Capital Commitment and Illiquidity in Corporate Bonds*

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We study liquidity in U.S. corporate bond markets from 2003 to 2014. Despite a temporary increase during the financial crisis, trade execution costs have decreased over time. However, alternative measures, including intraday and overnight dealer capital commitment, dealer participation as principals, turnover, the frequency of block trades, and interdealer trading, have not returned to pre-crisis levels and in many cases have worsened. The reduction in dealers' commitment to bond market making in recent years is attributable to bank-affiliated dealers, while non-bank dealers have increased their participation. The evidence supports that these outcomes reflect unintended consequences of post-crisis regulations focused on banking.

The liquidity of the corporate bond market has attracted substantial recent attention from practitioners, regulators, and academics. The financial crisis of 2007-2009 saw the broad deterioration of liquidity in both equity (e.g., Anand, Irvine, Puckett, and Venkataraman, 2013) and corporate bond (e.g., Dick-Nielsen, Feldhutter, and Lando, 2012; Friewald, Jankowitsch, and Subrahmanyam, 2012) markets. However, while Anand et al. (2013) find that equity market liquidity recovered after the financial crisis, concerns regarding corporate bond market liquidity appear to have become more widespread in recent years. For example, Daniel Gallagher, former Commissioner of the U.S. Securities and Exchange Commission (SEC) during 2015 expressed concern that "A lack of liquidity in corporate-bond markets could pose a 'systemic risk' to the economy."[1] Also during 2015, the Finance Industry Regulatory Authority (FINRA) issued an "investor alert" to "educate investors about bond liquidity, and the potential for decreased liquidity…".[2]

Concerns regarding corporate bond market liquidity have been attributed by some observers to post-crisis regulatory initiatives. For example, Pacific Investment Management Company (PIMCO) asserts that "the combination of post-crisis capital and liquidity regulations and a lower return environment has made banks less able and willing to function as market makers."[3] Others point to real time trade reporting as an explanation for reduced liquidity, and have proposed in particular that transaction reporting be delayed in the case of large customer-to-dealer trades.[4] However, not all observers are convinced that liquidity in the corporate bond markets has deteriorated. Some assert that concerns regarding bond market liquidity comprise a "myth" and arise from traditional bond dealers' desire to maintain their "privileged market position."[5] Janet Yellen, chair of the U.S. Federal Reserve, stated "It's not clear whether there is or is not a problem" (with liquidity), and added that "it's a question that needs further study."[6]

Our goal in this paper is to provide a comprehensive analysis of dealer liquidity provision in the corporate bond market over the 2003 to 2014 period. We are particularly interested in

[1] http://www.bloomberg.com/news/articles/2015-03-02/corporate-bond-market-poses-systemic-risk-sec-s-gallagher-says.
[2] http://www.finra.org/newsroom/2015/finra-issues-investor-alert-bond-liquidity.
[3] http://www.barrons.com/articles/a-look-at-bond-market-liquidity-1440103954.
[4] See, for example, "US Banks push for delay in reporting corporate bond trades", Financial Times, April 26, 2015. Available at http://www.ft.com/cms/s/0/c4176a68-ea8f-11e4-a701-00144feab7de.html#axzz3tI4IGSe7.
[5] "Overlooking the Other Sources of Liquidity", Wall Street Journal, July 26, 2015, available at http://www.wsj.com/articles/overlooking-the-other-sources-of-liquidity-1437950015.
[6] http://blogs.wsj.com/economics/2015/07/15/fed-chairwoman-janet-yellens-report-to-congress-live-blog/.

assessing changes in market quality in the years following the financial crisis, and in evaluating possible causes for any changes observed. To do so, we use an enhanced version of the TRACE database of transactions in U.S. corporate bonds, made available by FINRA. In addition to the standard TRACE data, the data we study includes masked dealer identities, which allows us to directly assess activity at the dealer level, as well as unmasked trade sizes and transactions in privately-traded 144A bonds.

We document that, despite an increase during the financial crisis period, average customer trade execution costs have decreased over time. For the full sample, the decrease is from an average of 0.52% (for a round trip trade) during the pre-crisis period to 0.42% in the two most recent years. However, execution costs are based on completed trades and do not capture either customers' difficulty in arranging trades or the implicit costs associated with trades that were desired but not completed. We therefore consider a number of additional measures of dealers' commitment to market making, including intraday capital provision, turnover, trade size, the proportion of customer trades completed on a principal rather than an agency basis, the proportion of trades that are dealer-to-dealer rather than customer-to-dealer, block volume, as well as intraday and overnight capital commitment surrounding block trades. The results, perhaps not surprisingly, show that all measures of dealer commitment declined during the financial crisis period. More informative, most measures of dealer commitment did not revert to pre-crisis levels and many measures worsened during the most recent years. All of the nine measures we consider point to significantly lower dealer capital commitment in recent years as compared to the pre-crisis period, and five point to significantly lower capital commitment in the recent years vs. the financial crisis period itself.

It is possible that the most notable reductions in bond market liquidity do not manifest during normal trading, but emerge when the market is stressed. To shed light on this possibility, we study the most active dealer on days when customer trading activity is unusually high. The results show that a larger proportion of stressful day activity is effectively completed on an agency rather than principal basis, and that dealers commit overnight capital to accommodate stressful day inventory less often during the most recent years compared to the pre-crisis period.

We consider possible causes for the finding that measures of dealer capital commitment have declined in the most recent period. Post crisis regulatory reforms, including elements of the Dodd-Frank Act such as the Volcker Rule, as well as Basel III requirements, were focused on

banking activities, and were not intended to affect bond market making. However, when we assess empirical results for bank-affiliated dealers and non-bank dealers, we find that non-bank dealers are *more* willing to commit capital, trade on a principal basis, complete block trades, hold inventory and trade on a principal basis on stressful days during the most recent years as compared to the pre-crisis period, while most measures deteriorated in recent years for bank-affiliated dealers. Overall, these results are consistent with the reasoning that regulatory initiatives focused on banking have contributed to bank-affiliated dealers' decreased willingness to commit capital to bond market liquidity, while non-bank dealers have increased bond trading participation in recent years.

We also assess the concern that TRACE transaction reporting contributes to the decrease in dealer willingness to commit capital observed in recent years. To do so, we conduct "difference-in-difference" analyses for the months surrounding TRACE introduction for both registered (public) bonds phased into transaction reporting in the 2003 to 2004 period and for non-registered (144A) bonds introduced to transaction reporting in 2014. Strikingly, we find little evidence of changes in the dealer capital commitment variables after TRACE introduction in either sample. In addition, we compare changes in dealer capital commitment during the financial crisis, when public bonds were subject to transaction reporting but 144A bonds were not, and find that the deterioration in dealer capital commitment was less for the TRACE-eligible bonds. These results do not support the claim that TRACE transaction reporting contributes to dealers' reduced capital commitment in recent years.

Collectively, the evidence indicates that the role of corporate bond dealers has changed in recent years, as bank-affiliated dealers are less inclined to play the role of a traditional market maker and instead move towards more of a matching role. Overall, customers pay lower trade execution costs, but the results suggest possible increases in foregone transactions and search costs in recent years. It will be of interest to assess if capital commitment by non-bank dealers and/or the emergence of electronic quotation venues (e.g. Hendershott and Madhavan, 2015) will in time offset the effects of decreased bank-affiliated dealer capital commitment.

This paper is organized as follows. We discuss related literature and develop hypotheses in Section I. We describe the data, dealer sample construction, and provide aggregate market statistics in Section II. Section III presents trading cost estimates. Section IV presents univariate results, and Section V presents multivariate results for capital commitment and block trading.

Section VI considers liquidity provision on stressful days. Section VII describes robustness tests. Section VIII discusses the impact of TRACE transaction reporting on liquidity provision. Finally, we summarize the results and present implications of the study in Section IX.

I. Related Literature and Hypotheses Regarding Post-Crisis Bond Liquidity

A. Bond Market Liquidity Literature

While the literature on market making and liquidity is vast, the majority of researchers' attention has focused on stock markets. Schultz (2001) provides the first systematic evidence regarding corporate bond trading, using a database of insurance company trades. He documents that institutional trades in corporate bonds incurred transactions costs that were large relative to those observed in equity markets.[7]

The introduction of corporate bond market transparency and the 2007-2009 financial crisis accelerated academic research focused on corporate bonds. The phased introduction of TRACE transaction reporting during the 2002 to 2005 period triggered at least three studies, including Edwards, Harris, and Piwowar (2006), Bessembinder, Maxwell, and Venkataraman (2006) and Goldstein, Hotchkiss, and Sirri (2007), each of which concluded that TRACE led to substantial reductions in trade execution costs paid by customers. Dick-Nielsen, Feldhutter, and Lando (2012) and Friewald, Jankowitsch and Subrahmanyam (2012) each document that corporate bond liquidity was substantially degraded during the 2007-2009 financial crisis.

As the corporate bond market lacks pre-trade transparency, authors have developed measures of corporate bond liquidity that do not require quotation data. Feldhutter (2012) shows that variation in trade prices across small vs. large trades is a useful measure of illiquidity for corporate bonds. Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008) construct and test a measure to capture "latent" liquidity in illiquid markets.

A number of recent papers examine dealer networks. Di Maggio, Kermani, and Song (2015) study the collapse of a large dealer in 2008 and find that disruption to the dealer network led to increased transaction costs. O'Hara, Wang, and Zhou (2015) document that more active insurance companies receive better transactions prices for similar trades as compared to less

[7] Researchers have also studied closely related markets. Asquith, Au, and Covert (2013) examine the market for borrowing corporate bonds (which facilitates the ability to take short positions), reporting a reduction in borrowing costs over time. Das, Kalimipalli, and Nayak (2014) argue that the advent of CDS trading has made bond markets less efficient and has not improved market liquidity. Loon and Zong (2014) find that post-trade transparency in the CDS market surrounding the advent of a central clearing led to improvements in liquidity and trading activity.

active insurance companies, particularly when the insurance company trades with the dominant dealer in the bond. Goldstein and Hotchkiss (2011) examine a dataset that covers the July 2002 to July 2008 period and that, like ours, includes dealer identification variables. They focus on institutional size trades, and document that dealers are less likely to hold an overnight inventory position in those bonds that are traded less frequently.

The literature has also shown that liquidity is important because it affects the pricing of corporate bonds. Chen, Lesmond, and Wei (2007) and Lin, Wang, and Wu (2011) document that illiquid bonds have significantly higher yield spreads, and that improvements in bond liquidity leads to reduced yield spreads. Bao and Pan (2013) show that illiquidity contributes to the observed volatility of bond prices, while Friewald and Nagler (2015) report that dealer inventories are significantly related to risk-adjusted bond returns. Cespa and Foucault (2014) show that a lack of liquidity can hinder efficient price discovery and reductions in liquidity can be self-reinforcing due to increases in information asymmetry.

The paper closest to ours is Bao, O'hara, and Zhou (2016), who study trades in corporate bonds in the wake of credit rating downgrades. They document that trades' price impacts have increased in recent periods, and more so for bank-affiliated dealers, as compared to the pre-crisis period. Our study extends the existing literature along several dimensions, including that we study bond liquidity for the entire market over a relatively long horizon, and we present evidence focused directly on dealers' willingness to commit capital to bond trading, for the overall sample and for stressful days characterized by unusually high customer volumes. We also present evidence relevant in assessing whether observed changes in corporate bond liquidity can be attributed to either TRACE transaction reporting or to post-crisis regulations focused on banking.

B. Hypotheses Regarding Possible Liquidity Deterioration

We assess two specific hypotheses that have been advanced to potentially explain reductions in corporate bond market liquidity. The first is that post-crisis regulatory reforms focused on banks have affected dealers' willingness to supply liquidity. The second is that the willingness to supply liquidity was affected by the introduction of post-trade transparency through the TRACE price-reporting system.

B.1. Post-Crisis Regulatory Reforms

The Dodd-Frank act was signed into law on July 21, 2010. Perhaps the most relevant portion of the Dodd-Frank act for the corporate bond market was the "Volcker Rule", which

required that bank holding companies and their affiliates refrain from risky proprietary trading for their own accounts. The Volcker Rule also restricted bank ownership of hedge or private equity funds that may also have provided liquidity to the bond markets. The Volcker Rule was originally scheduled to take effect on July 21, 2012, with a two-year conformance phase in period. However, implementation was delayed until an effective date of April 1, 2014, with the conformance period extended to July 21, 2015.[8]

The Volcker Rule was not intended to restrict market making activity, and specifically allows banks to conduct "riskless principal" trades that are "customer-driven." The rule also contains a market making exemption for trading desks that "routinely stand ready to purchase and sell financial instruments." However, as Duffie (2012) notes, market making is inherently a form of proprietary trading, and the Volcker Rule may have unintended consequences. He predicts that, under the Volcker Rule, "a bank that continues to offer substantial market making capacity to its clients would face a risk of regulatory sanction (and the attendant stigma) due to significant and unpredictable time variation in the proposed metrics for risk."

A number of banks announced closures of their proprietary trading operations in advance of the implementation of the Volcker rule, including J.P. Morgan and Goldman Sachs in September of 2010, Morgan Stanley in January of 2011, Bank of America in June 2011, Citigroup in January 2012, and RBC in April of 2014.[9] The Volcker rule may have affected bond market liquidity due to (1) the closing of proprietary trading desks and bank-owned hedge funds that comprised a material portion of pre-regulation trading activity, (2) increased compliance costs associated with market making, and (3) limits in market makers' ability to commit capital to assume risky inventory positions.

In addition to the Volcker rule, dealers affiliated with banks are potentially affected by implementation of the Basel III banking accords, which reduce allowable bank leverage and impose more restrictive definitions regarding banks' requisite capital holdings. The accords were originally announced in December 2010 with an effective date of January 1st 2013. After negotiation, the Federal Reserve Board approved the final U.S. implementation of Basel III on

[8] According to a Davis-Polk study, approximately sixty percent of the Dodd-Frank rulemaking had been completed as of the beginning of 2015. See http://www.davispolk.com/dodd-frank.

[9] "JPMorgan shifting its proprietary trading desk," 9/27/2010, NY Times; "Goldman to close prop-trading unit," 9/4/2010, Wall Street Journal; "Morgan Stanley to spin off prop trading unit," 1/10/2011, Reuters; "Bank of America is shutting down Merrill's bond prop trading desk," 6/10/2011, Business Insider; "Citigroup exits proprietary trading, says most staff leave," 1/27/2012, Bloomberg; "RBC exits half it prop-trading strategies as Volker Rule looms," 12/3/2014, Bloomberg.

