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Capital Commitment and Illiquidity in Corporate Bonds

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ABSTRACT

We study trading costs and dealer behavior in U.S. corporate bond markets from 2006 to 2016. Despite a temporary spike during the financial crisis, average trade execution costs have not increased notably over time. However, dealer capital commitment, turnover, block trade frequency, and average trade size decreased during the financial crisis and thereafter. These declines are attributable to bank-affiliated dealers, as nonbank dealers have increased their market commitment. Our evidence indicates that liquidity provision in the corporate bond markets is evolving away from the commitment of bank-affiliated dealer capital to absorb customer imbalances, and that postcrisis banking regulations likely contribute.

THE LIQUIDITY OF THE CORPORATE bond market has attracted substantial attention from practitioners, regulators, and academics in recent years. The financial crisis of 2007 to 2009 saw the broad deterioration of liquidity in both equity (e.g., Anand, Irvine, Puckett, and Venkataraman (2013)) and corporate bond

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(e.g., Dick-Nielsen, Feldhutter, and Lando (2012), Friewald, Jankowitsch, and Subrahmanyam, (2012)) markets. However, while equity market liquidity recovered after the financial crisis (Anand et al. (2013)), corporate bond market liquidity has become a widespread concern in recent years. For example, in 2015 Daniel Gallagher, Commissioner of the U.S. Securities and Exchange Commission (SEC), noted that "A lack of liquidity in corporate-bond markets could pose a 'systemic risk' to the economy,"[1] and a 2016 Greenwich Associates study reports that among 400 credit investors interviewed, more than 80% indicated that reduced liquidity in corporate bonds limits their investment strategies.[2]

Concerns regarding corporate bond market liquidity have been attributed by some to postcrisis regulatory initiatives. For example, Pacific Investment Management Company (PIMCO) asserts that "the combination of immediate-post-crisis capital and liquidity regulations and a lower return environment has made banks less able and willing to function as market makers."[3] However, not all observers are convinced that liquidity in the corporate bond markets has deteriorated. Indeed, some argue that concerns about bond market illiquidity comprise a "myth" and arise from traditional bond dealers' desire to maintain their "privileged market position."[4] Janet Yellen, former chair of the U.S. Federal Reserve, has 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."[5]

In this paper, we analyze liquidity and key aspects of dealer behavior in the corporate bond market over the 2006 to 2016 period. We are particularly interested in examining market quality in the years following the financial crisis, and in evaluating potential explanations for the changes observed. To do so, we use an enhanced version of the Trade Reporting and Compliance Engine (TRACE) database of U.S. corporate bond transactions, made available by Finance Industry Regulatory Authority (FINRA). In addition to the standard TRACE data, the data that we study include masked dealer identities, which allow 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 for corporate bonds have not increased markedly over time. In particular, we find that the average one-way trade execution cost during the 2014 to 2016 period averaged 0.42%, as compared to 0.40% during the 2006 to 2007 precrisis period.

[1] http://www.bloomberg.com/news/articles/2015-03-02/corporate-bond-market-poses-systemic-risk-sec-s-gallagher-says.

[2] https://www.greenwich.com/press-release/2017-liquidity-starved-bond-investors-could-get-relief-block-trading-solutions-and.

[3] http://www.barrons.com/articles/a-look-at-bond-market-liquidity-1440103954.

[4] "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.

[5] http://blogs.wsj.com/economics/2015/07/15/fed-chairwoman-janet-yellens-report-to-congress-live-blog/.

However, average trading costs could mask shifts in the composition of trading. Investment-grade bonds and large-issue-size bonds, which tend to be more liquid, each grew as a proportion of overall trading, as did trades that are most likely to be facilitated by electronic venues. Further, execution costs for completed trades do not capture search costs or the implicit costs associated with trades that were desired but not completed. We therefore consider a number of additional measures, including dealers' capital commitment measured at the intraday, overnight, and weekly horizons; turnover; average trade size; block trade frequency; and principal volume.

We use the term "capital commitment" to refer to dealers absorbing customer order imbalances into their own inventories. Capital commitment is particularly important to the functioning of markets where buyers and sellers arrive sporadically and search costs are relatively high. Corporate bond trading occurs largely in a telephone- and instant message–oriented dealer market with limited pretrade transparency, and days or weeks can elapse between trades in individual bonds. However, some corporate bond trading, particularly in recently issued bonds of larger issue sizes, is electronically facilitated. While a decline in dealer capital commitment may indicate a decrease in liquidity in the overall market, a decline induced by growth in electronic trading may reflect reduced search costs, which would imply an improvement rather than deterioration of liquidity.

We find, not surprisingly, that all measures of dealer capital commitment declined during the financial crisis. Potentially more informative, most measures of dealer commitment for the overall market have not reverted to precrisis levels. Indeed, many measures have continued to decline in recent years. All of the measures that we consider point to significantly lower dealer capital commitment in the recent 2014 to 2016 period, and many point to lower capital commitment in the recent period than in the financial crisis period itself.

We consider several possible explanations for the observed decline in overall dealer capital commitment in the recent period. First, postcrisis reforms in bank regulation, such as the Volcker Rule and Basel III requirements, while focused on banking rather than market-making activities, may have affected dealers' willingness or ability to commit capital to the provision of liquidity in the corporate bond market. Second, the U.S. Treasury department estimates that electronic platforms (the most important of which are "request for quotation" systems rather than limit order books) have captured 15% or more of customer-to-dealer market share in recent years, with the electronic share higher for investment-grade than for high-yield bonds. Third, corporate bond exchange-traded funds (ETFs) allow investors to gain exposure to corporate bond returns without directly trading in the dealer market.[6] However, market participants who create and redeem shares trade in the underlying, relatively

[6] Though bond ETFs have grown rapidly from 0.2% (net asset value to bonds outstanding) to 4.1% over our sample period, they remain substantially smaller than equity market ETFs. Bond ETF information is available to academics from ICI.org.

illiquid market. Indeed, Pan and Zheng (2017) show that corporate bond dealers manage inventory in part through the creation and redemption of ETF shares.

To assess the relative importance of these potential explanations, we compare outcomes between dealers that are affiliated with banks and nonbank dealers, as well as outcomes between trades that are more likely to involve electronic intermediation and those more likely to be handled through traditional methods. If regulation focused on banking affected corporate bond market-making, then postregulation outcomes should differ across bank-affiliated and nonbank dealers. In contrast, changes attributable to the emergence of corporate bond ETFs or electronically facilitated trading potentially affect all dealers.

Our results show that the decreases in dealer capital commitment in recent years are entirely attributable to bank-affiliated dealers. In particular, compared to the precrisis period, nonbank dealers increase intraday, overnight, and weekly capital commitment, turnover, block trading, and principal volume, while all of these measures are lower in recent years for bank-affiliated dealers. This result supports the interpretation that postcrisis regulations focused on banking have contributed to the reduction in dealers' capital commitment to the corporate bond market in recent years. The results also support the prediction of Duffie (2012) that nonbank dealers will step in to fill the void left by banks. However, nonbank dealers are significantly smaller than bank-affiliated dealers and thus have not fully offset the decline in bank-affiliated dealer capital. A decline in the overall supply of market-making capital is consistent with the evidence in Friewald and Nagler (2016) that the relation between dealer inventory positions and risk-adjusted bond returns has strengthened in recent years.

In the segment of the market in which electronically facilitated trades are most likely to occur, we document a decrease in capital commitment relative to trading volume for both bank and nonbank dealers. This result is consistent with the interpretation that less capital is required in the part of the market where electronic communications have reduced search costs.

It is possible that the most notable changes in the secondary market for corporate bonds do not arise during normal trading, but rather when the market is stressed. Further, it could be the case that nonbank dealers reduce their commitment and rely on traditional bank-affiliated dealers to provide liquidity in difficult times. To shed light on these possibilities, we study days when individual bonds are stressed by large customer block trades, as well as days characterized by market-wide stress, as identified by the credit market component of the Cleveland Federal Reserve Financial Stress Index. The results for both bond-level and market-wide stressful days mirror those for the overall sample. In particular, nonbank dealers have increased block volume and intraday, overnight, and weekly capital commitment on stressful days in recent periods relative to precrisis periods, while bank-affiliated dealers have reduced their market commitment on these days.

Taken together, the evidence indicates that the role of corporate bond dealers has changed in recent years. Bank-affiliated dealers in particular are less inclined to serve as traditional market-makers who commit capital to absorb

customer order imbalances. This shift is especially apparent in the most recent period, when banks have become increasingly subject to the requirements of the Volcker Rule. At the same time, nonbank dealers have increased their market share and their willingness to commit capital, albeit from small initial precrisis levels. Further, electronically facilitated trades are growing in importance, and both bank-affiliated and nonbank dealers have decreased their capital commitment as search costs have declined in those segments of the market where such trading is concentrated.

The stark divergence in recent-period outcomes for bank-affiliated versus nonbank dealers supports the view that postcrisis regulations focused on banking have contributed to the empirically observed reductions in turnover, average trade size, block trading frequency, and dealer capital commitment in the corporate bond market. It will be of interest to examine whether, in time, capital commitment by nonbank dealers and/or the continued emergence of electronic quotation venues will fully offset the effects of decreased bank-affiliated dealer capital commitment.

The paper is organized as follows. We discuss related literature and postcrisis regulation in Section I. We present the data, describe dealer sample construction, and provide aggregate market statistics in Section II. In Section III, we present trading cost estimates. Section IV describes our measure of dealer-level capital commitment and additional market quality variables. Section V presents results of multivariate regressions in which we assess the evolution of capital commitment and market quality over time, after allowing for changes in relevant control variables. In Section VI, we expand the analysis to consider capital commitment and market quality outcomes separately for bank-affiliated and nonbank dealers. In Section VII, we present bank and nonbank dealer outcomes on days that are particularly stressful. Finally, in Section VIII, we summarize the results and present implications of the study.

I. Related Literature and Postcrisis Regulation

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) was among the first to provide systematic evidence regarding corporate bond trading, showing that institutional trades in corporate bonds incurred transaction costs that were large relative to those observed in equity markets.[7]

The introduction of posttrade transparency in the corporate bond market and the 2007 to 2009 financial crisis accelerated research on corporate bond trading.

[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) and report 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 posttrade transparency in the CDS market surrounding the advent of a central clearinghouse led to improvements in liquidity and trading activity.

The phased introduction of TRACE transaction reporting during the 2002 to 2005 period triggered at least three studies, Edwards, Harris, and Piwowar (2007), Bessembinder, Maxwell, and Venkataraman (2006), and Goldstein, Hotchkiss, and Sirri (2007), each of which concludes 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) document that corporate bond liquidity decreased substantially during the 2007 to 2009 financial crisis.

Given that the corporate bond market lacks pretrade transparency, researchers have developed measures of corporate bond liquidity that do not require quotation data. Feldhutter (2012) shows that variation in trade prices between small and large trades captures illiquidity for corporate bonds, and Mahanti et al. (2008) construct a measure that captures "latent" liquidity in illiquid markets.

A number of recent papers examine dealer networks and dealer behavior. Di Maggio, Kermani, and Song (2016) 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) show that more active insurance companies receive better transaction prices for trades than less active insurance companies, particularly when the insurance company trades with the dominant dealer in the bond. Goldstein and Hotchkiss (2017) find that dealers' propensity to offset trades within the same day rather than commit capital for longer periods is highest for the most risky and illiquid bonds, indicating that dealers actively mitigate inventory risk via increased search. The literature also demonstrates that liquidity is important because it affects the valuation of corporate bonds. For instance, Chen, Lesmond, and Wei (2007) and Lin, Wang, and Wu (2011) document that illiquidity affects bonds' yield spreads, while Bao and Pan (2013) show that illiquidity contributes to the observed volatility of bond prices and Cespa and Foucault (2014) show that a lack of liquidity can hinder efficient price discovery.

