159	-0.0000***	-0.0000***	-0.0000***	0.2431
	(-8.03)	(-6.86)	(-10.65)		(-8.55)	(-7.56)	(-10.64)	
Top Bond	0.1985***	0.2266**	0.0116	0.4434				
	(2.79)	(2.46)	(0.16)					
Years to Maturity	0.1135***	0.1155***	0.0962***	0.5058	0.1084***	0.1153***	0.0770***	0.9025
	(12.42)	(9.22)	(12.18)		(7.71)	(5.88)	(6.59)	
Firm Size	-0.0000***	-0.0000***	-0.0000	0.5981	-0.0000***	-0.0000**	-0.0000**	0.6967
	(-4.47)	(-4.18)	(-1.27)		(-2.88)	(-2.39)	(-2.03)	
Investment Grade	-1.5523***	-1.6686***	-1.1977***	0.3161	-1.6649***	-1.8042***	-1.3171***	0.3175
	(-9.16)	(-7.65)	(-6.98)		(-7.36)	(-5.88)	(-6.54)	
Trace Execution	-0.1431	-0.0959			-0.6069*	-0.6062*		
	(-0.52)	(-0.34)			(-1.75)	(-1.78)		
Listed	0.3870***				0.6126***			
	(3.78)				(4.06)			
R-Squared	20.54%	22.30%	14.22%		18.65%	20.11%	14.01%	
F Statistic	82.13***	62.09***	61.10***		67.18***	49.99***	47.35***	



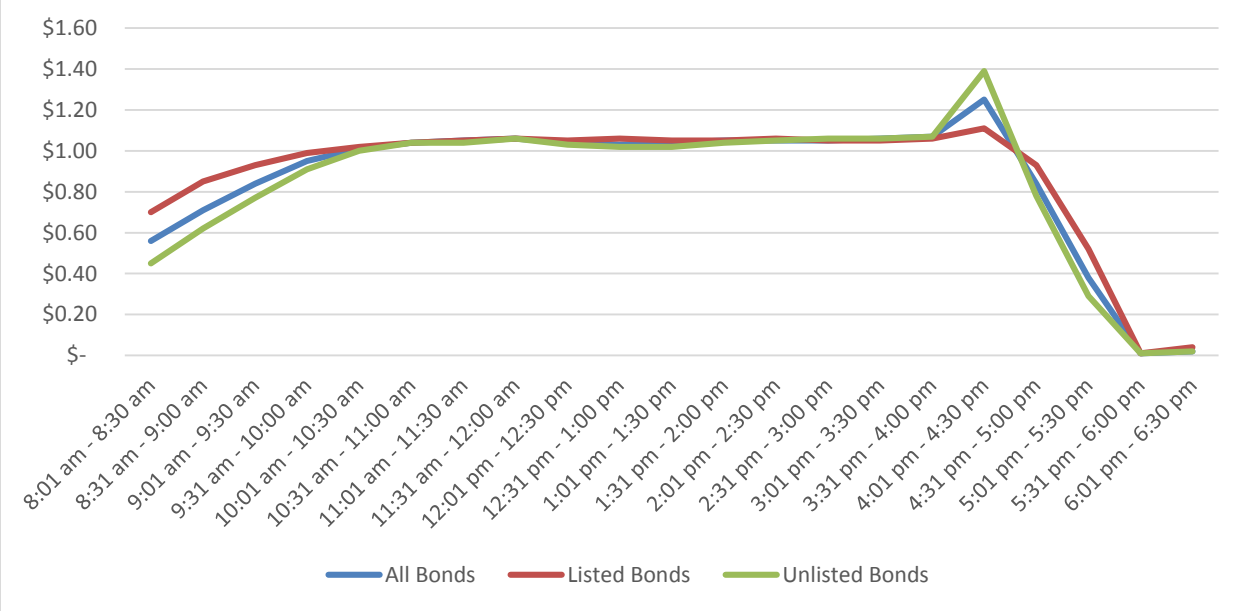
Graph 1. Intraday Average Number of Bond Trades.



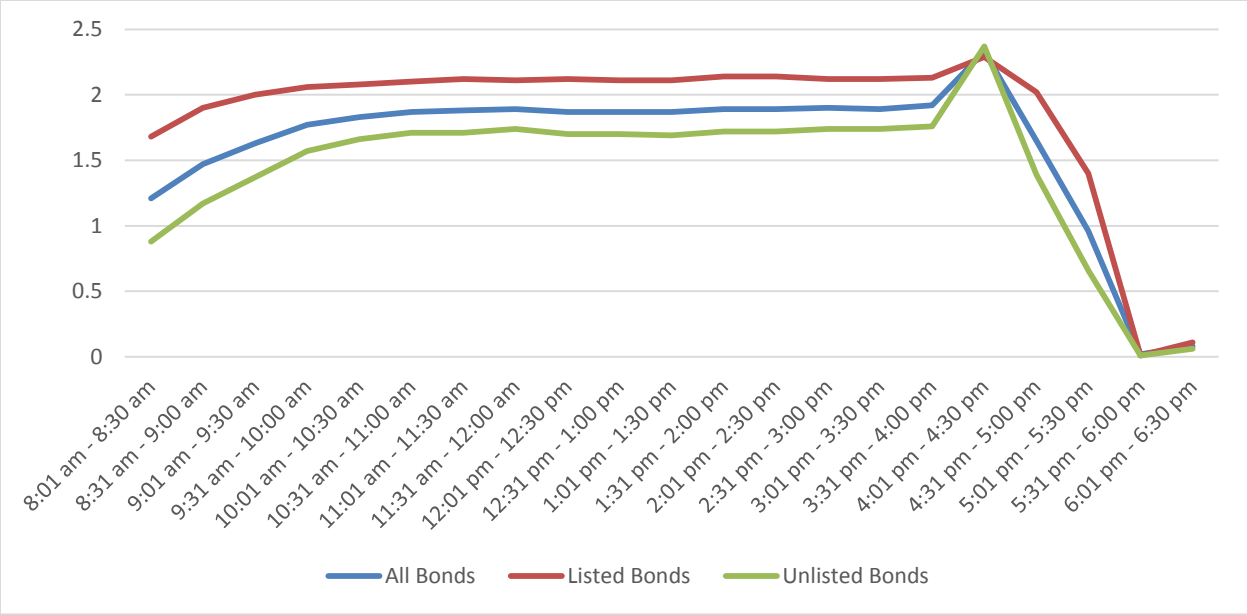
Graph 2. Average Intraday Bond Trade Size.



Graph 3. Average Intraday Bond Dollar Volume.



Graph 4. Average Intraday Bond Bid-Ask Spread.



Graph 5. Average Intraday Bond Volatility.