July 2, 2013, with effective dates for various aspects ranging from 2014 to 2018. Nevertheless, banks often discuss their compliance with Basel III requirements in investor presentations, even in advance of being bound by the requirements.[10]

As this discussion demonstrates, it is not possible to define a discrete date when the effects of regulatory initiatives such as the Volcker rule or the Basel III accords became binding. Further, as the closing of proprietary trading desks in advance of the formal effective date of the Volcker rule noted above illustrates, the effects of major new regulations can manifest themselves in advance of the formal compliance dates. We consider July 2012, when the Volcker rule was originally scheduled to be effective, to be the beginning of the "Regulatory Period." While the lack of a clear effective date precludes a simple difference-in-difference test, we are able to shed light on the question of whether post-crisis banking reforms have affected liquidity provision in the corporate bond market by examining results separately for those dealers that are affiliated with a bank holding company and dealers that are not so affiliated.

B.2. Transaction Reporting

We also consider whether reductions in liquidity could arise as an unintended consequence of the introduction of post-trade transparency to the corporate bond markets through the TRACE system. As Bessembinder and Maxwell (2008) note, a broad cross-section of bond market participants, including at least some customers in addition to dealers, have complained that bond trading became more difficult post-TRACE. Asriyan, Fuchs and Green (2015) show that if traders initially had asymmetric access to transaction data (as was surely the case in corporate bond markets), then the introduction of transparency reduces the rents of more informed traders, but may also reduce total welfare. Duffie, Dworczak, and Zhu (2014) introduce a model where the introduction of a benchmark (which improves transparency) in an opaque market can reduce welfare, for some parameters. A recent survey of industry participants reported that "Many of the market participants we spoke to felt that increased transparency (e.g.

[10] In addition, European banks with large corporate bond trading desks also face regulatory changes that potentially affect their capital commitments to U.S. trading desks. In February 2009, UBS announced that it is focusing on wealth management and other core businesses and making significant reductions in fixed income trading. In November of 2011, Credit-Suisse announced that it would accelerate previously announced plans to reduce their risk-weighted assets in fixed income by 50%. Barclays, as part of a strategic review in May of 2014 announced that that it is reducing its investment banking workforce by 25%. "Preparing UBS for the new market environment," 2/10/2009, UBS Investor Release. "Barclays strategic review," 2/12/2013, Barclays Investor Release. "Press release," 7/28/2011, Credit Suisse Media Release. "Deutsche Bank cuts prop trading, cautious about 2010," 2/4/2010, Reuters.

through TRACE) had undermined liquidity."[11] Allevanda and Cont (2010) focus on the reporting of large trades in particular, noting that "reporting of large size transactions also creates opportunities for predatory positioning or front running by other market participants, thus reducing the incentive for a participant to provide liquidity for large size trades."

To assess whether transaction reporting contributes to changes in corporate bond market liquidity, we exploit the fact that transparency was introduced for different bonds on two sets of clearly specified dates. The first focuses on the phased introduction of TRACE reporting for publicly-traded bonds during 2003 and 2004. The second considers the June 30, 2014 introduction of TRACE reporting for non-public 144A bonds. We conduct formal "difference-in-difference" tests for several measures of market quality around these two events to assess the hypothesis that TRACE transaction reporting contributes to diminished corporate bond market liquidity. We also compare changes in liquidity during the financial crisis for TRACE-eligible public bonds and non-TRACE 144A bonds.

II. Data and Sample Construction

In this section we describe the enhanced TRACE data and our dealer samples, and we report on aggregate corporate bond market statistics during the 2003-2014 sample period.

A. Data Description

We rely on an enhanced version of the TRACE data provided by FINRA. The data includes a dealer identification number, indication of whether the dealer is (as of 2016) affiliated with a bank, and unmasked trade sizes. The data includes trades disseminated to the public, as well as trades not disseminated. The full sample includes 80.88 million trades completed between January 2003 and December 2014. Table I reports the effects of data filters that we implement. First, we exclude all canceled and corrected trades. Second, we delete medium-term notes, as they trade very infrequently and are generally considered to be distinct from traditional corporate bonds. Third, we eliminate bonds that trade less than five times over the sample period and bonds that do not match to the Fixed Income Securities Database (FISD), which provides descriptive information on issue size, issue date, call features, maturity date, and bond rating. Fourth, we exclude all trades in any bond with a transaction size greater than the bond's issue

[11] Available at http://www.oliverwyman.com/content/dam/oliver-wyman/global/en/2015/mar/2015_Wholesale_Investment_Banking_Outlook.pdf.

size, bonds with FISD action type of "reopening" (issuance of additional debt on an existing issue), and bonds with missing dissemination dates. Finally, we exclude primary market transactions based on identifiers included in the enhanced version of TRACE data. After these filters, the sample is comprised of 61.91 million transactions in 40,416 distinct CUSIPs.

B. Dealer Samples

We conduct a number of analyses that focus on individual dealers, including measures such as the dealers' intraday commitment of capital to inventory. The sample includes a total of 2,466 dealers, most of whom trade only sporadically. For tractability, we focus the dealer-level analysis on the more active dealers, defined in two ways. First, we create a "Top 75%" sample. For each year, we select the largest dealers such that the dealers in combination have a seventy-five percent share of customer-dealer trading volume. The number of dealers that together comprise a 75% market share ranges from twelve in 2003 to fifteen in 2008. Individual dealers may enter or depart the Top 75% sample across years, and a total of thirty-two unique dealers enter the Top 75% sample at some point.[16]

We also obtain a number of results using a "Constant Dealer" sample that consists of the twenty-four dealers that (i) are active during all sample years, and (ii) were among the twenty most active dealers in at least one year. The "Top 75%" sample includes 29% of all trades, 61% of aggregate volume (including interdealer trading), and 76% of the customer-dealer volume. By comparison, the Constant Dealer sample includes 38% of all trades, 59% of aggregate volume, and 71% of customer-dealer volume.

The main advantage of studying the Constant Dealer sample is that any changes observed over time must reflect changes in the decisions of and outcomes to existing dealers, as opposed to changes in the composition of dealers. However, the Constant Dealer sample includes an increasing market share over time (from 51% in 2003 to 71% in 2014). The Top 75% sample in contrast focuses on dealers with a constant market share, and allows for changes in the composition of dealers over time. Many of the results we report in the paper are based on the Top 75% sample (with exception to the bank vs. non-bank and TRACE tests, which require a

[16] FINRA informed us that some firms have more than one dealer code assigned on TRACE. Multiple dealer codes can arise due to mergers, or when a firm has separate dealer codes for foreign desks. Of the 32 dealer identification codes contained in our "Top 75%" sample, five are not associated with unique firms. As a sensitivity test, we estimate key results using firm level rather than dealer code fixed effects in Table IA.VIII in the Internet Appendix, and find that all results are robust. We thank Alie Diagne of FINRA for identifying the multiple dealers codes associated with the same firm.

constant set of dealers). However, we report replicated tests using the Constant Dealer sample in the Internet Appendix that accompanies this article.

C. Sub-Period Definitions

To understand how liquidity and the willingness of dealers to commit capital to the corporate bond market have changed over time, we consider five sub-periods. TRACE transaction reporting, which has been shown to be associated with reduced transaction costs, was phased in for registered bonds by the end of 2005. We designate January 2003 to December 2005 as the "TRACE Phase-In" period. The "Pre-Crisis" period is January 2006 to June 2007, characterized by transaction reporting for most bonds, but prior to the onset of the financial crisis. We use this as our benchmark period in the portfolio time series regression analyses. We follow Friewald, Jankowitsch and Subrahmanyam (2012) and Dick-Nielsen, Feldhutter and Lando (2012) and define July 2007 to April 2009 as the "Crisis" period, and May 2009 to June 2012 as the "Post-Crisis" period. Finally, we designate July 2012 to May 2014 as the "Regulatory" period, for reasons discussed in Section I.[12]

D. Aggregate Market Statistics

Table II reports market statistics for the Aggregate Market sample, as described in Table I, on an annual basis from 2003 to 2014. Trading volume varies from $1.8 trillion to $2.3 trillion between 2003 and 2008. Trading activity has surged since then, to slightly over $3.8 trillion per year from 2010 to 2012, and to about $4.3 trillion per year in both 2013 and 2014. This rapid increase in trading activity was accompanied by rapid growth in corporate bonds outstanding, from $2.0 trillion (10,164 issues) in 2003 to over $5.8 trillion (13,574 issues) in 2014, due to robust new issuance activity. Trading activity relative to the amount of corporate bonds outstanding has been generally trending downward, from 114% in 2003 to a financial crisis low point of 62% in 2008, before recovering to over 80% in 2009 and 2010, and since declining again to 75% in 2013 and 2014. Table II also reports on the volume of trading disseminated through TRACE and volume not so disseminated.[13] The bonds whose trades were not reported through TRACE after February 2005 are private 144A bonds, many of which are high yield.

[12] We end our main analyses at May 2014, even though we have data through February 2015, because TRACE reporting was introduced for all non-registered (144A) bonds at the end of June 2014. We consider data through February 2015 in our analysis specifically focused on the effects of TRACE reporting.

[13] The exceptions are new issues and large trades in thinly traded bonds, which were disseminated to the public by January 2006.

III. Trade Execution Costs

We estimate customer trade execution costs by means of indicator variable regressions, as in Bessembinder, Maxwell, and Venkataraman (2006). We report results for all trades, and for trade size categories, including small (less than $100,000), medium (between $100,000 and $1 million), large (between $1 million and $5 million) and block (greater than $5 million) trades. We also report results for credit rating and issue size terciles, where the latter are assigned on an annual basis, based on the distribution of issue sizes in January. Finally, we report estimates for both TRACE-eligible and non-TRACE bonds.

The trading cost estimates are obtained by regressions of ΔPst, the percentage change in the trade price for a given bond from an observed trade at time 's' to the next observed trade at time 't', on $\Delta Q_{st} = Q_t - Q_s$, where Q_s and Q_t are indicator variables that equal one for customer buys and negative one for customer sells at times s and t. The resulting slope coefficient estimates the trade execution costs, and can be interpreted as the average amount by which the price that customers pay to purchase a security from a dealer exceeds the average amount received when customers sell the security to the dealer.[14] The analysis includes all customer-dealer trades. To improve the precision of the trading cost estimate, we include in the regression changes in control variables that can be anticipated to also affect bond prices. Each control variable is measured as the change from the beginning of the trading day that includes trade s to the end of the trading day that includes trade t.[15]

Table III reports the resulting trading cost estimates. Focusing first on the full sample, it is noteworthy that average (round trip) trade execution costs have decreased over time, from 0.61% in the TRACE Phase-In period to 0.42% in the Regulatory period. The overall decline in average trade execution costs was interrupted during the financial crisis, as average costs increased from 0.52% in the Pre-Crisis period to 0.72% in the Crisis period. However, trade execution costs were reduced to 0.62% in the Post-Crisis period and declined to the lowest level

[14] Estimation is based on the pooled sample using the Generalized Method of Moments. Each trade is weighted by the inverse of the square root of the elapsed time since the prior trade for the bond.

[15] The control variables include the percentage change in the Barclay's Capital U.S. 7-10 Year Treasury Bond Index, the percentage change in the S&P 500 Index, the percentage change in the Barclays Capital U.S. Corporate Bond Index, the percentage change in 7-10 Year Treasury Index in excess of the percentage change in the 3-month Treasury Index, and the percentage change in the Barclay's Capital U.S. High Yield Bond Index in excess of the percentage change in the Barclay's Capital U.S. Corporate Bond Index.

observed, 0.42% during the most recent Regulatory period. Figure 1 plots average customer trade execution costs over the sample period.

Table III also reports execution costs based on trade size and bond characteristics. Execution costs declined over time for each of the trade size categories. The largest decline is observed for retail-sized transactions of less than $100,000, from 0.84% during the TRACE Phase-In period to 0.61% during the Regulatory period, but trading costs also decline for medium-sized trades (from 0.33% to 0.27%), large-sized trades (from 0.25% to 0.19%), and block trades (from 0.20% to 0.17%). Consistent with the prior literature, we also find that trading costs decline with trade size. For example, during the Regulatory period, we estimate trading costs of 0.61% for small trades, 0.27% for medium trades, 0.19% for large trades, and 0.17% percent for block trades.

On balance, the results reported here fail to support the argument that corporate bond liquidity has deteriorated dramatically in recent years. Customer trade execution costs rose during the Crisis period, but moderated thereafter, and on balance are lowest during the most recent Regulatory period.[16] However, trade execution costs pertain to trades that are successfully completed. As such, they cannot account for difficulty in completing trades or for costs associated with trades that were desired but not completed. We next examine a number of alternative measures of market quality, focusing in particular on dealers' willingness to commit capital to market making in both normal and stressed periods, and on the execution of larger block-sized trades.

IV. Dealer Capital Commitment

We construct measures, described below, for both the Top 75% and Constant Dealer samples, using a portfolio-level methodology. Each bond is assigned to one of twelve portfolios, based on whether the bond is eligible for TRACE-transaction reporting, whether the bond is of small (less than $500 million), medium (between $500 million and $1 billion), or large issue size (greater than $1 billion), and whether the bond is rated investment grade or high yield. For each dealer-portfolio we construct two measures of intraday capital commitment on a daily basis, and

[16] These findings are consistent with two recent working papers that present coarser estimates of trading costs. Trebbi and Xiao (2016) examine U.S. data, Auilina and Suntheim (2016) examine U.K. data, each reporting that execution costs are not higher in recent years. In contrast, for a sample of bonds that are dropped from a corporate bond index, Dick-Nielsen and Rossi (2015) find that liquidity costs surrounding the index exclusion have increased after the financial crisis.

eight trade activity and block trading measures on a monthly basis. The Top 75% sample averages 13 dealers each period, so the analysis includes an average of 156 observations (twelve portfolios times thirteen dealers) per day or month. We describe our key variables below, and summarize the variable definitions in Appendix I.

A. Intraday Capital Commitment

The Federal Reserve Bank of New York publishes data on inventory held by primary bond dealers. However, until April 2013, the Federal Reserve reported dealer inventory based on an aggregate measure that included holdings in commercial paper and mortgage-backed securities along with corporate bonds.[17] Further, the Federal Reserve inventory data is aggregated across bonds and dealers, thereby precluding any cross-sectional analysis.

We therefore construct our own dealer-specific measures of corporate bond capital commitment. In particular, we construct a measure of intraday capital commitment as follows. We measure, as of the time of each completed trade, the absolute value of the difference between the dealer's accumulated (within the portfolio) principal buy volume and the dealer's accumulated principal sell volume, to that point in the day.[18] This measure is zero if the dealer's purchases on a principal basis are balanced equally to its sales, and increases to the extent that that the dealer's purchases vs. sales are unbalanced, in either direction. We then compute the average of this measure within each dealer-portfolio-day, weighting each observation by the time for which the capital is committed (i.e., until the next trade, or if no trade occurs then until the end of the day). Finally, we scale the measure by both market-wide volume and by the amount outstanding for bonds in the portfolio.

Results shown in Table IV reveal that intraday dealer capital commitment was highest during the Pre-Crisis period, 2.29% relative to aggregate volume and 0.0075% relative to the total amount outstanding. Dealers' average intraday capital commitment decreased during the Crisis period, to 1.74% of aggregate volume and to .0030% of the total amount outstanding.