B. Postcrisis Regulatory Reforms

We consider the possibility that postcrisis regulatory reforms that focused on banks have affected dealers' willingness to supply liquidity to the corporate bond market. A number of recent studies share this objective. Dick-Nielsen and Rossi (2015) study the removal of individual bonds from key indices, which is likely to generate customer selling pressure, and they document that transaction costs for these bonds more than doubled in the 2010 to 2013 period as compared to the precrisis period. Choi and Huh (2017) document increased use in recent years of matching (facilitating) trades, as opposed to traditional market-making by bond dealers. They show that bid-ask spreads on these matched trades are significantly lower than those on traditional market-making trades, which leads them to conclude that bid-ask spreads have increased in recent years for traditional market-making trades. Similarly, Schultz (2017) shows

that, in recent years, dealers in actively traded bonds have relied more on prearranged trades that are quickly offset by trades in the opposite direction.

The paper closest to this study is the contemporaneous work of Bao, O'Hara, and Zhou (2017). They study trades in individual bonds immediately following credit rating downgrades, when customers are likely to initiate sales, and find that the price impact of trades has increased and dealers' willingness to absorb order imbalances has decreased since the Volcker Rule (discussed further below) was implemented.[8] Further, like us, they find that the reduction in market quality is concentrated in bank-affiliated dealers.

Our study is distinct from prior studies in that we provide comprehensive evidence for the U.S. corporate bond market (both on an overall basis and on days when the market is likely to be stressed), we assess a number of additional measures of market quality, and we assess outcomes for trades that are more likely to be completed with electronic intermediation. It is reassuring that results regarding bank-affiliated versus nonbank dealers are consistent across our broad study of the full corporate bond market and the focused analysis of credit downgrades in Bao, O'Hara, and Zhou (2017).

B.1. The Dodd-Frank Act, the Volcker Rule, and the Basel Accords

The Dodd-Frank Act was signed into law on July 21, 2010. Several aspects of the Dodd-Frank Act focused specifically on banks. For example, the act requires that the Federal Reserve conduct an annual stress test of bank holding companies with $50 billion or more in total consolidated assets.[9] Perhaps the most relevant part of the Dodd-Frank Act for the corporate bond market was the Volcker Rule, which was intended to prevent institutions with access to FDIC insurance or to the Federal Reserve's discount window from engaging in risky proprietary trading. The Volcker Rule was originally scheduled to take effect on July 21, 2012. However, implementation was delayed until April 1, 2014. Large banks were required to be fully compliant by July 21, 2015, making good faith efforts to comply during the implementation period starting in April 1, 2014. A number of banks announced closures of their proprietary trading operations in advance of the implementation of the Volcker Rule.[10]

The Volcker Rule was not intended to restrict market-making activity, as it specifically allows banks to conduct "riskless principal" trades that are "customer-driven." The rule also contains a market-making exemption for

[8] However, Anderson and Stulz (2017) argue that, while liquidity has indeed decreased around systematic stress events, the decrease in liquidity after bond-specific events is actually less pronounced in recent data as compared to precrisis years.

[9] https://www.federalreserve.gov/newsevents/pressreleases/files/bcreg20160623a1.pdf.

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

trading desks that "routinely stand ready to purchase and sell financial instruments." However, Schultz (2017) observes that the Volcker Rule requires banks to report inventory turnover as well as the standard deviation of daily trading profits, implying that lower turnover or higher profit volatility may be interpreted as indicative of proprietary trading. The reporting requirement of inventory turnover could disincentive banks from taking positions in less-liquid bonds in particular. Duffie (2012) observes that market-making is inherently a form of proprietary trading, and that the Volcker Rule may have unintended consequences. Indeed, 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" (p. 4).

Dealers affiliated with banks have also been affected by implementation of the Basel 2.5 and Basel III banking Accords, which reduce allowable bank leverage and impose more restrictive definitions on banks' requisite capital holdings, in June 2012 and July 2013, respectively. A survey conducted in September 2015 by the Committee on the Global Financial Systems finds that respondents consider the Basel 2.5 capital charges as having a significant impact on banks' corporate bond trading activities.[11] Basel III, which involves leverage ratio, liquidity coverage, and net stable funding ratio tests, increases banks' capital costs.[12,13] The Basel Accords thus impose higher capital costs for risky assets, which in turn may disincentive banks from making markets in riskier bonds in particular.

As the discussion above suggests, it is not possible to point to a single date when the effects of postcrisis regulatory initiatives became binding. Indeed, as the closing of proprietary trading desks in advance of the formal effective date of the Volcker Rule illustrates, some effects of major new regulations can be seen in advance of the formal compliance dates. Thus, while we follow Bao, O'Hara, and Zhou (2017) and define April 1, 2014, as the beginning of the "Volcker period," we recognize that some effects might have been manifest in the market prior to this date.

Our analysis sheds light on the question of whether postcrisis banking reforms have affected liquidity provision in the corporate bond market by

[11] Committee on the Global Financial System, 2016, Fixed Income Market Liquidity, #55, p. 20.

[12] Committee on the Global Financial System, 2014, Market-making and Proprietary Trading: Industry Trends, Drivers and Policy Implications, #52, p. 28.

[13] In addition, European banks with large corporate bond trading desks also face regulatory changes associated with the Basel Accords 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 its risk-weighted assets in fixed income by 50%. Barclays, as part of a strategic review in May 2014, announced that that it is reducing its investment banking workforce by 25%. See "Preparing UBS for the new market environment," February 2, 2009, UBS Investor Release. "Barclays strategic review," February 12, 2013, Barclays Investor Release; "Press release," July 28, 2011, Credit Suisse Media Release, and "Deutsche Bank cuts prop trading, cautious about 2010," February 4, 2010, Reuters.

examining results separately for dealers that are affiliated with a bank holding company and dealers that are not so affiliated. Bank-affiliated dealers have been impacted by the Volcker Rule, stress tests, and the two Basel Accords. In contrast, nonbank dealers are unlikely to have been directly affected by these regulatory reforms.

II. Data and Sample Construction

In this section, we describe the enhanced TRACE data and the dealer samples that we construct, and we report aggregate corporate bond market statistics. Since the 2002 to 2005 TRACE phase-in period has been extensively examined by various studies that document reduced transaction costs subsequent to the introduction of transaction reporting, and to avoid confounding results by the introduction of transparency, we omit these years and report results for the January 2006 to October 2016 period.

A. Data Description

We rely on an enhanced version of the TRACE data provided by FINRA that includes trade data disseminated to the public as well as (144A bond) trades not disseminated to the public. The data include a dealer identification number, indication of whether the dealer is (as of 2016) affiliated with a bank, and unmasked trade sizes. The database includes over 109,000 unique CUSIPs. However, the majority of these pertain to instruments other than corporate bonds, such as retail notes, foreign government bonds, U.S. agency debentures, pay-in-kind bonds, corporate strips, medium-term notes, and convertible and preferred securities. We consider only the 24,648 CUSIPs identified by Fixed Income Securities Database (FISD) as nonputtable U.S. Corporate Debentures and U.S. Corporate Bank Notes (bond type = CDEB or USBN) with a reported maturity date.

The data include 70.75 million trades completed between January 2006 and October 2016 for these CUSIPS. Table I reports the effects of additional data filters that we implement. We exclude all bonds with less than five trades during the 11-year sample period, as well as bonds with a reported trade size that exceeds the bond's offer size, and bonds for which the TRACE implementation date is missing. We also exclude trades that are reported after the bond's amount outstanding is reported as zero in FISD, and trades with an execution date prior to January 2006. Finally, we exclude trades associated new issuances, including those indicated to be primary market transactions as well as secondary market transactions that occur immediately after the issuance.[14] With these filters imposed, the sample consists of 65.61 million transactions in 22,349 distinct CUSIPs.

[14] The intent is to avoid the possibility that results obtained here could be attributable to the growth in new bond issues and associated trades. If the offering day is on or before the 15th of the month, we exclude the remainder of the issue month; otherwise, we exclude the issue month and the following month.

Table I
Sample Construction

This table summarizes the sample construction. Corporate bond trade data are from TRACE (Trade Reporting and Compliance Engine) and bond descriptive data are from the Mergent Fixed Income Securities Database (FISD). The sample period is January 2006 to October 2016. The aggregate market sample, which includes all dealers and trades, comprises 22,837 unique bonds and 68.2 million trades. We construct two subsamples of active dealers. The Top 70% sample includes those dealers that capture 70% of customer trading volume each year. To construct the Constant Dealer sample, we first select dealers ranked in the top 30 by customer volume in any sample year and then retain dealers that trade each year in the sample period.

	# CUSIPs	# Trades
Aggregate Market Sample		
Corporate bonds in TRACE and FISD	24,648	70,752,451
Exclude bonds having less than five trades over the sample period	23,433	70,749,867
Exclude bonds with a trade size > issue size	23,357	70,285,747
Exclude primary market transactions	23,341	69,513,725
Exclude trades reported after amount outstanding falls to zero	23,172	69,405,828
Exclude bonds with missing TRACE dissemination date	23,166	69,404,280
Exclude trades with pre-2006 execution date	22,837	68,180,930
Exclude trades after offering date (offering day ≤ 15, exclude issue month, otherwise exclude issue month and following month)	22,349	65,611,097
Top 70% Sample		
% of aggregate trades	28%	
% of aggregate volume	68%	
% of customer volume	71%	
Constant Dealer Sample		
% of aggregate trades	58%	
% of aggregate volume	75%	
% of customer volume	76%	

B. Dealer Samples

We conduct a number of analyses that focus on capital commitment by individual dealers. The sample includes nearly 2,700 dealers, approximately 2,100 of which engage in customer trades, but most of whom trade only sporadically. For tractability, we focus the dealer-level analysis on the more active dealers, which we define in two ways. Both of these dealer samples exclude one relatively large dealer that, in 2014, began to report an immediately offsetting transaction for the large majority of its principal trades. Conversations with FINRA indicated that these transactions represented transfers of inventory to an off-shore subsidiary.[15] First, we create a "Top 70%" sample. For each year, we select the largest dealers that together represent 70% of customer-dealer trading volume. The number of dealers that comprise 70% of market share each year ranges between 10 and 12. Individual dealers may enter or depart

[15] Since November 2015, FINRA has required that dealers specifically flag such offshore affiliate transactions. See http://www.finra.org/industry/notices/15-14. Since the affiliate flag was not available for the majority of our sample period, we could not reliably identify which trades involved genuine capital commitment by this bank.

the Top 70% sample over time, and a total of 20 unique dealers enter the Top 70% sample at some point. Second, we construct a "Constant Dealer" sample that consists of the 35 dealers that (i) are active during all sample years and (ii) were among the 30 most active dealers during at least one year. The Top 70% sample includes 28% of all trades, 68% of aggregate volume (including interdealer trading), and 71% of the customer-dealer volume. By comparison, the Constant Dealer sample includes 58% of all trades, 75% of aggregate volume, and 76% of customer-dealer volume.

The main advantage of using 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 the entry of new dealers and the exit of existing dealers. However, the Constant Dealer sample market share increases over time (from 69% in 2006 to 78% in 2016), while the Top 70% sample focuses on dealers with a nearly constant market share. We employ the Top 70% sample in our main tests of changing capital commitment over the sample period. However, when we consider outcomes for bank-affiliated and nonbank dealers, we use the Constant Dealer sample, to ensure that outcomes reflect changes in the behavior of existing dealers as opposed to the entry and exit of dealers.

C. Subperiod Definitions

To shed light on how liquidity and the willingness of dealers to commit capital to the corporate bond market have changed over time, we consider five subperiods. First, we define the January 2006 to June 2007 interval as the precrisis period. During this period TRACE transaction reporting was in effect for all publically issued bonds, and the financial crisis was not yet manifest. We designate this period as the benchmark in our time-series regression analyses. Next, following Friewald, Jankowitsch, and Subrahmanyam (2012), Dick-Nielsen, Feldhutter and Lando (2012), Bao, O'Hara, and Zhou (2017), and Friewald and Nagler (2016), we define July 2007 to April 2009 as the crisis period. We designate May 2009 to June 2010 as the postcrisis period. The Dodd-Frank Act was signed into law on July 21, 2010, and we refer to July 2010 to March 2014 as the regulation period. Finally, following Bao, O'Hara, and Zhou (2017), we designate the post April 1, 2014, period as the Volcker period.