[17] The data can be downloaded from the MarketAxess website, http://www.marketaxess.com/research/market-insights/dealer_net_positions.php. The disaggregated data made available after April 2013 indicates that mortgage backed securities account for over 50% of the dealers' holdings. Studies that rely on the Federal Reserve data include Trebbi and Xiao (2016) and Dick-Nielsen and Rossi (2015).

[18] The capital commitment measure focuses on inventory acquired since the beginning of the day. The alternative of focusing on levels of inventory is not viable in the absence of data on dealer's beginning-of-sample inventory. To the extent that dealers end each day with their desired level of inventory, the present measure can be viewed as deviations of inventory from the desired level. We also construct intraday capital measures by accumulating inventory at the bond rather than the portfolio level, and obtain similar results. Results are available upon request.

Notably, dealers' average capital commitment continued to decline after the financial crisis, to 0.97% of aggregate volume and 0.0024% of the total amount outstanding during the Regulatory period. Stated alternatively, dealers' average intraday capital commitment decreased by 58% relative to aggregate volume and by 68% relative to the amount outstanding from the Pre-Crisis period to the Regulatory period. Figure 2 plots intraday dealer capital over the sample period for investment grade and high yield bonds for the Top 75% dealer sample.

B. Trading Activity and Trade Size

We next consider dollar volume relative to the amount outstanding (i.e., turnover) and average trade size. The data reported on Table IV verifies that corporate bond trading activity relative to the amount outstanding has decreased over time, from approximately 0.55% in the Pre-Crisis period to a low during the Crisis period of 0.27%. Trading activity has recovered only slightly, to 0.35% of the amount outstanding, in both the Post-Crisis and Regulatory periods. Average trade size has decreased steadily from $3.2 million in the Pre-Crisis period to $1.8 million in the Regulatory period, which is consistent with the notion that it is more difficult to execute larger trades in recent years.

C. Principal vs. Agent and Interdealer Trading

TRACE reporting requirements require a dealer to designate a transaction as a principal trade if the dealer takes ownership of the bond, however briefly. By this standard, almost all dealer-intermediated trades are principal trades. We consider also a narrower definition that excludes trades if the transaction is exactly offset by three or fewer opposite-direction trades by the same dealer, within one minute. Since the median bond trades only once every few months (see, for example, Edwards et al., 2007), it seems reasonable to infer that virtually all offsetting transactions that occur within one minute were in fact prearranged, implying that dealer capital was not meaningfully at risk. We refer to principal trades that are offset within one minute as "effectively-agent" trades.[19] Correspondingly, we measure as principal trades those trades that are coded as principal, but are not effectively-agent trades. As Table IV shows, the percentage of principal trading by this definition was 89.4% in the Pre-Crisis period, fell to 87.4% during the Crisis period, before partially recovering to 88.2% during the Regulatory period.

[19] Other studies, include Zitzewitz (2011) and Ederington, Guan, and Yadav (2015), also use a one-minute window, and refer to these trades as "riskless principal" transactions.

We also measure the proportion of trades that involve two dealers, as opposed to a customer and a dealer. Table IV shows that interdealer trading has decreased as a proportion of overall trading, from 27.2% during the Pre-Crisis period, to 25.0% during the Crisis period, and further to 16.5% during the Regulatory period. If interdealer trading is viewed as a form of risk sharing, as suggested by Gao, Schultz and Song (2015), the decline in interdealer trading indicates that dealers recently have more difficulty in laying off inventory risk.

D. Dealer Capital Commitment to Accommodate Block Trades

We also examine the frequency of block trading activity and dealers' trading behavior surrounding block trades. We define a block trade as any single transaction of at least $10 million. Block volume accounts for 22% of overall trading activity in the full sample, but declined from 27% of overall activity during the Pre-Crisis period to 19% during the Crisis period, before recovering partially to 22% in the Regulatory period.

We construct two measures of dealer's willingness to commit capital to absorb block trades into inventory. Each is constructed on a given day for those dealers who engage in a block trade. The first is the percentage of the block quantity reversed by the end of the day. For each bond-dealer-day with a block trade of $10 million or larger, we identify the largest block. If the block is a dealer buy (sell), we cumulate the total quantity of dealer sells (buys) for the day. The percent offset is the ending cumulative quantity divided by the block size. This measure is averaged over the portfolio-dealer-month. The second is the dealer's intraday capital commitment on the block day. To measure this, we record the cumulative trading completed on a principal basis by the block dealer up through each trade, and weight each observation by the elapsed time until the next trade by that dealer in that bond, or until the end of the day. This measure is scaled by the block size then averaged over the portfolio-dealer-month.

Block volume relative to overall volume fell from 26.9% in the Pre-Crisis period to 19.2% in the Crisis period, before partially recovering to 21.6% in the Regulatory period. However, there was a decrease over time in dealers' capital committed to facilitate block trading. The average percentage of a block trade offset by the end of day rose from 39.8% during the Pre-Crisis period to 47.7% during the Crisis period, and to 59.9% during the Regulatory period. Conversely, dealers' average intraday capital commitment on block days decreased from 78.3% during the Pre-Crisis period to 64.2% during the Crisis period and to 49.1% during the Regulatory period. Stated alternatively, the evidence supports that block trading has become less

frequent, and that dealers are less willing to commit capital overnight and instead quickly lay off a larger portion of the block trade to other dealers or customers, in recent years.

V. Portfolio Time-Series Regressions

The univariate means reported on Table IV indicate reductions in the most recent Regulatory period relative to the Pre-Crisis period in dealers' intraday capital commitment, bond turnover, average trade size, principal trading, interdealer trading, the frequency of block trading, and dealers' willingness to absorb block trades into overnight inventory. We next report the results of pooled time series regressions that include control variables, and allow for formal statistical tests for equality of coefficients across time periods.

For this analysis we use data from January 2006 to May 2014. The analysis therefore excludes the TRACE Phase-In period and the sample period after June 2014 when all 144A corporate bonds became transparent, so that results are not affected by the initiation of trade reporting for any group of bonds.[20] The estimation includes portfolio-dealer fixed effects and standard errors that are clustered by portfolio-dealer, with the exception of trading costs, which are estimated using portfolio fixed effects and robust standard errors. We include in these regressions control variables that measure prior month stock and bond market outcomes, as well as bond attributes. The inclusion of recent market-wide returns is based on results from equity markets (e.g., Hameed, Kang, and Viswanathan, 2010; Comerton-Forde et al., 2010) that lower returns reduce dealers' propensity to supply liquidity, via its impact on their market making profits. The additional control variables are the natural logarithm of average issue size and the natural logarithm of average bond age (time since issue) for bonds in the portfolio, the return to the Barclays Capital U.S. Corporate Bond Index and the S&P 500 index, and the change in the CBOE stock market volatility index (VIX) and the 3-month LIBOR.[21]

We include in the regressions indicator variables for the Crisis (July 2007-April 2009), Post-Crisis (May 2009-June 2012), and Regulatory (July 2012-May 2014) sub-periods. The regression intercept therefore pertains to the Pre-Crisis (January 2006-June 2007) benchmark period. We report *p*-values for each indictor variable coefficient that pertain to the hypothesis

[20] The effects of TRACE initiation are examined directly in Section VIII.

[21] We also report results using levels instead of the changes in VIX and LIBOR in Table IA.VI of the Internet Appendix. The levels of the VIX and LIBOR essentially identify the financial crisis period, when each variable was highly elevated.

that the coefficient for the indicated period does not differ from that for the benchmark period. We also indicate by use of asterisks at the bottom of each table whether formal statistical tests reject the hypothesis that coefficients on the indicator variables are equal across sub-periods.

A. Capital Commitment and Transaction Costs

Table V reports regression results focused on dealers' intraday capital commitment, turnover, average trade size, principal trading, interdealer trading, and average trade execution costs, based on the Top 75% sample. Focusing first on the coefficients estimated for the control variables we observe that bonds of larger issue size are generally associated with higher intraday dealer capital (columns 1 and 2), greater volume (column 3), larger average trade size (column 4), and more interdealer volume (column 6). More seasoned bonds are associated with lower intraday capital (column 2), lower trading volume and trade size (column 3 and 4), and less principal trading (column 5). The estimated coefficients on the stock and bond market returns in columns 1 through 4 are positive, indicating larger intraday dealer capital, higher dollar volume and larger trade sizes when prior market returns are positive. The positive coefficient estimates on the change in VIX indicate more trading activity (column 3 and 4), greater capital commitment (column 2), and more principal trading (Column 5) when market wide volatility increases, results that are consistent with Anand and Venkataraman (2016), who show that market makers in equity markets earn higher risk-adjusted profits when volatility is high. Changes in LIBOR are negatively related to dealer capital commitment (column 2), trade size (column 4), and trading on a principal basis (column 5), all of which are consistent with higher opportunity costs of committing capital when LIBOR rates are higher.

Results for the intraday dealer capital commitment variable, reported in columns 1 and 2 of Table V are arguably the most important for assessing the hypothesis that dealers have curtailed their commitment to providing liquidity in the corporate bond market. Coefficient estimates on each of the three sub-period indicator variables are negative and significant, indicating reduced intraday dealer capital commitment in each period relative to the January 2006 to June 2007 benchmark period. The coefficient estimates for the Regulatory period are the most negative, indicating the greatest reduction in dealer capital commitment, for each measure. Focusing on capital commitment relative to trading volume (column 1), the coefficient estimate for the Regulatory period is -1.07%, which is large relative to both the estimate for the Crisis period (-0.48%) and to the full-sample mean of the dependent variable (1.45%). That is, the

estimates indicate that the decrease in intraday capital commitment relative to the benchmark period is more than twice as great during the regulatory period as during the financial crisis. Formal statistical tests confirm that capital commitment relative to aggregate volume is significantly lower in the Regulatory period as compared to the other periods.

Results reported in column 3 of Table V indicate that trading activity relative to quantity outstanding was lower in all three sub-periods as compared to the benchmark period, but that the lowest rate of turnover occurred during the Crisis period. Results reported in column 4 indicate that average trade sizes have declined relative to the benchmark period, and are smallest during the Regulatory period. Results reported in column 5 show the proportion of total volume completed on a principal basis is reduced in all three periods relative to the benchmark period, with the biggest reduction coming during the Crisis period.

Interdealer volume (column 6) was also reduced during all three sub-periods, with the largest decrease observed for the most recent Regulatory period, and with each period significantly lower than the preceding. These reductions are also economically large. The decrease in interdealer trading during the Regulatory period relative to the benchmark period is 11.6%, as compared to the full sample average quantity of interdealer trading of 22.1%. Reductions in interdealer trading are consistent with the reasoning that risk sharing across dealers has deteriorated in the post-benchmark years.

On balance, the results reported in columns 1 to 6 of Table V suggest a more difficult trading environment in recent periods as compared to the January 2006 to June 2007 benchmark period. Dealers' intraday capital commitment, trading volume relative to amount outstanding, average trade size, principal trading, and interdealer trading have all declined. Deterioration of these measures during the financial crisis is not surprising or unanticipated. More noteworthy, these measures did not broadly recover, and many worsened, during the Regulatory period.

Column 7 of Table V reports results obtained when the dependent variable is average customer trade execution costs on a portfolio-month basis.[22] The coefficient estimates on each of the time period indicator variables are positive, indicating higher average trade execution costs relative to the benchmark period. The coefficient estimate for the Regulatory period of 0.026%

[22] Here, trading costs are estimated for bonds in each of the twelve portfolios (TRACE vs. non-TRACE, investment grade vs. high yield, and issue size tercile) on a monthly basis. The regressions include portfolio fixed effects and robust standard errors. Regressions are estimated using weighted least squares based on the number of trades used to estimate costs each portfolio-month.

is positive and statistically significant, but also significantly smaller than coefficient estimates for the Crisis (0.242%) and Post-Crisis (0.156%) periods. That is, the results reported in column 7 of Table V indicate that trading costs recovered after the financial crisis, but unlike the Table III evidence, show that trading costs remain marginally higher in the Regulatory period as compared to the benchmark period. This result potentially reflects that the dealer portfolio-month regressions place equal weight on each dealer, while results in Table III effectively provide greater weight to more active dealers.

B. Block Trading

Institutional traders frequently seek to transact large blocks. In Table IV we report on market conditions relevant to such executions. Block trading volume as a percentage of trading activity decreased in each sub-period relative to the benchmark (column 1), with the largest reduction occurring during the Crisis period. High yield bonds on average have significantly lower block trading activity than investment grade bonds during the benchmark period. However, the reduction in block trading during the Crisis period is greater for investment grade than for high yield bonds (column 4). During the most recent Regulatory period, only investment grade bonds show a decrease in block trading as a percentage of overall trading.

Results reported in columns 2 and 3 of Table VI show that dealers committed less capital to facilitate block trading in the periods subsequent to the benchmark period. In particular, they reverse a larger proportion of the block volume before the end of the day (column 2) and they hold a smaller quantity of intraday capital during the block day (column 3). Notably, the decrease in dealer capital commitment to block trading is greatest during the most recent Regulatory period, and the difference as compared to the Crisis period is statistically significant for each measure. That is, dealers' willingness to commit capital to facilitate block trades not only worsened during the Crisis period, but was further reduced during the Regulatory period, as opposed to recovering to Pre-Crisis period levels. These reductions are large in economic terms. For example, the increase in the percentage of block volume offset by the end of the day during the Regulatory period (column 2) of 14.95% is substantial relative to the full sample average, which is 47.71%.

The reduction in dealers' willingness to commit capital to facilitate block trades during the financial crisis was greater for investment grade than for high yield bonds, when focusing either on the percent of block volume reversed on the same day (column 5) or intraday capital

commitment on the block day (column 6). This relationship is reversed during the most recent Regulatory period, as the reduction in dealers' willingness to commit capital to facilitate block trading is greater for high yield as compared to investment grade bonds.

Together, these results indicate that dealers are less likely to hold bond positions acquired in block trades in inventory in the years subsequent to the January 2006 to June 2007 benchmark period, as average inventories on block-trade days are smaller and a larger percentage of the block is offset by opposite-direction trading on the same day. The results indicate that dealer's reluctance to hold block trade positions in inventory has significantly worsened during the Regulatory period as compared to the Crisis period.

C. Bank vs. Non-Bank Dealers

We next seek to shed some light on potential causes of shifts in dealer capital commitment and market outcomes in recent years. To do so, we repeat the analyses reported in Tables V and VI, while including indicator variables to allow the regression intercepts and time period coefficients to vary for dealers that are affiliated with banks vs. non-bank dealers. As noted, the data provided to us includes masked dealer identifications. However, FINRA identified for us the dealers that are affiliated with banks vs. those that are not so affiliated, as of 2016. A recent industry report identifies Cantor Fitzgerald & Co., Daiwa Capital Markets Americas, Jefferies & Company, and Nomura Securities International as examples of non-bank dealers active in the U.S. corporate bond market.[23] We rely for this analysis on the Constant Dealer sample, so that the results for the bank-affiliated and non-bank samples each reflect outcomes and choices of common sets of dealers, and do not reflect the entry of new participants or shifts of individual dealers across the bank-affiliated and non-bank samples.[24] Within the Constant Dealer sample, six dealers are non-bank, while eighteen are bank-affiliated.

Results are reported on Table VII. While we report results for each sub-period, this discussion focuses mainly on the most recent Regulatory period. Considering first measures of dealers' intraday capital commitment relative to trading volume (column 1), it is noteworthy that the reduction in capital commitment in the Regulatory period as compared to the benchmark

[23] The report is available at http://www.oliverwyman.com/content/dam/oliver-wyman/global/en/files/archive/2012/Oliver_Wyman_The_Volcker_Rule_Restrictions_on_Proprietary_Trading.pdf.
[24] In particular, Goldman Sachs and Morgan Stanley became bank holding companies during 2008. See http://www.nytimes.com/2008/09/22/business/22bank.html.

period is entirely attributable to bank-affiliated dealers (estimated coefficient, -0.57%). In contrast, non-bank dealers slightly increased their capital commitment during the Regulatory period (estimated coefficient, 0.22%) as compared to the benchmark period. Similar results are obtained when intraday capital commitment is measured relative to quantities outstanding (column 2). More broadly, it can be observed on Table VII that each of (i) the reduction in trading volume relative to amount outstanding, (ii) the reduction in average trade size, (iii) and the reduction in principal trading for the Regulatory period as compared to the benchmark period can all be entirely attributed to reductions on the part of bank-affiliated dealers. For each of these variables, the coefficient estimated for the Regulatory period is negative and statistically significant for bank-affiliated dealers, but positive (indicating greater amounts of each) and statistically significant for dealers not affiliated with banks.

Each of the results described in the preceding paragraph is consistent with the reasoning that bank-affiliated dealers have reduced the extent to which they commit capital to facilitate trading during the Regulatory period, while non-bank dealers have increased the extent to which they commit capital to facilitate trading. While the lack of clearly identifiable effective dates for regulations precludes definitive tests, the results are consist with the reasoning that post-crisis regulations that focus on banks, such as the Volcker Rule and the Basel Accords, have had the unintended consequence of decreasing bank-affiliated dealers willingness or ability to commit capital to facilitate trading in corporate bonds.

The coefficient estimate on interdealer volume as a percentage of total volume (column 6) during the Regulatory period is more negative for non-bank dealers (-53.9) than for bank-affiliated dealers (-14.2). This result may indicate that non-bank dealers are no longer able to effectively share inventory risk with bank-affiliated dealers during the Regulatory period.

Results with regard to block trades by bank vs. non-bank dealers are somewhat mixed. On one hand, non-bank dealers increased, while bank affiliated dealers decreased (column 7) block trading activity as a percentage of total trading during the Regulatory period. On the other hand, non-bank dealers increased during the regulatory period the percentage of block volume that they offset by the end of the day (column 8) by a greater amount than bank-affiliated dealers. This result may reflect non-bank dealers decreased ability to access the interdealer market, as noted above.

VI. Stressful Day Analysis

The results reported in the preceding sections rely on the full sample of trading days. However, it is possible that the most notable changes in bond market liquidity emerge when the market is stressed. To shed light on this possibility, we examine dealer trading behavior on days when customer trading activity is unusually high.

In particular, we examine bond-days when customer-dealer trading volume exceeds the average customer-dealer volume for the same bond over the prior six months by two standard deviations. On each of those days, we focus on the single most active dealer, a decision which reflects our understanding that an institutional customer often delegates the execution of a large order to a single dealer. The intent is to assess dealer behavior at times when customers demand unusually large quantities of liquidity, including occasions where a large desired transaction leads to a serious of moderately large trades rather than a single block transaction. We restrict the analysis to bond-days when the most active dealer's activity is economically substantial, by also requiring that active dealer volume with customers on the date exceeds $1 million. (Results, available on request, are similar when the threshold volume is $3 million or $5 million.

These criteria generate a sample of 429,334 stressful bond-days. For each of these, we divide the most active dealer's total trading into three categories. The first, is "effectively agent" volume, i.e. volume reported to FINRA as 'Agency' as well as volume that is exactly offset in trades with either customers or other dealers within one minute. The second, which we refer to as "reversed principal", is volume that is completed on a principal basis but is offset by opposite-direction volume by the end of the trading day. The third, which we refer to as "overnight capital" is volume that is completed on a principal basis that is not offset by the end of the trading day, i.e., that is absorbed as a change in overnight inventory.

A. Stressful Day Portfolio Time Series Regressions

Summary statistics for these measures are displayed in Table IV. On stressful days during the Pre-Crisis period, 10.6% of activity was effectively agent, 33.0% of volume was reversed by the end of the day, and the dealer committed overnight capital to 56.4% of volume. During the Crisis period, dealers' willingness to commit capital on stressful days decreased, as 13.7% of activity was effectively agent, 40.7% of volume was reversed by the end of the day, and the dealer committed overnight capital to 45.6% of volume. After stabilizing during the Post-Crisis period, dealers' capital commitment on stressful days continued to decline during the Regulatory

period, as the proportion of activity that was effectively agent rose to 17.1% and the proportion reversed by the end of the day rose to 40.9%, while the proportion where the dealer committed overnight capital declined to 42.0% of volume.

In Table VIII we report results of multivariate regressions that employ the same time period indicators and control variables as used for results on Tables VI and VII. All variables are computed at the portfolio-month level and all regressions are estimated using weighted least squares, where weights are the number of stressful event days in the portfolio-month. Regressions in columns 1-3 include portfolio fixed effects and all regressions report robust standard errors. Results in columns 1-3 pertain to all bond, while those in columns 4-6 incorporate indicator variables for investment grade and high yield bonds.

Focusing first on column 1 of Table VIII, it can be observed that the percentage of stressful day trading that is effectively agent increased, after allowing for variation in control variables, during the Crisis period as compared to the Pre-Crisis benchmark period, by 0.79%. The proportion of stressful day activity that is effectively agent during the most recent Regulatory period is greater than during the benchmark period (by 2.42%), and is also significantly greater than during the Crisis period. The proportion of stressful day activity completed on a principal basis but reversed before the end of the day (column 2) increased, after allowing for changes in control variables, in each sub-period as compared to the benchmark period. The increases are 9.90% during the Crisis period, 7.26% during the Post-Crisis period, and 8.93% during the Regulatory period, as compared to a full sample average of 39.0%

Most notably, the proportion of stressful day activity that is absorbed into the dealers' overnight inventory (column 3) decreased during each sub-period as compared to the benchmark period, after allowing for changes in control variables. The changes are -10.78% during the Crisis period, -7.02% during the Post-Crisis period, and -11.35% during the Regulatory period, each of which is substantial compared to the full-sample average of 49.2%. The coefficient estimate for the Regulatory period in columns 2 and 3 of Table VIII do not differ significantly from estimates during the Crisis period. That is, dealers' willingness to commit capital on stressful days in the Regulatory period remains at Crisis period levels.

B. Stressful Days: High Yield vs. Investment Grade Bonds

Columns 4-6 of Table VII report results of the regression analysis for stressful days and include indicator variables to allow coefficients to differ across investment grade and high yield

bonds. The coefficient estimate on the high yield indicator (which estimates the difference in the benchmark period intercept for high yield bonds as compared to investment grade) is positive in columns 4 and 5 of Table VIII, and is negative in column 6. That is, during the benchmark period dealers were more likely to trade on an effectively agent basis and less likely to carry inventory overnight on stressful days for high yield bonds as compared to investment grade bonds. These findings are consistent with Goldstein and Hotchkiss' (2011) evidence that dealers are less likely to hold an overnight inventory position in less-frequently traded bonds.

However, while dealers were less willing to carry stressful day inventory overnight during the Crisis period for both categories, the differential across investment grade and high yield bonds was reduced during the financial crisis. The change in the percentage of stressful day volume carried overnight during the Crisis period was -11.38% for investment grade bonds as compared to -7.36% for high yield bonds.[25]

During the most recent Regulatory period, the reduction in dealer's capital commitment on stressful days is greater for high yield bonds. The shift (relative to the benchmark period) in the percentage of volume handled on an effectively agent basis (column 4 of Table VIII) is 4.99% for high yield bonds as compared to 3.13% for investment grade bonds. More notably, the change (relative to the benchmark period) in the percentage of volume taken into overnight inventory (column 6 of Table VIII) is -16.34% for high yield bonds as compared to -9.93% for investment grade bonds. Each differential across investment grade and high yield bonds is statistically significant. That is, the results indicate that while dealers are less willing to bear overnight inventory risk on stressful days during the most recent Regulatory period overall, the decline is most notable for high yield bonds. Figure 3 plots the proportion of stressful day dealer capital that is carried overnight, for both investment grade and high yield portfolios.

C. Stressful Days: Bank-Affiliated vs. Non-Bank Dealers

We next report results of specifications similar to those reported in columns 4-6 of Table VIII, except that we now include indicator variables that allow coefficient estimates to differ for bank-affiliated vs. non-bank dealers. We report on Panel A of Table IX sample means by sub-period for the percent of stressful day activity that is effectively agent, that is principal but

[25] These results may reflect a selection effect. In an unreported analysis, we find that trading activity of high yield relative to investment grade bonds experienced a sharp decline during the financial crisis. Crisis period results for high yield bonds may therefore represent the relatively few high yield transactions that were completed, potentially involving well-connected buy-side institutions and their network of dealers.

reversed by end of day, and that is principal and carried overnight. Panel B of Table IX reports results from the corresponding multivariate regressions.

Focusing first on means reported on Panel A of Table IX, it can be observed that during the Pre-Crisis period, non-bank dealers were much more likely than bank-affiliated dealers (57.84% vs. 10.34%) to complete stressful day trades on an effectively agent basis, and were much less likely (10.66% vs. 53.47%) to commit overnight capital to accommodate stressful day trades. During the Crisis period, bank-affiliated dealers increased the frequency with which they handled stressful day volume on an effectively agent basis, to 15.14%, from 10.34% during the Pre-Crisis period, and decreased the percentage of stressful day volume that they absorbed into overnight inventory, to 43.01% from 53.47% during the Pre-Crisis period. In contrast, non-bank dealers *decreased* the frequency with which they handled stressful day volume on an effectively agent basis, to 41.84%, from 57.84% during the Pre-Crisis period, and *increased* the percentage of stressful day volume that they absorbed into overnight inventory to 29.16% from 10.66% during the benchmark period.

The shift by which non-bank dealers increased their capital commitment on stressful days while bank-affiliated dealers decreased their capital commitment (albeit from higher initial levels) was not reversed in the years after the Crisis period. During the most recent Regulatory period non-bank dealers completed 21.72% of stressful day volume on an effectively agent basis (compared to 41.84% during the Crisis period), and committed overnight capital to 31.65% of stressful day volume, compared to 29.16% during the Crisis period. By comparison, bank-affiliated dealers during the most recent Regulatory period completed 17.28% of stressful day volume on an effectively agent basis (compared to 15.14% during the Crisis period), and committed overnight capital to 42.54% of stressful day volume, compared to 43.01% during the Crisis period. To summarize, the means reported on Panel A of Table IX indicate that while non-bank dealers were much less likely than bank-affiliated dealers to commit capital to accommodate stressful day trades during the Pre-Crisis period, since then non-bank dealers have increased their willingness to commit capital on stressful days, while bank-affiliated dealers have decreased their capital commitment.

Panel B of Table IX reports results of multivariate regressions pertaining to capital commitment on stressful days for bank-affiliated and non-bank dealers. In general, the results confirm that the pattern of differences in simple means as described in the preceding paragraphs

is also observed after accommodating changes in control variables, and that differences across periods are statistically significant. In particular, the coefficient on the bank indicator, which estimates the difference in the regression intercept for bank-affiliated vs. non-bank dealers in the benchmark period, is economically large (-51.12% when explaining the proportion of volume conducted on an effectively agent basis and 37.78% when explaining the proportion of volume conducted on an overnight principal basis) and statistically significant. Coefficients on the bank-affiliated vs. non-bank indicators confirm that changes are always in the opposite direction for bank affiliated (more effectively agent volume and less overnight principal volume) vs. non-bank (less effectively agent volume and more overnight principal volume) in the Regulatory period as compared to the benchmark period. Statistical tests confirm that the changes in the capital commitment measures in the Regulatory period (relative to the benchmark period) are statistically different for banks and non-banks.

Collectively, the evidence regarding stressful days indicates that the role of corporate bond market dealers, and in particular those dealers affiliated with banks, has changed in recent years, as dealers are less inclined to commit capital, particularly on an overnight basis, and more inclined to prearrange customer trades in a search-and-match agency role. These results are consistent with the reasoning that post-crisis regulatory reforms focusing on banks, potentially including the Volcker Rule and the Basel III accords, have diminished bank-affiliated dealers ability and/or willingness to commit capital to facilitate liquidity in the corporate bond markets. The overall reduction in capital commitment by bank-affiliated dealers has been partially, but not fully, offset by increased willingness of non-bank dealers to commit capital.

VII. Robustness Tests

In this section we discuss the results of alternate specifications of the portfolio time series regression tests reported in Sections V, VI, and VIII. Tables IA.I, IA.III, and IA.V of the Internet Appendix replicate the portfolio time series regressions for dealer capital commitment measures (Table V), block activity (Table VI), and stressful day activity (Table VIII), but rely on the Constant Dealer sample rather than the Top 75% sample. The results are qualitatively similar to those using the Top 75% sample, indicating conclusions are not attributable to changes in the composition of dealers in the Top 75% sample. Tables IA.II, IA.IV, and IA.VI of the Internet Appendix replicate Tables V, VI, and VIII, but using levels rather than changes in the VIX and

Libor control variables. Again the results are qualitatively similar, indicating that conclusions are not sensitive to the inclusion of risk levels. This robustness indicates that the changes in capital commitment we document are not attributable to shifts in market risk.

Electronic quotations systems have slowly established a presence in the corporate bond markets. The available data does not allow us to distinguish trades completed after electronic requests for quotations from traditionally-negotiated trades. Hendershott and Madhavan (2015, Table I) show that electronic requests for quotations are rare for high yield bonds and for bonds with small issue size. In Table IA.VII of the Internet Appendix we replicate the analyses reported in Tables V, VI, and VIII using only portfolios of high yield bonds and portfolios in the smallest issue size tercile. Our results remain qualitatively similar. In addition, conversations with traders indicate that electronic quotations are rarely used for block trades, or on "stressful" days. Therefore, while some results for the full sample are potentially affected by a shift toward electronic requests for quotations, the high yield sample, block trading, and the analysis of stressful days should be largely free of any resulting effects.[26]

VIII. The Role of TRACE

As noted in Section I.B., some market observers have expressed the view that the public reporting of transaction prices through the TRACE system reduces dealers' willingness to commit capital to bond trading, and theoretical analyses of transparency do not rule out this possibility. In this section, we investigate the extent to which post-trade transparency impacts dealers' willingness to commit capital. We first consider the initiation of TRACE reporting, and then consider differential effects during the financial crisis for TRACE-eligible and non-TRACE bonds.