D. Aggregate Market Statistics

Table II reports aggregate market statistics for the 65.61 million trades that occurred between January 2006 and October 2016 and pass the filters described on Table I. Trading volume, including both customer-to-dealer and interdealer trades, was approximately $3 trillion in 2006 and 2007, before declining to $2.3 trillion during the financial crisis in 2008. Trading activity then surged to over $3.7 trillion per year from 2010 to 2012, and between $4.2 trillion and $4.4 trillion per year from 2013 to 2016 (annualized). This increase in trading activity was accompanied by rapid growth in corporate bonds outstanding, from

Table II
Summary Statistics

This table provides descriptive statistics on the size of the corporate bond market between January 2006 and October 2016. 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)
2006	3,141	3,331	8,050	0.94	2,770	372
2007	2,956	3,577	8,069	0.83	2,542	414
2008	2,309	3,658	7,567	0.63	2,095	215
2009	3,297	4,327	8,259	0.76	2,928	369
2010	3,752	4,820	8,996	0.78	3,133	620
2011	3,722	5,171	9,371	0.72	3,070	652
2012	3,851	5,723	10,052	0.67	3,115	737
2013	4,217	6,199	10,721	0.68	3,364	853
2014	4,227	6,557	10,967	0.64	3,801	426
2015	4,402	7,147	11,289	0.62	4,402	0
2016 (10 months)	3,723	6,726	10,291	0.55	3,723	0

$3.3 trillion (8,050 issues) in 2006 to over $7.1 trillion (11,289 issues) in 2015, due to robust new issuance activity.

Aggregate trading activity relative to the amount of corporate bonds outstanding has generally trended downward, from 94% in 2006 to a financial crisis low of 63% in 2008, before recovering to over 75% in 2009 and 2010, and since declining to 62% in 2015. Table II also reports the volume of trading disseminated through TRACE and volume not so disseminated. Bonds whose trades were not reported through TRACE after February 2005 are private 144A bonds, many of which are high-yield. All corporate bond trade prices are publicly reported through TRACE after May 2014.

III. Trade Execution Costs

We estimate customer trade execution costs by means of indicator variable regressions, following Schultz (2001), Edwards, Harris and Piwowar (2007), and Bessembinder, Maxwell, and Venkataraman (2006). We report results for the Aggregate, Top 70%, and Constant Dealer samples, as well as for small (less than $100,000), medium (between $100,000 and $1 million), large (between $1 million and $10 million), and block (greater than $10 million) trade size. We also report results for investment-grade and high-yield bonds, for issue size categories defined by $500 million and $1 billion cutoffs. We also break out transaction costs estimates for "young" bonds, which are those that were issued within one year prior to the trade date. Finally, we report results for "click" bond trades, that is, trades that are more likely to be completed through an electronic

request for quotation platform. Relying on the evidence in Hendershott and Madhavan (2015), we define this category as trades of $5 million or less in young, investment-grade, large issue size bonds. "Call" trades are all trades not defined as "Click."

The trading cost estimates are obtained by regressions of ΔP_{st}, the percentage change in the trade price for a given bond between 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 equal to one for customer buys and negative one for customer sells at times s and t. The resulting slope coefficient estimates the effective one-way trade execution cost and can be interpreted as half the difference between the price at which dealers will sell a bond and the price at which they will purchase the bond.[16] The analysis includes all customer-dealer trades. To improve the precision of the trading cost estimates, we include in the regression changes in control variables expected 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.[17]

Table III reports the resulting trading cost estimates. Focusing first on the aggregate sample, we can see that on average (one-way) trade execution costs were nearly the same at the end of the sample as they were at the beginning, equal to 0.40% during the precrisis period and 0.42% during the Volcker period. Average trading execution costs increased to 0.65% during the financial crisis, remained elevated at 0.63% during the postcrisis period, then declined to 0.47% during the regulation period and, as noted, 0.42% during the Volcker period. Figure 1 plots average customer trade execution costs over the sample period for investment grade and high-yield bonds.[18] Average trade execution costs are notably lower for the Top 70% and Constant Dealer samples, which by construction emphasize the largest dealers in the market, as compared to the aggregate sample. Assessing why trades with smaller dealers involve substantially higher execution costs comprises an interesting question for future research.

Table III also reports execution costs based on trade size and bond characteristics. In general, execution costs for each trade size category display similar intertemporal patterns, namely, increasing during the financial crisis and

[16] Estimation is based on the pooled sample using 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. Estimates for subsets of bonds are identified by an indicator variable to identify the time t trade that meets the corresponding definitional criteria.

[17] The control variables include the percentage change in the Barclays Capital U.S. the 7- to 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 three-month Treasury Index, and the percentage change in the Barclays Capital U.S. High-yield Bond Index in excess of the percentage change in the Barclay's Capital U.S. Corporate Bond Index.

[18] The slight uptick in average trade execution costs during the recent period can be explained in part by the commensurate decline in average trades size, reflecting the fact that execution costs in corporate bonds are typically larger (in percentage terms) for smaller trades.

Table III

Estimates of Transaction Costs on Customer Trades: 2006–2016

This table reports estimated one-way trade execution costs paid by customers in customer-to-dealer principal trades for the aggregate market, Top 70% and Constant Dealer samples described in Table I. Transaction costs are estimated following the regression-based model implemented by Bessembinder, Maxwell, and Venkataraman (2006). Small, medium, and large issue sizes are defined by $500 million and $1 billion cutoffs. "Young" refers to bonds that have traded less than one year. "Clicking" trades comprise trades in young, investment-grade, large issue bonds that are less than or equal to $5 million. All other trades are categorized as "calling" trades. Percentages of total volume attributable to each size category are reported in italics.

	January 2006 to June 2007	July 2007 to April 2009	May 2009 to June 2010	July 2010 to March 2014	April 2014 to October 2016
	Precrisis	Crisis	Postcrisis	Regulatory	Volcker
Aggregate Market Sample	0.40%	0.65%	0.63%	0.47%	0.42%
Top 70% Sample	0.24%	0.45%	0.35%	0.26%	0.25%
Constant Dealer Sample	0.31%	0.56%	0.54%	0.43%	0.39%
By Trade Size: Aggregate Market Sample					
Transaction Cost (%): ≤$100K	0.61%	0.89%	0.87%	0.69%	0.62%
% of Total Volume	*1%*	*2%*	*2%*	*2%*	*2%*
Transaction Cost (%): >$100K & ≤$1M	0.25%	0.47%	0.42%	0.31%	0.29%
% of Total Volume	*7%*	*9%*	*9%*	*9%*	*10%*
Transaction Cost (%): >$1M & ≤$10M	0.19%	0.33%	0.28%	0.21%	0.20%
% of Total Volume	*60%*	*60%*	*58%*	*61%*	*61%*
Transaction Cost (%): > $10M	0.16%	0.29%	0.23%	0.18%	0.16%
% of Total Volume	*32%*	*29%*	*31%*	*28%*	*27%*
By Bond Characteristics: Aggregate Market Sample					
Transaction Cost (%): Investment Grade	0.36%	0.71%	0.65%	0.45%	0.38%
% of Total Volume	*58%*	*64%*	*68%*	*63%*	*69%*
Transaction Cost (%): High Yield	0.46%	0.50%	0.56%	0.51%	0.51%

(*Continued*)

Table III—*Continued*

	January 2006 to June 2007	July 2007 to April 2009	May 2009 to June 2010	July 2010 to March 2014	April 2014 to October 2016
	Precrisis	Crisis	Postcrisis	Regulatory	Volcker
% of Total Volume	*42%*	*36%*	*32%*	*37%*	*31%*
Transaction Cost (%): Large Issue Size	0.36%	0.68%	0.57%	0.38%	0.33%
% of Total Volume	*37%*	*47%*	*49%*	*48%*	*52%*
Transaction Cost (%): Medium Issue Size	0.38%	0.64%	0.67%	0.48%	0.45%
% of Total Volume	*29%*	*29%*	*28%*	*32%*	*32%*
Transaction Cost (%): Small Issue Size	0.45%	0.59%	0.70%	0.64%	0.58%
% of Total Volume	*34%*	*24%*	*23%*	*20%*	*16%*
Transaction Cost (%): Young bonds	0.23%	0.50%	0.39%	0.31%	0.27%
% of Total Volume	*36%*	*36%*	*41%*	*42%*	*36%*
Transaction Cost (%): Old bonds	0.44%	0.69%	0.70%	0.53%	0.46%
% of Total Volume	*64%*	*64%*	*59%*	*58%*	*64%*
Transaction Cost (%): Clicking Trades	0.30%	0.66%	0.40%	0.32%	0.26%
% of Total Volume	*2%*	*5%*	*5%*	*5%*	*7%*
Transaction Cost (%): Calling Trades	0.41%	0.65%	0.65%	0.48%	0.44%
% of Total Volume	*98%*	*95%*	*95%*	*95%*	*93%*

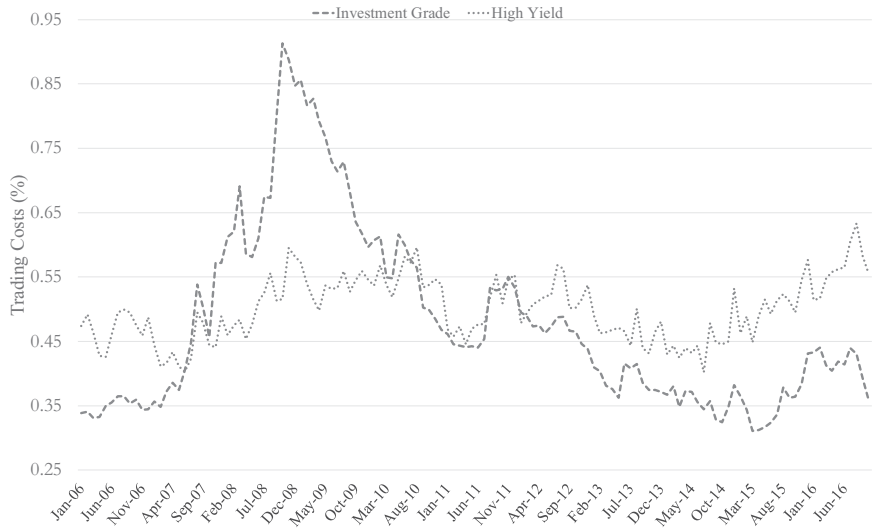

Figure 1. Monthly corporate bond trading costs on customer trades with dealers, 2006–2016. This figure plots estimated trade execution costs paid by customers in customer-to-dealer principal trades for the aggregate market sample described in Table I. Transaction costs are estimated following the regression-based model implemented by Bessembinder, Maxwell, and Venkataraman (2006).

remaining elevated immediately thereafter before declining in the recent Volcker period to levels close to those observed during the precrisis benchmark period. Consistent with prior studies, small trades pay the largest percentage execution costs in corporate bonds. Small-trade execution costs are approximately 0.61% during the precrisis period and the recent Volcker period, but increased to 0.89% during the financial crisis. In contrast, trade execution costs for block trades averaged 0.16% during the first and last periods, reaching a maximum of 0.29% during the financial crisis.

Average trade execution costs were modestly greater for high-yield than investment-grade bonds in the initial precrisis period (0.46% for high-yield bonds versus 0.36% for investment-grade bonds). However, liquidity evolved differently for investment-grade and high-yield bonds thereafter. Transaction costs for investment-grade bonds almost doubled during the financial crisis to 0.71% (from 0.36% in the precrisis period), before declining in the Volcker period to 0.38%. In contrast, the increase in transaction costs for high-yield bonds during the financial crisis was modest, to 0.50% from 0.46% precrisis. Notably, transaction costs for high-yield bonds did not decrease in the immediate postcrisis period, and remain moderately higher (0.51%) in the Volcker period as compared to the precrisis period, when they averaged 0.46%. This result is consistent with the evidence reported by Goldstein and Hotchkiss (2017).

The results in Table III also show that trade execution costs are lower for young bonds, which is broadly consistent with the well-documented "on-the-run" phenomenon, where newly issued Treasury and corporate securities enjoy more liquid markets (Krishnamurthy (2002) and Ronen and Zhou (2013)). During the January 2006 to June 2007 benchmark period, trading costs averaged 0.23% for young bonds versus 0.44% for older bonds. Trade execution costs for young and old bonds evolved similarly during and after the financial crisis.