A. The Introduction of TRACE Reporting

We report "difference-in-difference" estimates of the effect of TRACE reporting, using regressions analogous to those reported in Tables V to IX. The difference-in-difference tests are based on the Constant Dealer sample described in Table I, so that results cannot reflect changes in the mix of dealers providing liquidity to the market. We consider two transparency events. The first focuses on public bonds phased into TRACE reporting in March 2003, April

[26] In addition, some trades occur through "all-to-all" trading, by which buy-side firms trade directly, without traditional dealer intermediation. FINRA representatives indicate that most buy-side firms report such transactions through an affiliated FINRA-registered dealer.

2003, and October 2004. The second focuses on non-public 144A bonds, for which transaction reporting was introduced on June 30, 2014. The first sample includes bonds with participation by retail as well as institutional investors, while in contrast only qualified institutional investors participate in the 144A market.

This analysis include trades completed within the six months before and after each phase of the TRACE initiation, while excluding trades during the initiation month itself. We include in the regression analyses three indicator variables. The first, TREATED, equals one for those bonds in which transaction reporting is initiated, and zero for control bonds that do not experience a change in transparency, but are in the same portfolio as treated bonds in terms of investment grade vs. high yield status and issue size tercile. The second, POST, equals one for months after the relevant TRACE event and equals zero for the months before the TRACE event. The third is the product of the TREATED and POST indicators, which estimates the differential change in the dependent variable from the period before to after TRACE reporting is initiated, for treated bonds relative to control bonds.

Results obtained for the 2003 and 2004 initiation of TRACE reporting for publicly-traded bonds are reported in Panel A of Table X, while analogous results for the 2014 initiation of TRACE reporting for 144A bonds are reported on Panel B of Table X. Focusing first on the 2003 and 2004 events, the estimated coefficient on TREATED is positive and significant, indicating higher outcomes for treated firms prior to transaction reporting initiation, for dealers' capital commitment relative to volume and amount outstanding (columns 1 and 2), volume relative to amount outstanding (column 3), average trade size (column 4), and percentage of volume that is interdealer (column 6). The estimated coefficient on the POST indicator is positive and significant for interdealer volume, indicating more interdealer trading after transparency was initiated.

Turning to the key coefficient estimate on the product of POST and TREATED, we observe statistically insignificant coefficients for average trade size, principal volume, and interdealer volume, indicating a lack of TRACE-induced change (columns 4-6). The interaction term is positive and significant in columns 2 and 3. In column 2, intraday capital relative to amount outstanding, the coefficient estimate of 0.0009% is substantial relative to the full sample mean of 0.0040%. In column 3, dollar volume relative to amount outstanding, the estimated coefficient of 0.09% is also economically substantial relative to the full sample average of

0.65%. In contrast, the coefficient estimate on the interaction term for intraday capital relative to aggregate volume is negative and significant (column 1). On balance, the difference-in-difference analysis applied to the 2003 and 2004 TRACE initiation events for publicly traded bonds reveals substantial increases in trading activity and mixed evidence on intraday capital commitment, but provides little evidence of degraded market quality.

In Panel B of Table X we report analogous results obtained using data from the initiation of TRACE reporting for 144A bonds during 2014. Here we observe significant coefficients on the TREATED variable in all of columns 1 to 6, indicating that 144A bonds differed from publicly traded control bonds prior to the initiation of transaction reporting. In particular, 144A bonds had lower volume relative to amount outstanding, larger average trade sizes, higher intraday capital commitment relative to amount outstanding, lower capital commitment relative to volume, less trading on a principal basis, and a lower proportion of interdealer trades. We also observe significant coefficients on the Post variable in several columns of Table X, Panel B, indicating different outcomes in the second half of 2014 as compared to the first half for the full sample. In particular, dollar volume relative to amount outstanding, average trade size, intraday capital commitment relative to amount outstanding, and interdealer trading all decreased significantly for the full sample in the second half of 2014.

Most importantly, the estimated coefficient on the product of Post and TREATED is insignificant in all columns of Table X, Panel B, with the lone exception of the positive coefficient in column (3) for dollar volume relative to amount outstanding. That is, the difference-in-difference estimates from the 2014 sample indicate no effects of TRACE transaction reporting other than a slight increase in trading activity.

B. The Financial Crisis and TRACE Reporting

In the Sections IV-IX we document substantial declines in various measures of dealer capital commitment during the Crisis period as compared to the Pre-Crisis benchmark period, and find that these measures in general did not fully recover thereafter. Our difference-in-difference results focused on the initiation of transaction reporting for public bonds in 2003-2004 and for 144A bonds in 2014 provide no evidence to support the claim that the degraded liquidity in corporate bond markets in recent years is attributable to public transaction reporting through TRACE. We shed additional light on the assertion that transaction reporting adversely affects

liquidity by assessing whether the declines in liquidity during the financial crisis were more pronounced for transparent as compared to non-transparent bonds.

In Table XI we report results of multivariate regressions using the Constant Dealer sample that parallel the analyses reported in Tables V and VI, except that we here include indicator variables to allow the regression intercept and time-period coefficients to differ for public bonds, which were transparent, i.e. subject to TRACE transaction reporting, and private 144A bonds, which were opaque, i.e. not subject to transaction reporting, during the 2006 to May 2014 period examined.

The estimated coefficients on the opaque indicator variable show that 144A bonds had greater intraday capital commitment and larger average trade sizes, but lower turnover and less interdealer trading during the benchmark period. The positive coefficient on trade size reflects the absence of retail traders in the market for 144A bonds.

Focusing first on measures of dealers' intraday capital commitment relative to trading volume (column 1) and amount outstanding (column 2), we observe on Table XI negative coefficients for all sub-periods, indicating that dealer capital commitment as compared to the benchmark period declined during the Crisis, Post-Crisis, and Regulatory period for both transparent and opaque bonds. Notably, however, the reduction in dealer capital commitment is uniformly greater for opaque bonds as compared to transparent bonds. During the financial crisis, in particular, the reduction in intraday capital commitment relative to amount outstanding was three times greater (-0.003 vs. -0.001) for opaque as compared to transparent bonds, and the differential is statistically significant.

Trading volume relative to amount outstanding (column 3) also declined for both transparent and opaque bonds in all sub-periods, with significantly larger declines observed for opaque bonds relative to transparent bonds. In contrast, while principal trading and interdealer trading as a percentage of total trading also declined in each post-benchmark period, the declines do not differ significantly across transparent and opaque bonds.

On balance, the results in Table XI provide no support for the reasoning that decreases in liquidity and dealer capital commitment relative to the pre-crisis benchmark period are attributable to TRACE transaction reporting. In contrast, the reductions in dealer capital commitment and bond turnover after the benchmark period were greater for opaque bonds. In particular, the evidence does not support the claim that transparency differentially reduced

dealers' incentives to provide bond market liquidity during the period of heightened uncertainty that accompanied the financial crisis.

IX. Conclusion

Concerns that liquidity in corporate bond markets is deteriorating are widespread. We conduct a comprehensive analysis of corporate bond trading over the 2003 to 2014 period, and obtain a number of results relevant in evaluating these concerns. We document that, despite a temporary increase during the financial crisis, customer trade execution costs have on average decreased from 2003 to 2014. Thus the evidence for customer trade execution costs, obtained over a relatively long time series, provide no evidence of systematic degradation of corporate bond liquidity in recent years.

However, execution costs for completed trades do not capture the difficulty that customers may have encountered in locating counterparties, or the costs associated with trades that were desired but not consummated. We conduct a broader analysis that may indicate some possible concerns regarding liquidity in the corporate bond markets. Measures of dealers' intraday capital commitment, volume relative to amounts outstanding, trade size, completion of trades on a principal basis, interdealer trading, block volume, and the proportion of block volume taken into overnight inventory were all degraded during the financial crisis as compared to a pre-crisis benchmark period. Perhaps more surprisingly, these measures in general did not revert to pre-crisis levels in the years after the financial crisis abated, and in many cases worsened during the most recent Regulatory period. Our analysis of dealers' market-making behavior on stressful days characterized by abnormal liquidity demand from customers also reveals that dealers are more likely to trade on an agency basis and less willing to commit overnight capital to accommodate stressful day inventory, and in particular, for high yield bonds, in recent years.

We assess two explanations that have been advanced for potential decreases in dealer commitment to corporate bond liquidity. The first focuses on the public reporting of trade prices through TRACE. However, we conduct difference-in-difference analyses focusing on both the 2003-2004 initiation of transaction reporting for public bonds and the 2014 initiation of transaction reporting for 144A bonds, and find no evidence that TRACE reporting is associated with degraded market quality. In addition, we assess whether illiquidity observed in the corporate bond market during the financial crisis was worse for transparent bonds as compared to

opaque bonds, and find no support for this reasoning. Our analysis therefore does not support that TRACE transaction reporting contributes to illiquidity in the corporate bond market.

However, we do find evidence consistent with the reasoning that post-crisis regulations focused on banking activity have contributed. In particular, we assess changes in market quality for dealers that are affiliated with banks as compared to dealers not so affiliated. The results indicate that the reduction in recent years in intraday capital commitment, volume, trade size, principal provision, block trading, and capital commitment on stressful days can be fully attributed to bank-affiliated dealers, while non-bank dealers have partially offset the effects.

The results collectively imply that the role of bond market dealers, and in particular those affiliated with banks, has changed in recent years. Bank-affiliated dealers in particular are less likely to commit capital intraday, less likely to carry capital positions overnight, and are more likely to facilitate trades on an agency basis in recent years. The fact that these reductions are concentrated in bank-affiliated dealers is supportive of the possibility that they are attributable to unintended consequences of bank-specific regulations enacted in the wake of the financial crisis, including the Volcker Rule and the Basel III accords. The results show that the role of bank-affiliated corporate bond dealers is changing, most likely in response to regulation, and that of non-bank dealers is growing.

References

Anand, A., Irvine, P., Puckett, A., Venkataraman, K., 2013. Institutional Trading and Stock Resiliency: Evidence from the 2007-09 financial crisis. *Journal of Financial Economics*, v108, 773-797.

Anand, A, Venkataraman, K, 2016, Market conditions, fragility and the economics of market making, *Journal of Financial Economics*, forthcoming.

Asquith, P., A. Au, T. Covert, 2013, The market for borrowing corporate bonds, *Journal of Financial Economics*, v107i1, 155-182.

Asriyan, V., W. Fuchs, B. Green, 2015, Information spillovers in asset markets with correlated values, working paper.

Bao, J., M. O'Hara, and X. Zhou, 2016, The Volcker Rule and Market-Making in Times of Stress, working paper, Board of Governors of the Federal Reserve.

Bao, J and J. Pan, 2013, Bond illiquidity and excess volatility, *Review of Financial Studies*, v26i12, 3068-3103.

Bessembinder, H. and W. Maxwell, 2008, Markets: Transparency and the corporate bond market. *The Journal of Economic Perspectives, 22*(2), 217-234.

Bessembinder, H., W. Maxwell, and K. Venkataraman, 2006, Market transparency, liquidity externalities, and institutional trading costs in corporate bonds. *Journal of Financial Economics*, *82*(2), 251.

Cespa, G. and T. Foucault, 2014, Illiquidity contagion and liquidity crashes, *Review of Financial Studies*, v27i6, 1615-1660.

Chen, Long, David Lesmond and Jason Wei, 2007, Corporate yield spreads and bond liquidity, *Journal of Finance*, v52i1, 119-149.

Comerton-Forde, C., Hendershott, T., Jones, C., Moulton, P., Seasholes, A.S., 2010, Time variation in liquidity: the role of market-maker inventories and revenues. *Journal of Finance* 65, 295–331.

Das, S., M. Kalimipalli, and S. Nayak, 2014, Did CDS trading improve the market for corporate bonds? *Journal of Financial Economics*, v111i2, 495-525.

Dick-Nielsen, J., P. Feldhutter, D., Lando, 2012, Corporate bond liquidity before and after the onset of the subprime crisis, *Journal of Financial Economics*, v103i3, 471-492.

Dick-Nielsen, J., Rossi, M., 2015, Dealer inventory and the cost of immediacy, working paper, Copenhagen Business School and Texas A&M University.

Di Maggio, M., A. Kermani, Z.Song, 2015, The value of trading relationships in turbulent times, working paper.

Duffie, D, 2012, Market making under the proposed Volcker Rule, *Rock Center for Corporate Governance at Stanford University Working Paper* No. 106

Duffie, D., P. Dworczak, and H. Zhu, 2015, Benchmarks in search markets, *Stanford University Graduate School of Business Research Paper,* No. 14-47.

Ederington, L., W. Guan, W., and P.K. Yadav, 2015, Dealer spreads in the corporate bond market: Agent versus market-making roles, working paper, University of Oklahoma.

Edwards, A, L. Harris, and M. Piwowar, 2007, Corporate bond market transaction costs and transparency, *Journal of Finance*, v63i3, 1421-1451

Feldhutter, P, 2012, The same bond at different prices: Identifying search frictions and selling pressures, *Review of Financial Studies*, v25i4, 1155-1206.

Friewald, Nils, Rainer Jankowitsch and Marti G. Subrahmanyam, 2012, Illiquidity or credit deterioration: A study of liquidity in the US corporate bond market during financial crises, *Journal of Financial Economics*, v105i1, 18-36.

Friewald, Nils and Florian Nagler, 2015, Dealer inventory and the cross-section of corporate bond returns, working paper.

Harris, Larry, 2015, Transaction costs, trade throughs, and riskless principal trading in corporate bond markets, working paper.

Hendershott, T. and A. Madhavan, 2015, Click or call? Auction versus search in the over-the-counter market, *Journal of Finance*, v70i1, 419-447.

Gao, Pengjie, Paul Schultz and Zhaogang Song, 2015, Liquidity in a market for unique assets: specified pool and TBA trading in the mortgage backed securities market, working paper.

Goldstein, Michael and Edith Hotchkiss, 2011, Know when to hold them, know when to fold them: Dealer behavior in highly illiquid risky assets, working paper.

Green, R., 2007, Presidential address: Issuers, underwriters syndicates, and aftermarket transparency, *Journal of Finance*, v62i4, 1529-1550.

Hameed, A., Kang, W., Viswanathan, S., 2010, Stock market declines and liquidity. *Journal of Finance*, v65, 257–294.

Lin, Hai, Junbo Wang and Chunchi Wu, 2011, Liquidity risk and expected corporate bond returns, *Journal of Financial Economics*, v99i3, 628-650.