Finally, we consider average trade execution costs for clicking and calling trades as defined above. Clicking trades represent a small but growing (from 2% during the benchmark period to 7% during the Volcker period) share of the market. The results show that average execution costs are lower for clickable trades in both the January 2006 to June 2007 benchmark period (0.30% versus 0.41% for other trades) and in the recent Volcker period (0.26% versus 0.44%). Thus, the slight deterioration in execution costs for the overall sample is concentrated in trades that are more likely to occur through traditional telephone-based dealer trading, while execution costs for clicking trades declined modestly.

On balance, the results regarding average trade executions costs reported here do not support the notion that there has been a dramatic decline in corporate bond market liquidity in recent years. Customer trade execution costs rose during the crisis period, but moderated thereafter, and for the full sample are only 0.02% higher during the recent Volcker period as compared to the benchmark period.[19]

However, execution costs measure only the direct cost of trades that are successfully completed. As such, they do not account for elapsed time or other search costs, or for costs associated with trades that were desired but not completed. While databases exist to allow the assessment of time-to-completion and fill rates for institutional equity orders, to our knowledge no similar data exist for bond orders. In lieu of such data, we study dealers' willingness to commit capital to market-making, and also report on other aspects of market quality, overall and during stressed periods.

IV. Dealer-Level Measures of Market Quality

We construct several measures relevant to the assessment of liquidity and market quality, as described below, for both the Top 70% and Constant Dealer samples. Since most individual bonds trade only sporadically, we use a portfolio approach. Each bond is assigned to one of eight portfolios, six for public bonds and two for privately issued (144A) bonds. Public bonds are allocated to portfolios based on whether the bond is of small (less than $500 million), medium (between $500 million and $1 billion), or large (greater than $1 billion) issue size, and whether the bond is rated investment-grade or high-yield. Private

[19] These findings are consistent with two recent working papers that present coarser estimates of trading costs. Trebbi and Xiao (2016) examine U.S. data, Aquilina and Suntheim (2017) examine U.K. data, each reporting that execution costs are not higher in recent years.

(144A) bonds are allocated to two portfolios based on whether the bond is rated investment-grade or high-yield.[20] Below we report results that are aggregated across dealers; Tables IA.II and IA.III of the Internet Appendix contain results that pertain to an average dealer portfolio.[21]

A. Measuring Dealer 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 an aggregate dealer inventory measure that included holdings in commercial paper and mortgage-backed securities along with corporate bonds.[22] Further, the Federal Reserve inventory data are aggregated across bonds and dealers, which precludes any cross-sectional analysis. We therefore construct our own dealer-specific measures of corporate bond capital commitment. Our intent is to measure the extent to which dealers are willing to use their own capital to absorb customer order imbalances, as opposed to simply matching customers in an agency role. In the absence of initial inventory data for each dealer in each bond, we cannot construct a dealer's total inventory. Instead, we measure the extent to which dealers allow trading to flow through to changes in inventory.

A.1. Time-Weighted Daily Capital Commitment

Our first measure focuses on dealer capital commitment within the trading day, taking into account the time elapsed before a position is reversed. Specifically, we calculate, 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 accumulated principal sell volume (including trades with both customers and other dealers) up to that point in the trading day (i.e., since midnight). This measure equals zero if the dealer's purchases on a principal basis are equal to its sales and increases to the extent that the dealer's purchases versus sales are unbalanced in either direction. This measure therefore captures the extent to which the dealer allows its overall inventory position to move away from the level at the beginning of the day. We then compute the average of this measure within each dealer-portfolio-day, weighting each observation by the length of time that the capital is committed (i.e., until the next trade, or if no trade occurs then until midnight). Finally, we sum this measure across all dealer portfolios on a given day to obtain an aggregate (across dealers in the sample) measure of daily capital commitment. We report on both the total dollar capital commitment and the dollar figure scaled by trading volume for dealers in the sample. Note that, in contrast to the overnight measure

[20] Sample sizes for 144A bonds were too small to allow for assignment to issue size portfolios.

[21] The Internet Appendix may be found in the online version of this article.

[22] 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 indicate that mortgage-backed securities account for over 50% of dealers' holdings.

described next, daily capital commitment will be positive even if all inventory changes were reversed before the end of the trading day. In addition, the measure is larger when positions are entered earlier or exited later in the day, other things equal.

A.2. Overnight Capital Commitment

Our second measure focuses on dealers' willingness to allow customer trades to shift their inventory away from the beginning-of-day level without offsetting trades before the end of the day, that is, on the change in inventory since the beginning of the day that is carried overnight. Specifically, for each dealer-portfolio day, we calculate the absolute value of the dealer's principal buy volume less principal sell volume. We then sum this measure across dealer portfolios for each day, reporting the resulting total dollar overnight capital and the overnight capital relative to total daily trading activity for the dealers in the sample. This ratio has the simple interpretation as the percentage of daily trading activity that is carried into overnight inventory.

A.3. Weekly Capital Commitment

Finally, we measure dealers' willingness to commit capital over multiple days. This measure focuses on dealers' willingness to allow customer trades to shift their inventory away from the beginning-of-week level without offsetting trades before the end of the week, that is, the change in inventory since the beginning of the week that is carried over the weekend. In particular, we compare accumulated weekly (beginning at midnight Friday night) dealer principal buy volume for each portfolio to the accumulated principal sell volume for the week. We also sum this measure across dealer portfolios, reporting both the dollar total and the total relative to the week's trading activity for the dealers in the sample. The latter can be interpreted as the percentage of weekly trading activity that is carried as inventory over the following weekend.

A.4. Summary Statistics for Dealer Capital Commitment

Table IV reports summary statistics for the dealer capital commitment measure, while Figure 2 displays the time series of overnight capital commitment scaled by volume for the Top 70% dealer sample. The data in Table IV show a clear pattern whereby aggregate capital commitment for the dealers in the Top 70% sample declined during the financial crisis, rebounded in dollar (but not relative to volume) terms during the postcrisis period, before declining again during the regulatory period and declining further to near-crisis levels, during the recent Volcker period.

Top 70% dealers committed $1.38 billion in overnight capital on average for the full sample. Overnight capital commitment decreased from an average of $1.63 billion per night during the precrisis period to $1.17 billion per night during the financial crisis, before rebounding to $1.50 billion per night during

Table IV
Capital Commitment Summary Statistics

This table reports summary statistics on capital commitment measures. The capital commitment measures are aggregated at the daily and weekly levels and all other variables are aggregated at the monthly level. Daily, weekly, and monthly averages are reported for five subperiods and for the full January 2006 to October 2016 sample period. All variables are computed using the dealers in the Top 70% sample described in Table I. Variable definitions are provided in Internet Appendix Table IAI.

	January 2006 to June 2007	July 2007 to April 2009	May 2009 to June 2010	July 2010 to March 2014	April 2014 to October 2016	January 2006 to October 2016
	Precrisis	Crisis	Postcrisis	Regulatory	Volcker	Full Sample
Time-Weighted Daily Capital / Volume (%)	11.3	10.6	9.3	8.5	7.4	9.1
Time-Weighted Daily Capital ($ Millions)	872.0	603.4	780.6	721.9	703.5	724.5
Overnight Capital / Volume (%)	21.1	20.4	17.8	16.2	13.8	17.2
Overnight Capital ($ Millions)	1,625.0	1,168.0	1,498.8	1,383.9	1,310.6	1,375.4
Weekend Capital / Volume (%)	10.4	10.7	8.7	7.6	6.4	8.4
Weekend Capital ($ Millions)	3,881.0	2,941.7	3,513.5	3,165.2	3,043.6	3,234.7
Dollar Volume / Amount Outstanding (%)	7.1	4.8	5.6	4.7	4.1	5.0
Average Trade Size ($ Thousands)	2,004.3	1,326.2	1,490.2	1,279.8	1,212.8	1,394.6
Principal Volume / Total Volume (%)	91.3	91.7	92.5	92.1	94.3	92.5

the immediate postcrisis period. Overnight capital commitment declined to $1.39 billion during the regulatory period, and to $1.31 billion per night during the recent Volcker period. The decline in total overnight capital commitment during the financial crisis was only slightly more pronounced than the decline in trading activity as reported in Table II, as the proportion of trading carried into overnight inventory decreased from 21.1% during the precrisis period to 20.4% during the financial crisis. In contrast, the decrease in overnight capital commitment in recent years occurred even as trading volumes increased, and the proportion of trading activity carried into overnight inventory declined to 16.2% during the regulatory period and further to 13.8% during the Volcker period. These results indicate that dealers absorbed a smaller proportion of trading into inventory in recent years.

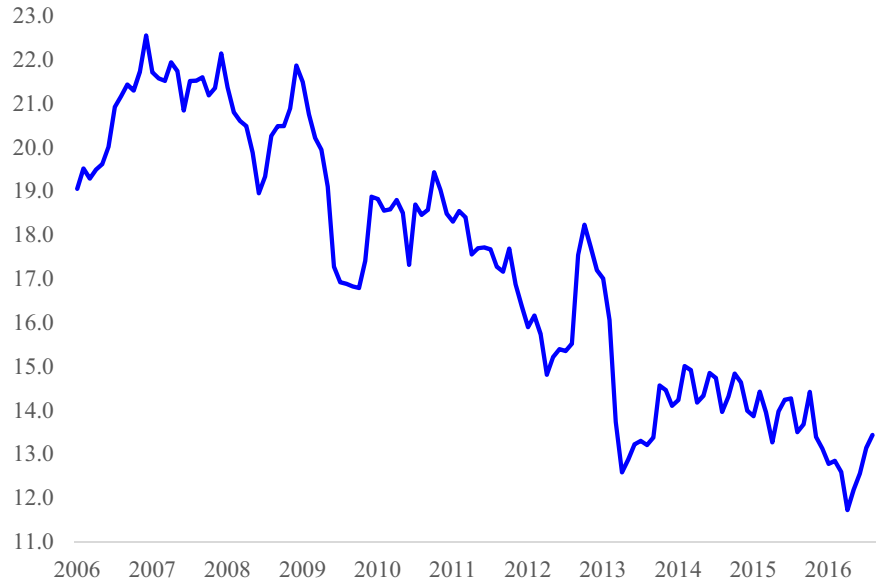

Figure 2. Overnight capital / volume (%) in corporate bonds, 2006–2016. This figure plots the six-month moving average aggregate overnight capital scaled by volume for the Top 70% dealers over the January 2006 to October 2016 period. Daily observations are averaged over each month. (Color figure can be viewed at wileyonlinelibrary.com)

In general, the summary statistics for time-weighted daily capital and weekly capital commitment are consistent with those for overnight capital commitment. Daily capital commitment relative to volume decreased from 11.3% during the precrisis period to 8.5% during the regulatory period and to 7.4% during the recent Volcker period. Similarly, the proportion of weekly trading carried as inventory over the weekend declined from 10.4% during the precrisis period to 7.6% during the regulatory period and 6.4% during the Volcker period.

Each measure of capital commitment indicates a notable decrease over time in the extent to which dealers allow their inventory to change as a consequence of trading, and decreased willingness to carry such changes overnight or over weekends. On balance, the results indicate that dealers were more likely to offset trades with trades in the opposite direction, thereby committing less of their own capital to absorb customer order imbalances, during the Volcker period as compared to the immediately preceding regulatory period, and, by most measures, even compared to the financial crisis period.

B. Other Indicators of Market Quality Measured at the Dealer Level

B.1. Trading Activity and Trade Size

Overall trading activity is a commonly used proxy for market liquidity, with the obvious interpretation that larger volumes are indicative of a more

liquid market, other things equal. In addition to trading activity relative to the amount outstanding (i.e., turnover), we consider the average trade size. The data reported in Table IV verify that corporate bond trading activity by the Top 70% sample relative to the amount outstanding has decreased over time, from 7.1% in the precrisis period to 4.8% during the financial crisis. Monthly turnover partially rebounded to 5.6% during the precrisis period before falling to 4.7% during the regulatory period and to 4.1% during the recent Volcker period.

Average trade size for dealers in the Top 70% sample decreased from $2 million in the precrisis period to $1.33 million during the financial crisis. The average trade size increased to $1.49 million in the postcrisis period before falling to $1.28 million during the regulatory period and $1.21 million during the Volcker period. A decrease in trade sizes could reflect customers' desire to trade in smaller increments, for example, due to the entry of more retail customers, or could indicate that it is difficult to locate counterparties for larger trades that are desired.

B.2. Principal versus Agent Trading

A simple measure of dealers' willingness to commit capital to enhance liquidity is their completion of trades on a principal basis (the dealer is the counterparty to the customer trade) rather than an agent basis (the dealer arranges for a trade between two customers or with another dealer). TRACE reporting requires that a dealer 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 employ a narrower definition of principal trades that excludes those trades that are 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, e.g., Edwards, Harris, and Piwowar (2007), it seems reasonable to infer that virtually all offsetting transactions that occur within one minute are in fact prearranged and that dealer capital is not meaningfully at risk.[23]

As Table IV shows, the percentage of principal trading in the Top 70% sample was 91.3% in the precrisis period, increased slightly to 91.7% during the crisis period, and then increased slightly to 92.1% of volume during the regulatory period before increasing notably to 94.3% of volume during the recent Volcker period. In Section V, we further assess which dealers—bank-affiliated or nonbank—are responsible for the increase in principal trading observed in the recent sample.

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

V. Time-Series Regressions

The univariate means reported on Table IV indicate reductions in the recent Volcker period relative to the precrisis period in dealers' capital commitment, bond turnover, and average trade size. In Table V, we report results of time-series regressions that include control variables and that allow for formal statistical tests for equality of coefficients across time periods. Probability values are based on Newey-West standard errors, with the number of lags selected automatically based on the criterion described in Newey and West (1994).

The control variables in these regressions allow for changes in market conditions. We control for recent market-wide stock (S&P 500 index) and bond (Barclays Capital U.S. Corporate Bond Index) returns, since Hameed, Kang, and Viswanathan (2010) and Comerton-Forde et al. (2010) show that lower returns reduce dealers' propensity to supply liquidity, via their impact on market-making profits. We also control for changes in the Chicago Board Options Exchange (CBOE) stock market volatility index (VIX) and the three-month LIBOR. We also include aggregate flows into or out of corporate bond mutual funds and ETFs to account for transaction demand on the part of corporate bond funds.[24] Finally, we include the percentage of total trading that occurs in trades of $100,000 or less to account for retail trading activity.[25]

The key variables in this specification are indicator variables for the crisis (July 2007 to April 2009), postcrisis (May 2009 to June 2010), regulatory (July 2010 to March 2014), and Volcker (April 2014 to October 2016) subperiods. The regression intercept pertains to the precrisis (January 2006 to June 2007) benchmark period, and thus the coefficient estimates on the period indicator variables measure changes in the regression intercepts relative to the benchmark period. We report p-values for each indictor variable coefficient, and indicate via asterisks at the bottom of Table V whether formal statistical tests reject the hypothesis that coefficients on the indicator variables are equal across subperiods.

A. Capital Commitment

In columns (1) to (6) of Table V, Panel A, we report results obtained when the dependent variable in the regression is one of the measures of dealer capital commitment. The first two columns pertain to time-weighted daily capital, the second pair to overnight capital, and the third pair to weekly capital, with

[24] This variable is standardized by total net asset value in the prior month. Data on fund flows are obtained from the Investment Company Institute.

[25] While the coefficients estimated on these control variables are not our main focus, we find that dealer capital commitment in dollars is positively associated with recent stock market returns. Increases in VIX are associated with decreased capital commitment relative to trading volume, but (perhaps surprisingly), with greater capital commitment in dollars. Increases in LIBOR are associated with decreased capital commitment relative to volume, as are increased gross flows to or from bond mutual funds and ETFs. Finally, increased retail trading is associated with smaller capital commitment.

Table V

Time-Series Regressions: Capital Commitment

This table reports time-series regression results over the January 2006 to October 2016 period. Each regression includes four time period indicators; the benchmark period is the January 2006 to June 2007 precrisis period. The capital commitment measures are computed at the daily and weekly levels and all other variables are computed at the monthly level. All dependent variables are computed using the dealers in the Top 70% sample described in Table I. All regressions report Newey-West standard errors and include market controls. Tests for statistical differences between time periods are included below the regression results. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. "ns" stands for not significant at a 10% confidence level. Variable definitions are provided in Internet Appendix Table IAI. Sample period (January 2006 to October 2016) averages for each dependent variable are shown above the regression results.

	(1) Time-Weighted Daily Capital / Volume (%)	(2) Time-Weighted Daily Capital ($ Millions)	(3) Overnight Capital / Volume (%)	(4) Overnight Capital ($ Millions)	(5) Weekend Capital / Volume (%)	(6) Weekend Capital ($ Millions)	(7) Dollar Volume / Amount Outstanding (%)	(8) Ln Average Trade Size ($ Thousands)	(9) Principal Volume/ Total Volume (%)
Dependent Variable Average	9.1	724.5	17.2	1,375.4	8.4	3,234.7	5.0	7.2	92.5
Crisis	−0.3	−201.1***	0.1	−332.6***	0.1	−590.7***	−1.9***	−0.2**	−0.4
	(0.527)	(0.000)	(0.897)	(0.000)	(0.885)	(0.000)	(0.000)	(0.014)	(0.567)
Postcrisis	−1.6***	12.6	−2.6**	71.1	−1.8**	78.5	−0.8***	0.1	0.7
	(0.008)	(0.752)	(0.023)	(0.355)	(0.010)	(0.692)	(0.003)	(0.310)	(0.223)
Regulatory	−2.2***	−96.4***	−3.6***	−141.2**	−2.9***	−411.7*	−2.1***	−0.2**	0.1
	(0.000)	(0.009)	(0.000)	(0.043)	(0.000)	(0.056)	(0.000)	(0.028)	(0.862)
Volcker	−3.5***	−129.1***	−6.4***	−240.7***	−4.2***	−620.6***	−2.8***	−0.3***	2.6***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Corp Bond Index Return ($t-1$)	2.6	66.6	4.4	61.9	2.4	936.8	0.8	0.3	−9.8*
	(0.532)	(0.784)	(0.585)	(0.895)	(0.684)	(0.529)	(0.561)	(0.276)	(0.055)
Stock Market Index Return ($t-1$)	−5.0	393.7	−11.6	722.0	−8.6*	1,423.0	4.9***	1.2***	−2.3
	(0.239)	(0.119)	(0.159)	(0.139)	(0.083)	(0.218)	(0.003)	(0.000)	(0.646)
Chg. in VIX ($t-1$)	−0.1	7.9	−0.3	15.0	−0.3*	25.5	0.1**	0.0***	−0.1
	(0.223)	(0.297)	(0.238)	(0.303)	(0.092)	(0.529)	(0.042)	(0.001)	(0.373)
Chg. in Three-Month Libor ($t-1$)	0.4	−187.2**	0.6	−369.8***	2.1	−472.7	−1.8***	−0.3***	−2.5
	(0.699)	(0.012)	(0.720)	(0.008)	(0.161)	(0.103)	(0.001)	(0.000)	(0.249)

(*Continued*)

Table V—*Continued*

	(1) Time-Weighted Daily Capital / Volume (%)	(2) Time-Weighted Daily Capital ($ Millions)	(3) Overnight Capital / Volume (%)	(4) Overnight Capital ($ Millions)	(5) Weekend Capital / Volume (%)	(6) Weekend Capital ($ Millions)	(7) Dollar Volume / Amount Outstanding (%)	(8) Ln Average Trade Size ($ Thousands)	(9) Principal Volume/ Total Volume (%)
ABS(MF + ETF Flows $(t-1)$ / Tot. Out.$(t-2)$)	31.0	−3,228.9	67.1	−6,243.5	0.2	−6,957.1	−33.7**	−4.3	−19.9
	(0.356)	(0.146)	(0.274)	(0.140)	(0.996)	(0.493)	(0.035)	(0.154)	(0.499)
% Retail Volume	−40.0*	−4,165.6***	−78.2*	−7,785.2***	11.7	−21,588.2***	−26.8*	−17.4***	43.0
	(0.058)	(0.001)	(0.055)	(0.001)	(0.628)	(0.000)	(0.070)	(0.000)	(0.204)
Constant	11.8***	962.0***	22.0***	1,795.0***	10.3***	4,272.6***	7.8***	14.8***	90.8***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2,716	2,716	2,716	2,716	566	566	130	130	130
Adjusted R^2	0.124	0.168	0.145	0.149	0.259	0.167	0.657	0.673	0.401
Test: Crisis = Postcrisis	**	***	***	***	***	***	***	***	*
Test: Crisis = Regulatory	***	***	***	***	***	ns	ns	ns	ns
Test: Crisis = Volcker	***	***	***	**	***	ns	***	***	***
Test: Postcrisis = Regulatory	ns	***	ns	***	ns	**	***	***	ns
Test: Postcrisis = Volcker	***	***	***	***	***	***	***	***	**
Test: Regulatory = Volcker	***	ns	***	**	***	ns	***	ns	***

even-numbered columns measuring capital commitment in dollars and odd-numbered columns measuring capital commitment relative to trading volume.

When focusing on capital commitment in dollars (columns (2), (4), and (6)), the results point to an economically and statistically significant decline during the financial crisis as compared to the precrisis benchmark period. The decrease is $201 million in daily capital commitment, $333 million in overnight capital commitment, and $591 million in weekend capital commitment. However, when measured relative to trading activity, the results show no significant decrease in capital commitment during the financial crisis, after allowing for variation in the control variables. In particular, the coefficient estimate on the crisis-period indicator variable is consistently statistically insignificant (columns (1), (3), and (5)).

The coefficient estimates on the indicator variable for the postcrisis period show an insignificant increase in capital commitment in dollars as compared to the precrisis period, after allowing for variation in the control variables. However, capital commitment relative to trading volume decreased by statistically significant amounts during the postcrisis period as compared to the benchmark period, with the point estimates indicating a decrease of 1.6% in daily capital, 2.6% in overnight capital, and 1.8% in weekly capital.

Looking at the regulatory period, the results in Table V point to decreased capital commitment relative to the precrisis benchmark, both in dollar terms and relative to trading volume. The decreases in dollar capital commitment during the regulatory period are smaller (and except for weekend capital, the differentials are statistically significant at the 5% level) than those observed during the financial crisis. However, in light of increased volumes, capital commitment as a percentage of trading activity decreased significantly during the regulatory period as compared to both the precrisis benchmark period and the crisis period. The decline relative to the precrisis benchmark period is 2.2% in daily capital relative to volume, 3.6% in overnight capital relative to volume, and 2.9% in weekly capital relative to volume.

Outcomes for the Volcker period are of particular interest due to the increased restrictions on bank trading activity specified by the Volcker Rule. The results in Table V point to decreased capital commitment during the Volcker period after allowing for variation in the control variables, in terms of both dollar capital commitment and capital commitment relative to trading activity. Notably, capital commitment relative to trading volume during the Volcker period is lower not only relative to the precrisis benchmark, but also relative to the crisis, postcrisis, and regulatory periods, with the differential across periods statistically significant in each case.

The decreases in dealer capital commitment during the Volcker period are economically substantial. Focusing on overnight capital commitment in dollars, the decrease during the Volcker period relative to the precrisis benchmark is $241 million, which is large relative to the full sample average of $1.38 billion, and also relative to the decline in the immediately preceding regulatory period, which was $141 million. Overnight capital commitment relative to trading volume decreased by 6.4% during the Volcker period as compared to the precrisis

benchmark, which is large relative to the full-sample average of 17.2%. By comparison, overnight capital commitment relative to trading volume decreased by 3.6% during the immediately preceding regulatory period.

To summarize, the results reported in Table V indicate economically large and statistically significant decreases in dealer capital commitment during the Volcker period as compared to preceding periods, after allowing for changes in the control variables. Capital commitment relative to trading volume is substantially lower during the Volcker period than during the financial crisis or the immediately preceding regulatory period. These results are consistent with the views that the Volcker Rule has reduced dealers' willingness to commit capital in support of market-making in corporate bonds. However, these results are also consistent with the views that increased competition and reduced search costs attributable to growth in electronic trading and in the holdings of corporate bond mutual funds and ETFs decreased the need for capital commitment by traditional dealers. We provide more evidence on this issue in Section VI below, where we consider outcomes separately for bank-affiliated and nonbank dealers.