Loon, YC and ZDK Zhong, 2014, The impact of central clearing on counterparty risk, liquidity, and trading: Evidence from the credit default swap market, *Journal of Financial Economics*, v112i1, 91-115.

Mahanti, Sriketan, Amrut Nashikkar, Marti Subrahmanyam, George Chacko and Gaurav Mallik, 2008, Latent liquidity: A new measure of liquidity, with an application to corporate bonds, *Journal of Financial Economics,* v88i2, 272-298.

O'Hara, Maureen, Yihui Wang, and Xing Zhou, 2015, Best execution of corporate bonds, working paper.

Schultz, Paul, 2001, Corporate bond trading costs: A peek behind the curtain, *Journal of Finance*, i56v2, 677-698.

Vayanos, D., J. Wang, 2012, Liquidity and asset returns under asymmetric information and imperfect competition, *Review of Financial Studies*, v25i5, 1339-1365.

Zitzewitz, E., 2011, Paired bond trades, working paper, Dartmouth college.

Table I
Sample Construction

The table below reports a description of the data. Corporate bond trade data is from TRACE (Trade Reporting and Compliance Engine) and bond descriptive data is from the Mergent Fixed Income Securities Database (FISD). The sample period is January 2003 to December 2014. The Aggregate Market sample that includes all dealers and trades includes 40,416 unique cusips and 61.9 million trades. We construct two subsamples of active dealers. The Top 75% sample includes the dealers that capture 75% of customer trading volume each year. To construct the Constant Dealer sample, we select dealers ranked in the top 20 by customer volume in any sample year then retain dealers that trade each year in the sample period.

Aggregate Market Sample	# Cusips	# Trades
All cusips with TRACE trade data (canceled/corrected trades are excluded)	92,806	80,878,964
Exclude medium term notes	65,788	69,798,562
Exclude bonds having less than 5 trades over the sample period	54,922	69,774,943
Exclude cusips that do not match to FISD	41,357	65,642,051
Exclude transactions with trade size > issue size	41,005	65,209,830
Exclude cusips with FISD Action Type "Reopening"	40,622	63,161,801
Exclude cusips with missing dissemination date	40,616	63,160,097
Exclude primary market transactions	40,416	61,913,794
Top 75% Sample		
% of aggregate trades	29%	
% of aggregate volume	61%	
% of customer volume	76%	
Constant Dealer Sample		
% of aggregate trades	38%	
% of aggregate volume	59%	
% of customer volume	71%	

Table II

Summary Statistics

This table provides descriptive statistics on the size of the corporate bond market between 2003 and 2014. All statistics are computed using the Aggregate Market sample described in Table I.

Year	Trading Volume (Billions)	Corporate Bond Outstanding Amount (Billions)	# of Corporate Bonds Outstanding	Trading Volume Relative to Amount Outstanding	TRACE Reported Volume (Billions)	Volume not Disseminated on TRACE (Billions)
2003	2,288	2,014	10,164	1.14	1,211	1,077
2004	1,975	2,050	11,640	0.96	1,219	756
2005	1,966	2,202	12,795	0.89	1,745	220
2006	2,248	2,512	13,342	0.89	1,940	307
2007	2,229	2,770	13,862	0.80	1,872	357
2008	1,799	2,881	13,331	0.62	1,620	179
2009	2,931	3,666	13,189	0.80	2,554	377
2010	3,872	4,691	15,534	0.83	3,168	704
2011	3,899	5,085	15,303	0.77	3,146	753
2012	3,884	5,497	15,169	0.71	3,034	850
2013	4,293	5,696	14,334	0.75	3,340	953
2014	4,371	5,833	13,574	0.75	3,873	498

Table III

Estimates of Transaction Costs on Customer Trades

The table reports estimated trade execution costs paid by customers in customer-to-dealer principal trades for the Aggregate Market sample described in Table I. Transaction costs are estimated following the regression based model implemented by Bessembinder, Maxwell, and Venkataraman (2006). Transaction costs are estimated for the full sample and for trade size and bond characteristic subsamples over five periods between 2003 and 2014.

	Jan. 2003 - Dec. 2005	Jan. 2006 - Jun. 2007	Jul. 2007 - Apr. 2009	May 2009 - Jun. 2012	Jul. 2012 - May 2014
	TRACE Phase-In	Pre-Crisis	Crisis	Post-Crisis	Regulatory
Full Sample					
Transaction Cost (%)	0.61%	0.52%	0.72%	0.62%	0.42%
Trade Size Subsamples					
Transaction Cost (%): <=100K Trades	0.84%	0.75%	0.96%	0.84%	0.61%
% of Total Volume	2%	2%	2%	2%	2%
Transaction Cost (%): >100K & <=1 mill.	0.33%	0.25%	0.47%	0.37%	0.27%
% of Total Volume	9%	7%	9%	9%	10%
Transaction Cost (%): >1 mill. & <=5 mill.	0.25%	0.19%	0.34%	0.26%	0.19%
% of Total Volume	36%	33%	38%	34%	35%
Transaction Cost (%): >5 mill.	0.20%	0.16%	0.32%	0.22%	0.17%
% of Total Volume	53%	58%	51%	55%	53%
Bond Characteristics Subsamples					
Transaction Cost (%): Investment Grade	0.64%	0.50%	0.78%	0.62%	0.40%
Transaction Cost (%): High Yield	0.54%	0.56%	0.52%	0.59%	0.46%
Transaction Cost (%): Large Issue Size	0.52%	0.38%	0.64%	0.52%	0.35%
Transaction Cost (%): Medium Issue Size	0.88%	0.93%	1.02%	0.92%	0.57%
Transaction Cost (%): Small Issue Size	0.92%	0.93%	1.00%	0.98%	0.83%
Transaction Cost (%): TRACE Reported	0.56%	0.54%	0.73%	0.64%	0.44%
Transaction Cost (%): Not TRACE Reported	0.70%	0.13%	0.27%	0.17%	0.14%

Table IV

Portfolio Analysis Summary Statistics

This table reports summary statistics of variables used in the capital committment, block trading, and stressful day portfolio analyses reported in Tables V-XI. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. The intraday capital commitment measures are computed at the portfolio-dealer-day level, stressful day and transaction cost measures are computed at the portfolio-month level, and all other variables are computed at the portfolio-dealer-month level. Averages are reported for five sub-periods and for the full January 2003 to May 2014 sample period. Measures are first averaged at the portfolio-period level then averaged across all portfolios. All variables are computed using the dealers in the Top 75% sample described in Table I. Variable definitions are provided in Appendix I.

	Jan. 2003 - Dec. 2005	Jan. 2006 - Jun. 2007	Jul. 2007 - Apr. 2009	May 2009 - Jun. 2012	Jul. 2012 - May 2014	Jan. 2003 - May 2014
	TRACE Phase-In	Pre-Crisis	Crisis	Post-Crisis	Regulatory	Full Sample
Intraday Capital Commitment / Aggregate Volume (%)	2.06	2.29	1.74	1.25	0.97	1.60
Intraday Capital Commitment / Amount Outstanding (%)	0.0074	0.0075	0.0030	0.0031	0.0024	0.0045
Dollar Volume / Amount Outstanding (%)	0.56	0.55	0.27	0.35	0.35	0.41
Average Trade Size (Thousands)	2,439	3,209	2,275	2,107	1,838	2,294
Principal Volume / Total Volume (%)	91.56	89.39	87.38	88.96	88.24	89.24
Interdealer Volume / Total Volume (%)	26.46	27.19	24.95	21.91	16.46	23.11
Transaction Cost (%)	0.49%	0.31%	0.47%	0.42%	0.34%	0.42%
Block Volume / Total Volume (%)	20.86	26.95	19.16	22.51	21.56	21.91
% of Block Quantity Reversed by End-of-Day	41.56	39.76	47.74	49.33	59.93	48.62
Intraday Capital Committment on Block Day / Block Size (%)	79.51	78.30	64.18	60.77	49.15	65.11
% of Stressful Day Activity "Effectively Agent"	8.8	10.6	13.7	13.2	17.1	12.5
% of Stressful Day Activity Reversed by End-of-Day	36.3	33.0	40.7	39.7	40.9	38.3
% of Stressful Day Activity Dealer Commits Overnight Capital	54.9	56.4	45.6	47.1	42.0	49.2

Table V

Portfolio Time Series Regressions: Capital Commitment

This table reports portfolio time series regression results over the January 2006 to May 2014 period. Each regression includes three time period indicators; the benchmark period is January 2006 to June 2007. The intraday capital commitment measures are computed at the portfolio-dealer-day level, the transaction cost measure is computed at the portfolio-month level, and all other variables are computed at the portfolio-dealer-month level. With exception to the transaction costs variable, which is computed using the entire sample of dealers, all dependent variables are computed using the dealers in the Top 75% sample described in Table I. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. Regressions 1-6 include portfolio-dealer fixed effects and clustered standard errors. The transaction costs regression (Regression 7) is estimated using weighted least squares (based on the number of trades used to estimate costs each portfolio-month), portfolio fixed effects, and robust standard errors. All regressions include portfolio bond characteristics and market controls. Tests for statistical differences between time periods are included below regression results. ***, **, and * stand for statistical significance at the 1%, 5%, and 10% level, respectively. Dependent variable definitions are provided in Appendix I. Sample period (January 2006 to May 2014) averages of each dependent variable are shown above regression results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Intraday Capital Commitment / Aggregate Volume (%)	**Intraday Capital Commitment / Amount Out. (%)**	**Dollar Volume / Amount Out. (%)**	**Ln (Trade Size)**	**Principal Volume / Total Volume** (%)	**Interdealer Volume / Total Volume (%)**	**Transaction Costs (%)**
Dependent Variable Average	1.451	0.00358	0.37	14.40	88.51	22.06	0.39
July 2007 - April 2009	-0.481***	-0.00416***	-0.2413***	-0.277***	-3.74***	-3.98***	0.242***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
May 2009 - June 2012	-0.834***	-0.00381***	-0.1230***	-0.304***	-2.69***	-7.36***	0.156***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
July 2012 - May 2014	-1.068***	-0.00433***	-0.1101***	-0.411***	-2.56***	-11.58***	0.026***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.007)
Ln (Average Issue Size)	0.332***	0.00100***	0.0665*	0.187*	2.30	4.33*	0.023
	(0.000)	(0.000)	(0.094)	(0.097)	(0.184)	(0.080)	(0.499)
Ln (Average Bond Age)	-0.017	-0.00021***	-0.0926***	-0.087***	-1.65**	-0.84	-0.019
	(0.405)	(0.004)	(0.000)	(0.000)	(0.039)	(0.171)	(0.466)
Corp Bond Index Return (t - 1)	0.151	0.00026	0.1808***	0.334***	-6.13	-7.64***	0.256
	(0.548)	(0.597)	(0.000)	(0.003)	(0.104)	(0.008)	(0.259)
Stock Market Index Return (t - 1)	0.420	0.00492***	0.4238***	1.961***	18.08***	2.56	-0.270
	(0.129)	(0.000)	(0.000)	(0.000)	(0.000)	(0.502)	(0.352)
Chg. in VIX (t - 1)	-0.004	0.00008***	0.0106***	0.034***	0.29**	-0.21**	-0.003
	(0.606)	(0.001)	(0.000)	(0.000)	(0.022)	(0.045)	(0.720)
Chg. in 3-Month Libor (t - 1)	-0.162*	-0.00054***	0.0006	-0.136***	-1.56*	-0.87	-0.062
	(0.055)	(0.000)	(0.953)	(0.000)	(0.097)	(0.263)	(0.261)
Constant	-2.275**	-0.00577**	-0.1032	12.433***	65.34***	-26.86	0.221
	(0.021)	(0.025)	(0.850)	(0.000)	(0.006)	(0.423)	(0.629)
Observations	348,557	348,557	16,764	16,704	16,676	16,704	1,212
Adjusted R-squared	0.102	0.149	0.642	0.684	0.396	0.424	0.766
Test: Jul 07-Apr 09 = May 09-Jun 12	***	***	***	ns	*	***	***
Test: Jul 07-Apr 09 = Jul 12-May 14	***	ns	***	***	ns	***	***
Test: May 09-Jun 12 = Jul 12-May 14	***	***	ns	***	ns	***	***

Table VI

Portfolio Time Series Regressions: Block Trading

This table reports portfolio time series regression results over the January 2006 to May 2014 period. Each regression includes three time period indicators; the benchmark period is January 2006 to June 2007. All variables are computed at the portfolio-dealer-month level and all dependent variables are computed using the dealers in the Top 75% sample described in Table I. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. Regressions 1-3 shows regression results for the full sample. Regressions 1-3 include portfolio-dealer fixed effects and clustered standard errors. Regressions 4-6 shows results for investment grade and high yield portfolios. Regressions 4-6 include dealer fixed effects and robust standard errors. All regressions include the portfolio bond characteristics and market controls shown in Table V. Tests for statistical differences between time periods are included below regression results in regressions 1-3 and tests for differences between investment grade and high yield portfolios are shown in regressions 4-6. ***, **, and * stand for statistical significance at the 1%, 5%, and 10% level, respectively. Dependent variable definitions are provided in Appendix I. Dependent variable sample period (January 2006 to May 2014) averages are shown above regression results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Block Volume / Total Volume (%)	**% of Block Quantity Reversed by End-of-Day**	**Intraday Capital Commit. on Block Day / Block Size (%)**	**Block Volume / Total Volume (%)**	**% of Block Quantity Reversed by End-of-Day**	**Intraday Capital Commit. on Block Day / Block Size (%)**
Dependent Variable Average	27.04	47.71	65.52	27.04	47.71	65.52
July 2007 - April 2009	-6.05***	8.37***	-14.66***			
	(0.000)	(0.000)	(0.000)			
May 2009 - June 2012	-2.29***	7.22***	-14.81***			
	(0.001)	(0.000)	(0.000)			
July 2012 - May 2014	-3.08***	14.95***	-23.60***			
	(0.000)	(0.000)	(0.000)			
High Yield				-23.11***	21.37***	-15.69***
				(0.000)	(0.000)	(0.000)
July 2007 - April 2009 x Investment Grade				-7.70***	13.22***	-17.47***
				(0.000)	(0.000)	(0.000)
July 2007 - April 2009 x High Yield				-4.71***	3.35	-11.57***
				(0.000)	(0.151)	(0.000)
May 2009 - June 2012 x Investment Grade				-5.87***	7.39***	-14.22***
				(0.000)	(0.000)	(0.000)
May 2009 - June 2012 x High Yield				0.56	7.37*	-15.31***
				(0.551)	(0.066)	(0.000)
July 2012 - May 2014 x Investment Grade				-9.75***	12.71***	-20.03***
				(0.000)	(0.000)	(0.000)
July 2012 - May 2014 x High Yield				2.74*	17.32***	-26.88***
				(0.055)	(0.000)	(0.000)
Observations	16,704	13,609	13,609	16,704	13,609	13,609
Adjusted R-squared	0.409	0.307	0.293	0.379	0.276	0.270
Test: Jul 07-Apr 09 = May 09-Jun 12	***	ns	ns			
Test: Jul 07-Apr 09 = Jul 12-May 14	***	***	***			
Test: May 09-Jun 12 = Jul 12-May 14	ns	***	***			
Test: Jul 07-Apr 09 X IG = Jul 07-Apr 09 x HY				*	***	**
Test: May 09-Jun 12 x IG = May 09-Jun 12 x HY				***	ns	ns
Test: Jul 12-May 14 x IG = Jul 12-May 14 x HY				***	ns	**
Controls	YES	YES	YES	YES	YES	YES