B. Other Market Quality Measures

In Table V, we also report results obtained when the dependent variable is trading volume relative to the amount outstanding (i.e., turnover, column (7)), natural logarithm of average trade size (column (8)), and principal volume as a percentage of total volume (column (9)). In general, the results indicate shifts in market quality during the financial crisis as compared to the precrisis benchmark that were accentuated rather than reversed in the periods following the financial crisis.

Results reported in column (7) of Table V show that monthly turnover was reduced by 1.9% during the financial crisis as compared to the precrisis benchmark. This decline is substantial relative to the full sample average turnover (for the Top 70% sample) of 5%. Turnover continued to decline thereafter, and during the recent Volcker period was 2.8% lower than during the benchmark period, after allowing for changes in the control variables. Results reported in column (8) of Table V show a similar pattern in average log trade size, which was 0.20 lower during the financial crisis and 0.30 lower during the recent Volcker period, as compared to the precrisis benchmark.

A notable exception to the overall pattern is observed for principal volume as a percentage of total volume (column (9)). Principal trading was not significantly different during the financial crisis period, the postcrisis period, or the regulatory period, but increased by a statistically significant 2.6% during the recent Volcker period, as compared to the precrisis period.

Taken together, the results reported in Table V suggest a different trading environment in the recent Volcker period as compared to the January 2006 to June 2007 benchmark period: dealers' daily, overnight, and weekly capital commitment, trading volume relative to amount outstanding, and average trade size have all declined. Decreases in these measures during the financial crisis

period are not unanticipated. More noteworthy is the fact that these measures have not recovered during the regulatory period and Volcker periods.

VI. Possible Explanations for Decreased Capital Commitment

We next examine the possibility that the secondary market for corporate bonds has been affected by postcrisis regulations focused on banks. To do so, we estimate results separately for dealers that are affiliated with banks and for dealers that are not bank affiliated. We also consider the potential effects of increases in electronically facilitated trading.

As noted above, the data provided to us mask dealer identifications. However, FINRA identified for us the dealers in our Constant Dealer sample that are affiliated with banks versus those that are not so affiliated. A recent industry report identifies Cantor Fitzgerald & Co., Daiwa Capital Markets Americas, Jefferies & Company, and Nomura Securities International as examples of prominent nonbank dealers active in the U.S. corporate bond market.[26]

It should be noted that FINRA designates (classifies) each dealer as bank-affiliated or not based on their 2016 status, that is, bank affiliation status does not evolve over time. In particular, Goldman Sachs and Morgan Stanley, which became bank holding companies during 2008, would be identified for our purposes as bank-affiliated dealers throughout our sample.[27] This research design is appropriate for our purposes, because we are not interested in assessing the effects of dealer shifts from nonbank to bank status in the midst of the financial crisis. Rather, we seek to assess the effects of postcrisis banking regulations, which depend on dealers' status as bank-affiliated (treated) or not bank-affiliated (nontreated) at the time the regulations become effective.

For this analysis, we shift to the Constant Dealer sample, so that the results for the bank-affiliated and nonbank samples reflect outcomes and choices of common sets of dealers and do not reflect the entry or exit of participants. Within the Constant Dealer sample, 10 dealers are nonbank, while 25 are bank-affiliated.

A. Summary Statistics for Bank and Nonbank Dealers

Table VI provides sample statistics by subperiod for bank and nonbank dealers contained in the Constant Dealer sample. Panel A reports on market shares, average customer trade execution costs, and other trading statistics, while Panel B reports on capital commitment measures.

The data in Panel A of Table VI show that nonbank dealers' share of overall trading activity is relatively small but has increased substantially over time. During the precrisis period, nonbank dealers participated in 4.4% of overall trading volume, as compared to 13.5% during the Volcker period. The nonbank

[26] 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.

[27] See http://www.nytimes.com/2008/09/22/business/22bank.html.

Table VI

Capital Commitment Summary Statistics: Bank versus Nonbank Dealers

This table reports summary statistics for bank and nonbank dealers in the Constant Dealer sample described in Table I. Panel A reports trading statistics for the bank and nonbank samples of dealers. Panel B reports daily and weekly averages over five subperiods of capital commitment measures for bank and nonbank dealers. The capital commitment measures are computed at the daily and weekly levels and all other variables are computed at the monthly level. Variable definitions are provided in Internet Appendix Table IAI.

	January 2006 to June 2007	July 2007 to April 2009	May 2009 to June 2010	July 2010 to March 2014	April 2014 to October 2016
	Precrisis	Crisis	Postcrisis	Regulatory	Volcker
Panel A: Trading Statistics					
Nonbank Market Share	4.4%	5.1%	7.0%	10.2%	13.5%
Nonbank Market Share: Customer Volume	2.4%	3.3%	5.5%	9.2%	12.5%
Bank Sample					
Dollar Volume / Amount Outstanding (%)	6.5	4.5	5.3	4.7	4.0
Average Trade Size ($ Thousands)	1,258.3	880.9	798.2	817.4	761.3
Principal Volume / Total Volume (%)	92.1	90.0	90.9	91.0	91.2
Transaction Cost (%)	0.31%	0.56%	0.53%	0.40%	0.37%
Nonbank Sample					
Dollar Volume / Amount Outstanding (%)	0.3	0.2	0.4	0.5	0.6
Average Trade Size ($ Thousands)	373.5	188.8	206.1	241.6	305.9
Principal Volume / Total Volume (%)	63.1	78.5	73.0	82.3	87.2
Transaction Cost (%)	0.37%	0.63%	0.61%	0.54%	0.44%
Panel B: Capital Commitment					
Bank Sample					
Time-Weighted Daily Capital / Volume (%)	11.7	10.9	9.6	9.0	7.8
Time-Weighted Daily Capital ($ Millions)	882.1	610.2	816.7	800.2	765.6
Overnight Capital / Volume (%)	22.0	21.1	18.3	17.1	14.7
Overnight Capital ($ Millions)	1,656.6	1,182.3	1,571.6	1,535.3	1,439.5
Weekend Capital / Volume (%)	11.0	11.3	9.2	8.2	7.4
Weekend Capital ($ Millions)	4,022.9	3,051.4	3,772.1	3,592.8	3,563.6
Nonbank Sample					
Time-Weighted Daily Capital / Volume (%)	8.3	7.6	8.2	8.9	8.1
Time-Weighted Daily Capital ($ Millions)	28.3	21.8	53.5	89.4	126.3
Overnight Capital / Volume (%)	15.5	14.1	15.4	17.3	15.4
Overnight Capital ($ Millions)	53.1	40.6	101.6	173.9	241.4
Weekend Capital / Volume (%)	9.6	8.4	8.9	9.8	8.8
Weekend Capital ($ Millions)	162.8	118.0	286.6	483.3	675.5

dealer share of customer-to-dealer volume rose more sharply, from 2.4% during the precrisis period to 12.5% during the Volcker period. When stated relative to the quantity outstanding, nonbank turnover increased from 0.3% per month during the precrisis period to 0.6% during the Volcker period, while bank-affiliated dealer turnover decreased from 6.5% during the precrisis period to 4.0% during the Volcker period.

Average execution costs for trades executed by nonbank dealers were slightly greater (six to seven basis points) than for trades executed by bank-affiliated dealers during both the precrisis benchmark and the recent Volcker period. The higher execution costs for nonbank trades are attributable in part to the fact that their trades were smaller on average. In particular, the average trade size for nonbank dealers during the precrisis period was $0.37 million, while that for bank-affiliated dealers was $1.26 million. Average trade size decreased over time, to $0.31 million for nonbank dealers during the Volcker period, and more sharply to $0.76 million for bank-affiliated dealers during the Volcker period.

Finally, Panel A of Table VI shows that the increase in principal trading during the Volcker period is attributable to nonbank dealers. In particular, the proportion of nonbank dealers' overall trading completed on a principal basis rose from 63.1% during the precrisis period to 87.2% during the Volcker period, while that for bank-affiliated dealers decreased modestly from 92.1% to 91.2%.

Panel B of Table VI reports capital commitment measures for bank-affiliated and nonbank dealers contained in the Constant Dealer sample. Two distinctions are worth noting. First, nonbank dealer capital commitment was much lower than that of bank-affiliated dealers during the precrisis benchmark period, for all measures of capital commitment. Focusing, for example, on overnight capital commitment, nonbank dealers collectively carried an average of $53 million overnight during the precrisis benchmark, as compared to $1.66 billion for bank-affiliated dealers. When stated as a percentage of own daily trading volume (i.e., as the percentage of trading carried into overnight inventory), the divergence during the precrisis period was less stark, as nonbank dealers carried 15.5% overnight, while bank-affiliated dealers carried 22.0% overnight.

Second, while both bank-affiliated and nonbank dealers reduced their capital commitment during the financial crisis, nonbank dealers have increased their capital commitment in recent years while bank-affiliated dealers have decreased their capital commitment for all measures. Focusing again on overnight capital, nonbank dealers increased their capital commitment from $53 million during the benchmark period to $241 million during the recent Volcker period, with 8 of the 10 individual nonbank dealers increasing their capital commitment. In contrast, bank-affiliated dealers decreased their capital commitment from $1.66 billion during the precrisis period to $1.44 billion during the Volcker period. When stated relative to trading volume, nonbank dealers' overnight capital commitment remained essentially unchanged from 15.5% during the precrisis period to 15.4% during the Volcker period, while bank-affiliated overnight capital commitment declined markedly from 22.0% during the precrisis period to 14.7% during the recent Volcker period.

Results for daily and weekly capital commitment are broadly similar to those for overnight capital commitment.

B. Regression Outcomes for Bank and Nonbank Capital Commitment

In Table VII, Panel A, we report results of regressions similar to those reported in Table V, except that we include indicator variables to allow for differing time-period-specific intercepts for bank-affiliated and nonbank dealers. These results are more informative than the comparison of summary statistics reported in Table VI because the regression analysis includes the control variables as previously employed for the results reported in Table V.

The coefficient on the bank indicator gives the difference in the benchmark period intercept between bank-affiliated dealers and nonbank dealers. For each subperiod subsequent to the benchmark, we include the product of the subperiod indicator and both bank and nonbank indicators. The coefficient estimates on these interactive terms indicate the change in the intercept estimate relative to the base period for bank and nonbank dealers, respectively. Note that, while Table VII includes indicator variable coefficients for each subperiod, in this discussion we focus mainly on the recent Volcker subperiod.

The empirical results for all six measures of capital commitment (columns (1) to (6)) are generally consistent with the view that the decline in capital commitment during the recent Volcker period as compared to the precrisis benchmark is attributable to bank-affiliated dealers. This result strongly supports the prediction of Duffie (2012) that the Volcker Rule would likely have unintended consequences in terms of bank-affiliated dealers' ability and willingness to commit capital to enhance bond market liquidity. This result is also consistent with the finding of Bao, O'Hara, and Zhou (2017) that bank-affiliated dealers absorb into inventory less of the order imbalances that occur in the wake of bond downgrades during the Volcker period.

The difference between indicator variable coefficients for bank-affiliated and nonbank dealers during the Volcker period is statistically significant at the 1% level. The change in capital commitment of bank-affiliated dealers during the Volcker period as compared to the benchmark period is negative and statistically significant at the 1% level for five of the six measures of capital commitment. In contrast, the change in capital commitment of nonbank dealers in the Volcker period as compared to the precrisis period is positive and statistically significant for five of six measures of capital commitment.[28]

[28] Increased competition for traditional dealers has emerged in the form of corporate bond ETFs, particularly for investment-grade bond indices. In Internet Appendix Table IA.VI, we report regression coefficients that correspond to those in Table VII, Panel A, except that the subsamples are defined for investment-grade and high-yield bonds. In each of these subsamples, we find, in line with the overall sample, that bank-affiliated dealers have reduced their capital commitment while nonbank dealers have increased their capital commitment during the regulatory and the Volcker periods, relative to the precrisis benchmark period. These results suggest that our main conclusions are robust to increased competition from bond ETFs.

Table VII

Time-Series Regressions: Bank versus Nonbank Dealers

This table reports time-series regression results over the January 2006 to October 2016 period for bank- and nonbank-affiliated dealers. Each regression includes four period indicators; the benchmark period is January 2006 to June 2007. The capital commitment measures are computed at the daily and weekly levels and all other variables are computed at the monthly level. All dependent variables are computed using the Constant Dealer sample described in Table I. All regressions report Newey-West standard errors and include market controls. Tests for statistical differences between changes (relative to the benchmark period) in bank dealer and nonbank dealer activity each period are included below the regression results. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. Dependent variable sample period (January 2006 to October 2016) averages are shown above the regression results. Panel A shows the results for all bonds and trades in the Constant Dealer sample. Panel B shows results for the sample of "clicking" trades, which comprise trades in young (age less than one year), investment-grade, large issue (issue size of at least $1 billion) bonds that are less than or equal to $5 million. All other trades are categorized as "calling" trades. An [a] next to the coefficient indicates that call and click trade coefficients are statistically different at the 5% level. "ns" stands for not significant at a 10% confidence level.

Panel A: Full Sample

	(1) Time-Weighted Daily Capital / Volume (%)	(2) Time-Weighted Daily Capital ($ Millions)	(3) Overnight Capital / Volume (%)	(4) Overnight Capital ($ Millions)	(5) Weekend Capital / Volume (%)	(6) Weekend Capital ($ Millions)	(7) Dollar Volume / Amount Outstanding (%)	(8) Ln Average Trade Size ($ Thousands)	(9) Principal Volume / Total Volume (%)
Dependent Variable Average	8.9	423.7	16.9	808.2	9.1	1,988.1	2.6	6.1	85.1
Bank	3.5***	853.7***	6.5***	1,603.5***	1.4***	3,860.1***	6.2***	1.2***	29.0***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Crisis × Nonbank	0.4	19.9	0.8	36.6	−0.4	106.2	0.0	−0.4***	17.1***
	(0.311)	(0.154)	(0.386)	(0.161)	(0.582)	(0.171)	(0.763)	(0.000)	(0.000)
Crisis × Bank	0.3	−245.4***	1.3	−425.2***	1.1*	−820.5***	−1.9***	−0.2*	−0.4
	(0.477)	(0.000)	(0.151)	(0.000)	(0.073)	(0.000)	(0.000)	(0.052)	(0.495)
Postcrisis × Nonbank	1.2*	72.8***	2.4*	137.4***	0.3	309.0***	0.4**	−0.2**	10.8***
	(0.063)	(0.000)	(0.071)	(0.000)	(0.617)	(0.007)	(0.020)	(0.012)	(0.004)
Postcrisis × Bank	−0.9*	−17.7	−1.2	3.9	−0.8	−65.5	−0.9***	−0.1	−0.2
	(0.081)	(0.618)	(0.202)	(0.953)	(0.256)	(0.735)	(0.000)	(0.141)	(0.912)
Regulatory × Nonbank	1.9***	76.7***	4.2***	150.4***	1.0*	424.9***	0.2*	−0.2**	20.8***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.053)	(0.000)	(0.075)	(0.035)	(0.000)
Regulatory × Bank	−1.5***	−66.3**	−2.5***	−91.7	−2.0***	−325.6*	−1.8***	−0.2**	0.5
	(0.001)	(0.033)	(0.004)	(0.111)	(0.000)	(0.070)	(0.000)	(0.011)	(0.505)
Volcker × Nonbank	0.6**	107.3***	1.5**	206.1***	−0.4	572.8***	0.3***	−0.0	25.3***
	(0.027)	(0.000)	(0.011)	(0.000)	(0.209)	(0.000)	(0.001)	(0.560)	(0.000)

(*Continued*)

Table VII—*Continued*

Panel A: Full Sample

	(1) Time-Weighted Daily Capital / Volume (%)	(2) Time-Weighted Daily Capital ($ Millions)	(3) Overnight Capital / Volume (%)	(4) Overnight Capital ($ Millions)	(5) Weekend Capital / Volume (%)	(6) Weekend Capital ($ Millions)	(7) Dollar Volume / Amount Outstanding (%)	(8) Ln Average Trade Size ($ Thousands)	(9) Principal Volume / Total Volume (%)
Volcker × Bank	−3.1***	−107.2***	−5.7***	−199.2***	−3.2***	−399.2**	−2.5***	−0.4***	0.2
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.031)	(0.000)	(0.000)	(0.802)
Observations	5,434	5,434	5,434	5,434	1,132	1,132	260	260	260
Adjusted R^2	0.118	0.866	0.126	0.864	0.182	0.895	0.958	0.960	0.826
Test: Crisis × Nonbank = Crisis × Bank	ns	***	ns	***	**	***	***	***	***
Test: Postcrisis × Nonbank = Postcrisis × Bank	***	***	***	**	*	**	***	**	***
Test: Regulatory × Nonbank = Regulatory × Bank	***	***	***	***	***	***	***	ns	***
Test: Volcker × Nonbank = Volcker × Bank	***	***	***	***	***	***	***	***	***
Market Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Clicking Trades

	(1) Time-Weighted Daily Capital / Volume (%)	(2) Time-Weighted Daily Capital ($ Millions)	(3) Overnight Capital / Volume (%)	(4) Overnight Capital ($ Millions)	(5) Weekend Capital / Volume (%)	(6) Weekend Capital ($ Millions)	(7) Dollar Volume / Amount Outstanding (%)	(8) Ln Average Trade Size ($ Thousands)	(9) Principal Volume / Total Volume (%)
Dependent Variable Average	16.1	36.8	31.4	71.6	18.3	202.6	1.8	6.0	89.0
Bank	0.8[a]	45.7***,[a]	0.8[a]	87.0***,[a]	−3.4[a]	222.2***,[a]	3.0***,[a]	0.6***,[a]	9.6**,[a]
	(0.351)	(0.000)	(0.596)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.029)
Crisis × Nonbank	−7.4***,[a]	−2.0	−13.9***,[a]	−4.2	−10.6***,[a]	−10.6	−0.1*	−0.9***,[a]	2.7[a]
	(0.000)	(0.235)	(0.000)	(0.215)	(0.000)	(0.368)	(0.081)	(0.000)	(0.554)

(*Continued*)

Table VII—*Continued*

Panel B: Clicking Trades

	(1) Time-Weighted Daily Capital / Volume (%)	(2) Time-Weighted Daily Capital ($ Millions)	(3) Overnight Capital / Volume (%)	(4) Overnight Capital ($ Millions)	(5) Weekend Capital / Volume (%)	(6) Weekend Capital ($ Millions)	(7) Dollar Volume / Amount Outstanding (%)	(8) Ln Average Trade Size ($ Thousands)	(9) Principal Volume / Total Volume (%)
Crisis × Bank	−2.5***,a	−1.6 a	−3.5***,a	−0.1a	−0.6	26.5a	−0.5***,a	−0.3***	−3.5***,a
	(0.000)	(0.647)	(0.009)	(0.993)	(0.554)	(0.182)	(0.000)	(0.007)	(0.001)
Postcrisis × Nonbank	−5.2***,a	4.5 a	−10.3***,a	7.4a	−8.4***,a	3.4 a	0.2	−0.7***,a	−7.1a
	(0.000)	(0.127)	(0.000)	(0.208)	(0.000)	(0.866)	(0.338)	(0.000)	(0.135)
Postcrisis × Bank	−7.0***,a	17.3***	−13.3***,a	34.2***	−6.8***,a	93.1***	−0.3a	−0.2***	−9.0***,a
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.119)	(0.007)	(0.000)
Regulatory × Nonbank	−5.7***,a	5.8***,a	−10.7***,a	11.0***,a	−7.9***,a	31.5**,a	0.2*	−0.4**	3.6 a
	(0.000)	(0.002)	(0.000)	(0.003)	(0.000)	(0.018)	(0.062)	(0.034)	(0.449)
Regulatory × Bank	−6.3***,a	20.0***,a	−11.7***,a	40.0***,a	−5.3***,a	131.8***,a	0.3*,a	−0.3***	−7.2***,a
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.084)	(0.000)	(0.000)
Volcker × Nonbank	−7.8***,a	11.8***,a	−14.4***,a	23.3***,a	−9.7***,a	69.4***,a	0.3***	−0.1	6.0 a
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.261)	(0.196)
Volcker × Bank	−8.8***,a	33.9***,a	−16.7***,a	65.9***,a	−7.1***,a	225.6***,a	−0.0a	−0.2***,a	−4.5**,a
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.922)	(0.001)	(0.010)
Observations	5,426	5,426	5,426	5,426	1,132	1,132	260	260	260
Adjusted R^2	0.200	0.786	0.189	0.773	0.228	0.782	0.924	0.857	0.209
Test: Crisis × Nonbank = Crisis × Bank	***	ns	***	ns	***	**	***	***	ns
Test: Postcrisis × Nonbank = Postcrisis × Bank	ns	***	ns	***	ns	***	***	***	ns
Test: Regulatory × Nonbank = Regulatory × Bank	ns	***	ns	***	*	***	ns	ns	**
Test: Volcker × Nonbank = Volcker × Bank	ns	***	ns	***	*	***	*	ns	**
Market Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

For example, dollar overnight capital commitment (column (4)) of bank-affiliated dealers declined by $199 million during the recent period as compared to the precrisis benchmark after allowing for changes in the control variables. By comparison, overnight capital commitment of nonbank dealers increased by $206 million from the precrisis benchmark to the Volcker period after allowing for changes in the control variables. When stated relative to trading activity (i.e., as a percentage of trading carried into overnight inventory), the decrease (column (3)) for bank-affiliated dealers is 5.7%, while the increase for nonbank dealers is 1.5%. Results for the other measures of capital commitment are broadly similar to those for overnight capital.

It is also instructive to compare outcomes for the recent Volcker period to the immediately preceding regulatory period. Coefficient estimates on the Volcker period indicator are larger in absolute magnitude than those on the regulatory period indicator when the dependent variable is capital commitment in dollars (columns (2), (4), and 6)), for both bank- affiliated dealers and nonbank dealers. For example, the decrease in overnight capital commitment for bank-affiliated dealers during the regulatory period (as compared to the benchmark period) was $92 million, versus $199 million during the Volcker period. The implication is that bank-affiliated dealers sharply reduced their capital commitment after the Volcker Rule became effective. In contrast, the increase in overnight capital commitment for nonbank dealers during the regulatory period (as compared to the benchmark period) was $150 million, versus $206 million during the Volcker period. The implication is that, unlike bank-affiliated dealers, nonbank dealers continued to increase their overnight capital commitment after the Volcker Rule became effective.[29]

The coefficient estimates for the bank-affiliated indicator reported in Table VII pertain to all 25 bank-affiliated dealers in the Constant Dealer sample. We consider whether results are uniform for large versus small dealers by estimating the regression specification separately for the 10 largest and 15 smaller bank-affiliated dealers, where dealer size is measured based on full-sample trading volume. The results, reported in Table IA.IV of the Internet Appendix, indicate a decline in capital commitment in the Volcker period for both large and small bank-affiliated dealers. While dollar amounts are naturally greater for large dealers, dollar amounts relative to trading volume are similar. Focusing on overnight capital, for example, the decline in dollar capital commitment during the Volcker period as compared to the benchmark period is $171 million for large dealers and $31 million for small dealers. The decline as a percentage of trading volume is 5.8% for large dealers and 6.0% for small dealers. We conclude that the finding that bank-affiliated dealers have reduced capital commitment in the corporate bond markets during the Volcker period is robust across large and small dealers.

[29] Note, however, that the increase in overnight capital commitment during the Volcker period versus the preceding regulatory period for nonbank dealers was less than proportionate to their increase in trading volume, as evidenced by a smaller coefficient estimate during the Volcker period in column (3).

C. Regression Outcomes for Other Market Quality Measures for Bank and Nonbank Dealers

In columns (7) to (9) of Table VII, Panel A, we report results for bank and nonbank dealers when the dependent variable is volume relative to amount outstanding (i.e., turnover), average trade size, and the percentage of total volume completed on a principal basis, respectively. The results indicate that the patterns observed for sample means reported in Table VI are also observed after allowing for changes in the control variables, and that differences in outcomes for bank-affiliated versus nonbank dealers during the Volcker period are consistently statistically significant.