Table VII

Portfolio Time Series Regressions: Bank vs. Non-Bank Dealers

This table reports portfolio time series regression results over the January 2006 to May 2014 period for bank and non-bank affiliated dealers. Each regression includes three time period indicators; the benchmark period is January 2006 to June 2007. The intraday capital commitment measures are computed at the portfolio-dealer-day level and all other variables are computed at the portfolio-dealer-month level. All dependent variables are computed using the sample of Constant Dealers described in Table I. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. All regressions include portfolio fixed effects and robust standard errors. All regressions include portfolio bond characteristics and market controls. Tests for statistical differences between changes (relative to the benchmark period) in bank dealer and non-bank dealer activity each period are included below regression results. ***, **, and * stand for statistical significance at the 1%, 5%, and 10% level, respectively. Dependent variable sample period (January 2006 to May 2014) averages are shown above regression results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Intraday Capital Commitment / Aggregate Volume (%)	**Intraday Capital Commit. / Amount Out. (%)**	**Dollar Volume / Amount Out. %**	**Ln (Trade Size)**	**Principal Volume / Total Volume (%)**	**Interdealer Volume / Total Volume (%)**	**Block Volume / Total Volume (%)**	**% of Block Quantity Reversed by End-of-Day**	**Intraday Capital Commit. on Block Day / Block Size (%)**
Dependent Variable Average	0.7936	0.001937	0.1988	13.93	83.90	31.47	16.29	52.73	57.86
Bank	1.140***	0.00361***	0.2475***	1.430***	26.48***	-29.22***	15.04***	11.92	-9.01
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.149)	(0.166)
July 2007 - April 2009 x Non-Bank	-0.045***	-0.00013***	-0.0288***	-0.190**	9.60***	2.07	-0.07	-1.24	2.37
	(0.000)	(0.000)	(0.000)	(0.038)	(0.000)	(0.223)	(0.951)	(0.907)	(0.790)
July 2007 - April 2009 x Bank	-0.179***	-0.00206***	-0.1198***	-0.292***	-3.40***	-5.72***	-3.77***	9.00***	-13.69***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
May 2009 - June 2012 x Non-Bank	0.090***	0.00020***	0.0070	0.627***	17.46***	-34.82***	6.13***	31.31***	-35.36***
	(0.000)	(0.000)	(0.203)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
May 2009 - June 2012 x Bank	-0.421***	-0.00195***	-0.0623***	-0.410***	-3.15***	-8.77***	-1.92***	6.05***	-13.13***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
July 2012 - May 2014 x Non-Bank	0.218***	0.00045***	0.0441***	0.702***	25.20***	-53.95***	7.84***	30.48***	-36.40***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
July 2012 - May 2014 x Bank	-0.571***	-0.00230***	-0.0599***	-0.475***	-1.50***	-14.24***	-3.02***	11.91***	-19.52***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	603,554	603,554	28,995	26,095	25,078	26,095	26,095	15,571	15,571
Adjusted R-squared	0.042	0.058	0.171	0.272	0.047	0.185	0.187	0.100	0.099
Test: Jul 07 - Apr 09 x Non-Bank = Jul 07 - Apr 09 x Bank	***	***	***	ns	***	***	***	ns	*
Test: May 09 - Jun 12 x Non-Bank = May 09 - Jun 12 x Bank	***	***	***	***	***	***	***	***	***
Test: Jul 12 - May 14 x Non-Bank = Jul 12 - May 14 x Bank	***	***	***	***	***	***	***	**	**
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table VIII

Portfolio Time Series Regressions: Stressful Day Analysis

This table reports portfolio time series regression results over the January 2006 to May 2014 period. Each regression includes three time period indicators; the benchmark period is January 2006 to June 2007. A description of the identification of "stressful days" can be found in Section VI of the paper. All variables are computed at the portfolio-month level using the dealers in the Top 75% sample described in Table I. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. Regressions 1-3 shows regression results for the full sample and include portfolio fixed effects. Regressions 4-6 shows results for investment grade and high yield portfolios. All regressions show robust standard errors and include the portfolio bond characteristics and market controls shown in Table V. All regressions are estimated using weighted least squares; weights are based on the number of stressful event days used to estimate measures in each portfolio-month. Tests for statistical differences between time periods are included below regression results in regressions 1-3 and tests for differences between investment grade and high yield portfolios are shown in regressions 4-6. ***, **, and * stand for statistical significance at the 1%, 5%, and 10% level, respectively. Dependent variable definitions are provided in Appendix I. Sample period averages of each dependent variable are shown above regression results.

	(1)	(2)	(3)	(4)	(5)	(6)
	% of Stressful Day Activity "Effectively Agent"	**% of Stressful Day Activity Reversed by End-of-Day**	**% of Stressful Day Activity where Dealer Commits Overnight Capital**	**% of Stressful Day Activity "Effectively Agent"**	**% of Stressful Day Activity Reversed by End-of-Day**	**% of Stressful Day Activity where Dealer Commits Overnight Capital**
Dependent Variable Average (Jan. 06-May 14)	13.8	39.0	47.3	13.8	39.0	47.3
July 2007 - April 2009	0.793**	9.989***	-10.782***			
	(0.023)	(0.000)	(0.000)			
May 2009 - June 2012	-0.234	7.257***	-7.023***			
	(0.410)	(0.000)	(0.000)			
July 2012 - May 2014	2.417***	8.930***	-11.347***			
	(0.000)	(0.000)	(0.000)			
High Yield				5.368***	21.295***	-26.663***
				(0.000)	(0.000)	(0.000)
July 2007 - April 2009 x Investment Grade				-0.778*	12.161***	-11.383***
				(0.079)	(0.000)	(0.000)
July 2007 - April 2009 x High Yield				1.947***	5.416***	-7.363***
				(0.001)	(0.000)	(0.000)
May 2009 - June 2012 x Investment Grade				0.040	7.097***	-7.137***
				(0.909)	(0.000)	(0.000)
May 2009 - June 2012 x High Yield				0.955*	6.567***	-7.523***
				(0.071)	(0.000)	(0.000)
July 2012 - May 2014 x Investment Grade				3.133***	6.801***	-9.934***
				(0.000)	(0.000)	(0.000)
July 2012 - May 2014 x High Yield				4.994***	11.342***	-16.336***
				(0.000)	(0.000)	(0.000)
Observations	1,211	1,211	1,211	1,211	1,211	1,211
Adjusted R-squared	0.681	0.784	0.860	0.551	0.798	0.858
Test: Jul 07-Apr 09 = May 09-Jun 12	***	***	***			
Test: Jul 07-Apr 09 = Jul 12-May 14	***	ns	ns			
Test: May 09-Jun 12 = Jul 12-May 14	***	***	***			
Test: Jul 07-Apr 09 x IG = Jul 07-Apr 09 x HY				***	***	***
Test: May 09-Jun 12 x IG = May 09-Jun 12 x HY				ns	ns	ns
Test: Jul 12-May 14 x IG= Jul 12-May 14 x HY				**	***	***
Controls	YES	YES	YES	YES	YES	YES

Table IX

Stressful Day and Bank vs. Non-Bank Dealers

This table reports results for the stressful day large dealer analysis for bank and non-bank affiliated dealers. Panel A reports variable averages for five sub-periods over the January 2003 to May 2014 sample period for bank and non-bank dealers. Measures are first averaged at the portfolio-period level then averaged across all portfolios. All measures in both panels are computed using the Constant Dealer sample described in Table I. Panel B reports portfolio time series regression results over the January 2006 to May 2014 period for bank and non-bank dealers. Each regression includes three time period indicators; the benchmark period is January 2006 to June 2007. All measures are computed at the portfolio-bank-month level. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. All regressions include portfolio fixed effects, the portfolio bond characteristics and market controls shown in Table V, and robust standard errors. Regressions are estimated using weighted least squares where weights are based on the number of stressful event days used to estimate measures in each portfolio-bank-month. Tests for statistical differences between changes (relative to the benchmark period) in bank dealer and non-bank dealer activity each period are included below regression results. ***, **, and * stand for statistical significance at the 1%, 5%, and 10% level, respectively. Dependent variable definitions are provided in Appendix I. Sample period averages of each dependent variable are shown above regression results.

Panel A: Univariate Statistics

	Jan. 2003 - Dec. 2005	Jan. 2006 - Jun. 2007	Jul. 2007 - Apr. 2009	May 2009 - Jun. 2012	Jul. 2012 - May 2014
	TRACE Phase-In	Pre-Crisis	Crisis	Post-Crisis	Regulatory
Bank Sample					
% of Stressful Day Activity "Effectively Agent"	10.76	10.34	15.14	13.90	17.28
% of Stressful Day Activity Reversed by End-of-Day	37.55	36.18	41.85	39.93	40.17
% of Stressful Day Activity where Dealer commits Overnight Capital	51.69	53.47	43.01	46.17	42.54
Non-Bank Sample					
% of Stressful Day Activity "Effectively Agent"	55.77	57.84	41.84	27.31	21.72
% of Stressful Day Activity Reversed by End-of-Day	26.04	31.50	29.00	46.27	46.63
% of Stressful Day Activity where Dealer commits Overnight Capital	18.19	10.66	29.16	26.42	31.65

Panel B: Portfolio Time Series Regressions			
	(1)	(2)	(3)
	% of Stressful Day Activity "Effectively Agent"	**% of Stressful Day Activity Reversed by End-of-Day**	**% of Stressful Day Activity where Dealer Commits Overnight Capital**
Dependent Variable Average (Jan. 06-May 14)	14.7	39.9	45.4
Bank	-51.119***	13.337***	37.782***
	(0.000)	(0.000)	(0.000)
July 2007 - April 2009 x Non-Bank	-38.933***	31.446***	7.488
	(0.000)	(0.000)	(0.163)
July 2007 - April 2009 x Bank	2.256***	9.063***	-11.319***
	(0.000)	(0.000)	(0.000)
May 2009 - June 2012 x Non-Bank	-39.114***	25.416***	13.698***
	(0.000)	(0.000)	(0.000)
May 2009 - June 2012 x Bank	1.057***	5.048***	-6.106***
	(0.000)	(0.000)	(0.000)
July 2012 - May 2014 x Non-Bank	-44.781***	27.401***	17.379***
	(0.000)	(0.000)	(0.000)
July 2012 - May 2014 x Bank	3.469***	5.599***	-9.068***
	(0.000)	(0.000)	(0.000)
Observations	2,022	2,022	2,022
Adjusted R-squared	0.672	0.716	0.843
Test: Jul 07-Apr 09 x Non-Bank = Jul 07-Apr 09 x Bank	***	***	***
Test: May 09-Jun 12 x Non-Bank = May 09-Jun 12 x Bank	***	***	***
Test: Jul 12-May 14 x Non-Bank = Jul 12-May 14 x Bank	***	***	***
Controls	YES	YES	YES

Table X
Impact of TRACE

This table reports portfolio regression results for the six months preceding and following transparency events. Panel A reports 2003-2004 transparency events in March 2003, April 2003, and October 2004. Panel B reports the 2014 transparency event in June 2014. 'Post-TRACE' refers to the six months subsequent to the TRACE shock. 'TREATED' refers to a portfolio of bonds experiencing the transparency event. The intraday capital commitment variables are computed at the portfolio-dealer-day level and all other variables are computed at the portfolio-dealer-month level. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. Portfolios of control firms that do not experience a transparency shock but are similar to treatment firms in terms of investment grade/high yield and issue size are included in the analysis. All dependent variables are computed using the Constant Dealer sample described in Table I. All regressions include dealer fixed effects and the portfolio bond characteristics and market controls shown in Table V. Standard errors are clustered at the dealer level. Dependent variable definitions are provided in Appendix I. Tests for differences between the 'Post x Treated' coefficients in Panel A and Panel B are shown at the bottom of Panel B. ***, **, and * stand for statistical significance at the 1%, 5%, and 10% level, respectively. Twelve month event period averages of each dependent variable are shown above regression results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Intraday Capital Commit. / Aggregate Volume (%)	**Intraday Capital Commit. / Amount Out. (%)**	**Dollar Volume / Amount Out. (%)**	**Ln (Trade Size)**	**Principal Volume / Total Volume (%)**	**Interdealer Volume / Total Volume (%)**
Panel A: 2003-2004 Transparency Events For Non-144A Bonds						
Dependent Variable Average	0.2574	0.004040	0.6503	14.48	88.14	37.02
Post-TRACE Period	-0.003	0.00001	0.0018	0.044	1.23	2.12***
	(0.740)	(0.966)	(0.953)	(0.167)	(0.363)	(0.007)
TREATED	0.024***	0.00135***	0.1106***	0.073***	0.32	2.05***
	(0.009)	(0.002)	(0.000)	(0.006)	(0.696)	(0.001)
Post x TREATED	-0.038**	0.00087***	0.0923***	-0.008	-0.18	0.62
	(0.024)	(0.005)	(0.006)	(0.640)	(0.827)	(0.187)
Observations	72,418	72,418	2,527	2,526	2,352	2,526
Adjusted R-squared	0.238	0.164	0.425	0.550	0.471	0.841
Panel B: 2014 Transparency Event For 144A Bonds						
Dependent Variable Average	0.2248	0.001686	0.3394	14.11	84.52	28.84
Post-TRACE Period	-0.012	-0.00032***	-0.0742***	-0.084**	-1.71	-1.64**
	(0.674)	(0.000)	(0.002)	(0.020)	(0.334)	(0.031)
TREATED	-0.267***	0.00029***	-0.2489***	0.660**	-8.69***	-4.52**
	(0.000)	(0.004)	(0.007)	(0.023)	(0.009)	(0.039)
Post x TREATED	0.014	0.00002	0.0558**	-0.003	2.63	-0.44
	(0.587)	(0.736)	(0.049)	(0.949)	(0.210)	(0.542)
Observations	70,498	70,498	1,751	1,732	1,628	1,732
Adjusted R-squared	0.016	0.168	0.492	0.648	0.309	0.934
Controls (Panel A and B)	YES	YES	YES	YES	YES	YES
Test: Post x TREATED Panel A = Post x TREATED Panel B	**	ns	ns	ns	ns	ns

Table XI

Portfolio Time Series Regressions: TRACE vs. Non-TRACE

This table reports portfolio time series regression results over the January 2006 to May 2014 period for TRACE-reported (transparent) and non-TRACE reported (opaque) bonds. Each regression includes three time period indicators; the benchmark period is January 2006 to June 2007. The intraday capital commitment measures are computed at the portfolio-dealer-day level and all other variables are computed at the portfolio-dealer-month level. All dependent variables are computed using the sample of Constant Dealers described in Table I. Bonds are placed in twelve portfolios based on TRACE status, investment grade and high yield, and small, medium, and large issue size. All regressions include dealer fixed effects and clustered standard errors. All regressions include the portfolio bond characteristics and market controls shown in Table V. Tests for statistical differences between changes (relative to the benchmark period) in transparent versus opaque bonds are shown below regression results. ***, **, and * stand for statistical significance at the 1%, 5%, and 10% level, respectively. Dependent variable definitions are provided in Appendix I. Sample period (January 2006 to May 2014) averages of each dependent variable are shown above regression results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Intraday Capital Commit. / Aggregate Volume (%)	**Intraday Capital Commit. / Amount Out. (%)**	**Dollar Volume / Amount Out.**	**Ln (Trade Size)**	**Principal Volume / Total Volume** (%)	**Interdealer Volume / Total Volume (%)**
Dependent Variable Average	0.794	0.00194	0.1988	13.93	83.90	31.47
Opaque	0.8272***	0.002***	-0.0389*	0.564***	-2.22	-5.33*
	(0.000)	(0.001)	(0.081)	(0.000)	(0.233)	(0.052)
July 2007 - April 2009 x Transparent	-0.0859***	-0.001***	-0.0624***	-0.203*	-1.63	-5.11**
	(0.009)	(0.000)	(0.001)	(0.074)	(0.486)	(0.040)
July 2007 - April 2009 x Opaque	-0.1855**	-0.003***	-0.1423***	-0.221***	-2.93	-6.50***
	(0.046)	(0.000)	(0.000)	(0.008)	(0.227)	(0.010)
May 2009 - June 2012 x Transparent	-0.1709**	-0.001**	-0.0019	-0.379**	-0.36	-11.41**
	(0.023)	(0.013)	(0.944)	(0.046)	(0.930)	(0.011)
May 2009 - June 2012 x Opaque	-0.4480**	-0.002***	-0.0896**	-0.118	-2.01	-14.39***
	(0.030)	(0.002)	(0.010)	(0.356)	(0.530)	(0.000)
July 2012 - May 2014 x Transparent	-0.1915**	-0.001**	-0.0017	-0.449**	3.12	-19.68***
	(0.028)	(0.011)	(0.960)	(0.027)	(0.475)	(0.002)
July 2012 - May 2014 x Opaque	-0.6542**	-0.003***	-0.0743**	-0.169	-0.38	-21.37***
	(0.011)	(0.001)	(0.044)	(0.260)	(0.926)	(0.000)
Observations	603,554	603,554	28,995	26,095	25,078	26,095
Adjusted R-squared	0.106	0.138	0.478	0.592	0.249	0.458
Test: Jul 07 - Apr 09 x Transparent = Jul 07 - Apr 09 x Opaque	ns	***	***	ns	ns	ns
Test: May 09 - Jun 12 x Transparent = May 09 - Jun 12 x Opaque	*	***	***	**	ns	ns
Test: Jul 12 - May 14 x Transparent = Jul 12 - May 14 x Opaque	***	***	***	**	ns	ns
Controls	YES	YES	YES	YES	YES	YES

Appendix I
Variable Definitions

Panel A: Dependent Variables	
Intraday Capital Commitment	'Intraday Capital Commitment' refers to daily unsigned, time-weighted changes in capital for each dealer in a portfolio. Capital commitment is measured at the time of each completed trade in a portfolio as the absolute value of the difference between the dealer's accumulated principal buy volume and the dealer's accumulated principal sell volume to that point in the day. The measure is aggregated over each dealer-portfolio-day by weighting each observation by the time for which the capital is committed (i.e., until the next trade, or if no trade occurs then until the end of the day). This measure is scaled both by aggregate volume (across all dealers) and by total amount outstanding for bonds in the portfolio.
Dollar Volume / Amount Out.	Aggregate dollar volume scaled by total amount outstanding for each portfolio-dealer-month.
Average Trade Size	Average dollar trade size over each portfolio-dealer-month.
Principal Volume / Total Volume	Trades are classified as 'principal' if not reported as 'Agency' by FINRA or 'reversed' within one minute. Trades are classified as 'reversed' when an exact offsetting quantity (either a customer or interdealer trade) occurs or a combination of 2-3 trades offsets the customer trade within 60 seconds prior or subsequent to the trade. Principal volume is aggregated then scaled by total volume each portfolio-dealer-month.
Interdealer Volume / Total Volume	Interdealer trades are those completed with another dealer reporting to FINRA. Interdealer volume is aggregated then scaled by total volume each portfolio-dealer-month.
Transaction Costs %	Transaction costs are estimated following the regression based model implemented by Bessembinder, Maxwell, and Venkataraman (2006). Estimation details are provided in Section III of the paper.
Block Volume / Total Volume	'Block' refers to a single large trade by a dealer of at least $10 million. Block volume is aggregated then scaled by total volume each portfolio-dealer-month.
% of Block Quantity Reversed by End-of-Day	For each bond-dealer-day with a block trade of at least $10 million, we identify the largest block trade based on quantity and if the block is a buy (sell), we cumulate the quantity of sells (buys) for the day. The percent reversed is the ending cumulative quantity divided by the block size. This measure is averaged over each portfolio-dealer-month.
Intraday Capital Commitment on Block Day / Block Size	This measure is computed for each bond-dealer-day where a trade of $10 million or larger is reported. For the relevant bond, we record cumulative daily trading by the dealer who participated in the block trade, and weight each observation by the elapsed time until the next trade by that dealer in that bond, or until the end of the day. This measure is scaled by the block size then averaged over the portfolio-dealer-month.
% of Stressful Day Activity "Effectively Agent"	A 'stressful day' is a bond-day when customer-to-dealer trading volume exceeds the average customer-to-dealer volume for that bond over the prior six months by two standard deviations. To ensure the active dealer's activity is economically large, we require that active dealer trading activity (both buying and selling in the bond) exceeds $1,000,000. The activity by the active dealer that is 'effectively agent' is comprised of trading volume reported as 'Agency' by FINRA or 'reversed' within one minute. Trades are classified as 'reversed' when an exact offsetting quantity (either a customer or interdealer trade) occurs or a combination of 2-3 trades offsets the customer trade within 60 seconds prior or subsequent to the trade. This measure is averaged over each portfolio-month.
% of Stressful Day Activity Reversed by End-of-Day	The activity by the active dealer that is 'reversed principal' is volume that is completed on a principal basis that is offset by opposite direction volume by the end of the trading day. This measure is averaged over each portfolio-month.
% of Stressful Day Activity where Dealer Commits Overnight Capital	The activity where the active dealer commits 'overnight capital' is volume that is completed on a principal basis that is not offset by the end of the trading day, i.e., that is absorbed as a change in overnight inventory. This measure is averaged over each portfolio-month.

Panel B: Control Variables	
Average Issue Size	The average issue size across all bonds in each portfolio-month.
Average Bond Age	The average age of all bonds in each portfolio-month.
Corp Bond Index Return (t - 1)	The return to the Barclays Capital U.S. Corporate Bond Index in the previous month.
Stock Market Index Return (t - 1)	The return to the S&P 500 index in the previous month.
Chg. in VIX (t - 1)	The change in the CBOE stock market volatility index (VIX) in the previous month.
Chg. in 3-Month Libor (t - 1)	The change in 3-month LIBOR in the previous month.

Figure 1: Corporate bond trading costs on customer trades with dealers, 2003-2014

The figure reports estimated trade execution costs paid by customers in customer-to-dealer principal trades for the Aggregate Market sample described in Table I. Transaction costs are estimated following the regression based model implemented by Bessembinder, Maxwell, and Venkataraman (2006).

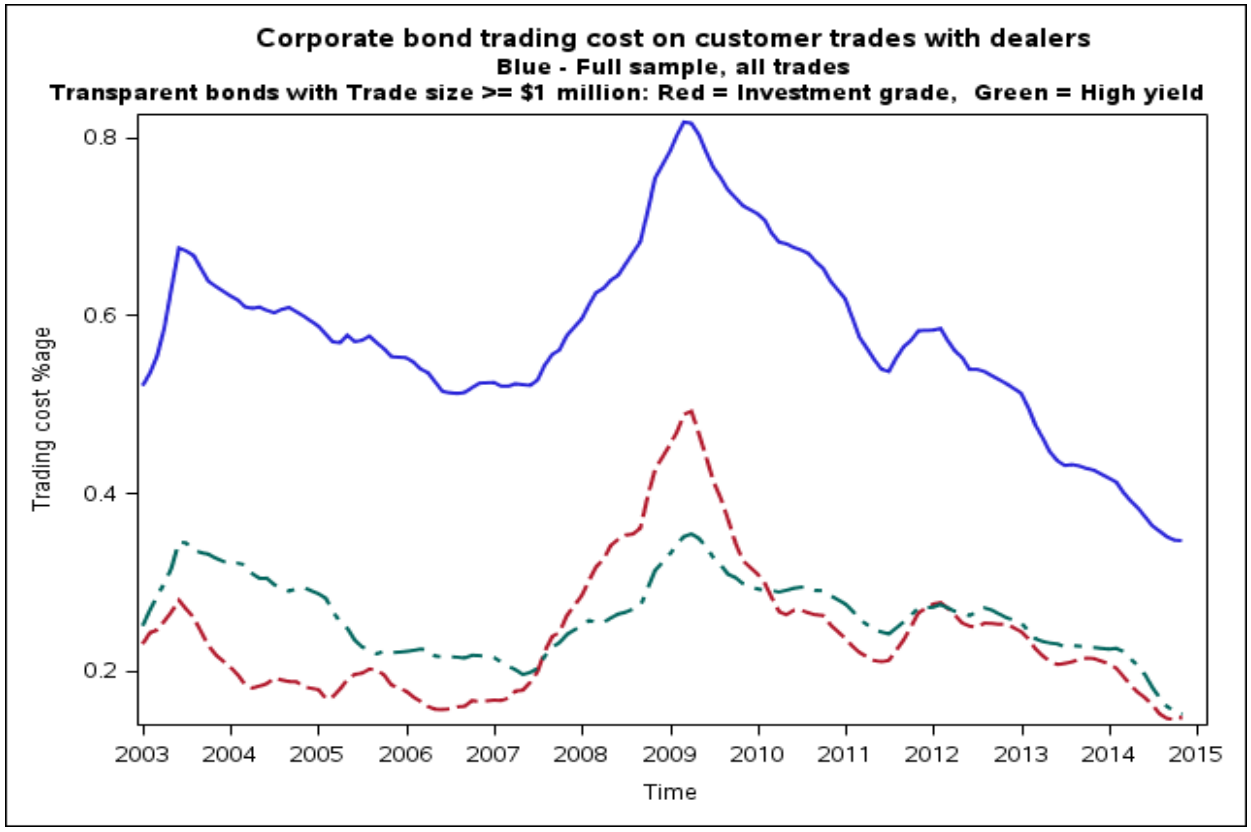

Figure 2: Intraday Capital Commitment in corporate bonds, 2003-2014

These figures show the six-month moving average intraday capital commitment for investment grade portfolios and high yield portfolios over the June 2003 to May 2014 period. The solid blue line refers to investment grade portfolios and the dashed brown line refers to high yield portfolios. Daily portfolio-dealer observations are averaged over each month then portfolio-dealer-month observations are value-weighted by total volume in the current month. The left figure scales intraday capital by aggregate volume and the right figure scales intraday capital by total amount outstanding. Both figures are based on the Top 75% dealer sample.

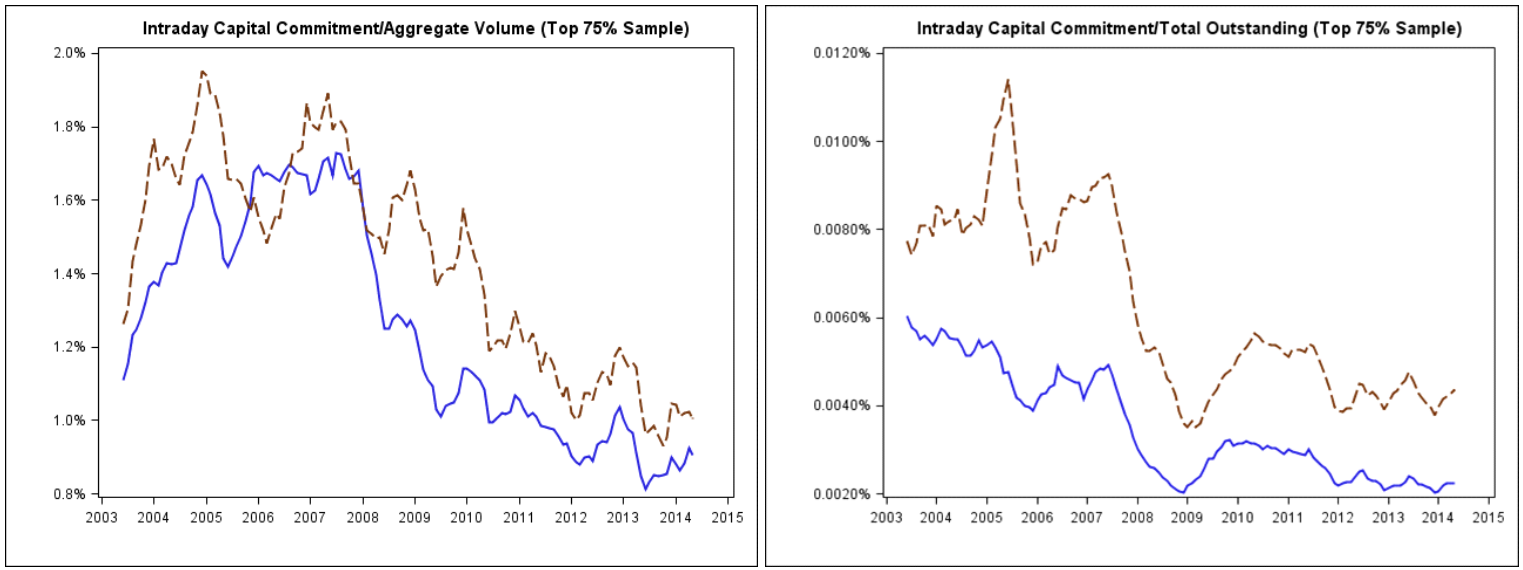

Figure 3: Stressful Day activity where dealer commits overnight capital, 2003-2014

This figure shows the six-month moving average percent of stressful day trading activity where the dealer commits overnight capital over the July 2003 to May 2014 period for the Top 75% sample. The solid blue line refers to investment grade portfolios and the dashed brown line refers to high yield portfolios. Monthly portfolio observations are averaged over each month for investment grade and high yield portfolios.