In particular, trading activity by nonbank dealers relative to the amount outstanding (column (7)) increased by 0.3% during the Volcker period relative to the benchmark period, while trading activity by bank-affiliated dealers decreased by 2.5%, after allowing for changes in control variables. The average log trade size for bank-affiliated dealers (column (8)) decreased a statistically significant $0.40 million relative to the benchmark period after allowing for changes in the control variables, while the decrease for nonbank dealers was statistically insignificant. Finally, principal trading relative to total trading (column (9)) increased by a statistically significant 25.3% for nonbank dealers during the recent period as compared to the benchmark period, while the change for bank-affiliated dealers was statistically insignificant.

Each of the results above is consistent with the view that in recent years bank-affiliated dealers have reduced the extent to which they commit capital to facilitate trading, while nonbank dealers have increased the extent to which they commit capital to facilitate trading. While the lack of clearly identifiable effective dates for regulations precludes fully definitive tests, the results support the view that postcrisis regulations that focus on banks, such as the Volcker Rule and the Basel Accords, have had the consequence of decreasing bank-affiliated dealers' willingness or ability to commit capital to facilitate trading in corporate bonds.

D. Click versus Call Trades

Electronic limit order books, which allow for the submission of executable orders and online transactions, have come to dominate trading in equity and futures markets. In contrast, electronic platforms for corporate bonds, while growing rapidly, still account for a small share of of overall trading. A 2015 survey by Greenwich Associates, for instance, reports that electronic venues accounted for 8% of investment-grade corporate bond trading in 2010, and 20% in 2015.[30] In addition, most activity involves electronic requests for quotations, as opposed to direct executions. A 2013 Greenwich Associates industry survey

[30] See Greenwich Associates, "The Continuing Corporate Bond Evolution," Q4 2015.

thus concludes that "true corporate bond e-trading is a long way from becoming reality."[31]

Trades that use electronic platforms cannot be directly identified on TRACE, as each is reported by the broker-dealer involved without any specific flag. Hendershott and Madhavan (2015) study the largest electronic request for quotation platform, operated by MarketAxess, and document that market participants are most likely to click rather than call a traditional dealer when conducting smaller trades in recently issued, large issue size, investment-grade bonds. We thus assess capital commitment and market quality separately for bank and nonbank dealers, for click trades, which we define as trades of $5 million or less in investment-grade bonds that are within one year of issuance and thus have an issue size of at least $1 billion. Not all trades in this category are executed via electronic means, but we expect electronic platforms to be more prevalent for these trades.

Table VII, Panel B, presents the results of time-series regressions identical to those in Panel A, except that now they pertain to the clickable trade subsample. Click trades account for a small but increasing portion of overall trading, ranging (Table III) from 2% during the benchmark period to 7% during the recent Volcker period. Corresponding results for the call trades subsample are reported in Internet Appendix Table IA.V. Not surprisingly, results for the call sample generally mirror those reported in Panel A of Table VIII for the full sample. In Panel B of Table VIII, we indicate coefficient estimates that differ significantly across the click and call samples (p-value < 0.05) with a superscripted letter a. We find statistically significant differences between the click and call samples for the majority of the coefficients. We focus this discussion mainly on coefficient estimates for the Volcker period to assess the evolution of outcomes over time.

The results in Panel B of Table VIII show that both bank-affiliated and nonbank dealers have increased their dollar capital commitment (columns (2), (4), and (6)) to click trades over time. However, as noted, the click sample's share of overall trading has grown rapidly. Relative to trading volume (columns (1), (3), and (5)), the coefficient estimates on capital commitment during the Volcker period (as well as during the immediately preceding regulatory period) are negative for both bank-affiliated and nonbank dealers, and are not statistically different from each other.

These results support the view that the increased competition and reduced search costs associated with electronic request for quotation systems have reduced the demand for dealer intermediation services in the segment of the corporate bond market where electronic venues are most prevalent. Both bank-affiliated and nonbank dealers have responded by committing less capital to this segment of the market, relative to volume. In contrast, in the segments of the market where electronic venues have less of an impact, nonbank

[31] See "Corporate Bond E-Trading: Same Game, New Playing Field," McKinsey& Company-Greenwich Associates, p. 5.

Table VIII

Stressful Day Summary Statistics

This table reports summary statistics for the stressful day analysis for bank-affiliated and nonbank dealers. The capital commitment measures are aggregated at the daily and weekly levels. Daily and weekly averages are reported for five subperiods. All variables are computed using the Constant Dealer sample described in Table I. Variable definitions are provided in Internet Appendix Table IAI. Panel A reports statistics for bond-level stress based on the occurrence of large block trades (trade size of at least $10 million). Panel B reports statistics for days characterized by market-wide stress based on the Federal Reserve Bank of Cleveland Stress Index. A description of the identification of stressful days can be found in Section VII.

	January 2006 to June 2007	July 2007 to April 2009	May 2009 to June 2010	July 2010 to March 2014	April 2014 to October 2016
	Precrisis	Crisis	Postcrisis	Regulatory	Volcker
Panel A: Bond-Level Stress: Block Trading					
Bank Sample					
Block Volume / Total Volume (%)	22.5	19.0	23.6	20.6	18.8
Time-Weighted Daily Capital / Volume (%)	30.8	23.3	25.9	24.0	20.8
Overnight Capital / Volume (%)	62.0	47.3	53.6	48.9	41.0
Weekly Capital / Volume (%)	42.9	33.5	35.4	31.4	25.9
Nonbank Sample					
Block Volume / Total Volume (%)	7.8	8.2	10.1	10.7	10.1
Time-Weighted Daily Capital / Volume (%)	9.7	7.6	12.1	13.6	12.0
Overnight Capital / Volume (%)	14.0	9.9	19.5	27.1	22.6
Weekly Capital / Volume (%)	12.5	7.5	13.8	20.2	15.8
Panel B: Market-Wide Stress: Federal Reserve Bank of Cleveland Stress Index					
# Events	12	23	4	23	24
Bank Sample					
Time-Weighted Daily Capital / Volume (%)	12.0	9.8	10.0	8.5	6.8
Time-Weighted Daily Capital ($ Millions)	826.9	611.1	923.1	784.7	753.6
Overnight Capital / Volume (%)	22.3	19.0	19.8	16.2	12.7
Overnight Capital ($ Millions)	1,534.8	1,186.3	1,812.1	1,504.4	1,403.8
Weekend Capital / Volume (%)	22.0	18.9	18.2	16.0	13.1
Weekend Capital ($ Millions)	9,440.5	7,085.3	10,635.4	8,666.8	8,342.5
Nonbank Sample					
Time-Weighted Daily Capital / Volume (%)	8.1	7.8	8.8	8.8	7.8
Time-Weighted Daily Capital ($ Millions)	23.7	20.8	60.4	92.3	128.4
Overnight Capital / Volume (%)	15.1	14.5	17.1	16.9	14.7
Overnight Capital ($ Millions)	43.0	38.5	117.3	178.4	242.9
Weekend Capital / Volume (%)	15.5	13.0	15.6	16.6	14.6
Weekend Capital ($ Millions)	308.1	228.6	697.2	1,054.6	1,411.2

dealers have increased their capital commitment to the overall market, even as bank-affiliated dealers have withdrawn.

VII. 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 under unusual duress. To shed light on this possibility, we next examine dealer trading behavior on days when it can be reasonably inferred that the market is stressed. For robustness, we consider both stressful days identified on a bond-specific basis as well as a market-wide basis.

The bond-specific stress measure we consider is the occurrence of a block trade of $10 million or more, and we study the individual dealers who complete block trades. The processing of a block transaction tends to dominate a dealer's trading for the day. We find that, for bank-affiliated dealers, a block transaction accounts on average for 92% of the dealer's total trading in the block direction for the day (i.e., total daily buy trading if the block is a buy, and vice versa). The corresponding figure for nonbank dealers is 94%.

A dealer who executes a block trade on a principal basis commits significant capital to bond market-making. However, the extent of capital commitment also depends on how long the position remains on the dealer's books, as opposed to being offloaded through opposite-direction trades to other dealers or to customers. We compute time-weighted daily capital commitment and overnight capital commitment on the days that dealers in the Constant Dealer sample complete block trades, as previously described. We also compute weekly capital commitment for the dealer in the same manner as the previously described weekly capital commitment, except that we now focus on the one-week period from the date of the block trade instead of Friday. We then sum the dollar capital commitment measures across all dealers who completed block trades during the given day and scale by the same dealers' total trading activity over the corresponding day or week.

We also employ an indicator of market-wide stress. The Federal Reserve Bank of Cleveland constructs a Financial Stress Index. While this index has been discontinued due to a data error, we focus on its credit market component, which is a simple combination of five interest rate spreads (between U.K. and U.S. Treasury bills, AAA corporate bonds and U.S. Treasuries, commercial paper and Treasury bills, and 10-year U.S. Treasury notes versus three-month U.S. Treasury bills) and the bid-ask spread in U.S. Treasury bills (Oet et al. (2011)).[32] We classify individual days as stressed if the change in this index is

[32] For a general description, see https://www.clevelandfed.org/newsroom-and-events/publications/economic-commentary/2012-economic-commentaries/ec-201204-the-cleveland-financial-stress-index-a-tool-for-monitoring-financial-stability.aspx. Daily observations on the credit spread component are downloaded from https://fred.stlouisfed.org/series/CMRKTSD678FRBCLE. The index was discontinued on May 5, 2016, so this analysis ends at that date.

more than 1.96 standard deviations (computed separately by subperiod) above its subperiod mean.

Table VIII reports summary statistics for the variables used in the stressful day analyses based on the Constant Dealer sample. We find that the proportion of trade that occurs in the form of blocks greater than $10 million has decreased for bank-affiliated dealers but increased for nonbank dealers, between the benchmark period and the Volcker period. Further, capital commitment on stressful days defined both on a bond-specific and a market-wide basis has decreased for bank-affiliated dealers and increased for nonbank dealers over time.

In Table IX, we report results of regression specifications similar to those in Table VII, but focusing in particular on stressful days, to assess whether the documented changes hold and are statistically significant after allowing for changes in the control variables. Panel A of Table IX pertains to stressful days identified on a bond-specific basis, while Panel B pertains to stressful days identified based on market-wide conditions.[33]

A. Portfolio Time-Series Regressions for Bond-Specific Stressful Days

Coefficient estimates on the bank indicator pertain to the difference between bank-affiliation and nonbank dealers during the precrisis benchmark period. Estimates reported on Panel A of Table IX show that bank-affiliated dealers accommodated significantly more block trading and committed more capital during the precrisis period.

Turning to coefficient estimates for the bank-affiliation and nonbank indicator variables during the Volcker period, which estimate changes relative to the precrisis benchmark period that are not accounted for by changes in the control variables also included in the regression, we find that nonbank dealers increased both the frequency of block trading and overnight and weekly capital commitment relative to block trading volume on stressful days, while bank-affiliated dealers decreased block trading and capital commitment on stressful days, each as compared to the precrisis benchmark period. The difference in coefficient estimates across bank-affiliated and nonbank dealers is statistically significant in each instance.

The coefficient estimates are also economically large, and in many ways are more striking than the estimates reported in Table VII. Focusing on block volume as a percentage of total volume (column (1)), the decrease for bank-affiliated dealers during the Volcker period is 3.0%, while the increase for nonbank dealers is 3.0%, allowing for changes in the control variables. By comparison, the average for this variable is 15.1%. The increase during the Volcker period in overnight capital commitment relative to block-day volume

[33] We continue to assess statistical significance while relying on Newey-West standard errors. However, since stressful days are irregularly spaced in the data, we do not implement the Newey and West (1994) method to select the lag length. Results reported in Table IX are based on two lags. We verified that inference is unaffected by longer lag length specifications.

Table IX

Time-Series Regressions: Stressful Days

This table reports time-series regression results over the January 2006 to October 2016 period for bank-affiliated and nonbank dealers on stressful days. Each regression includes four period indicators; the benchmark period is January 2006 to June 2007. The capital commitment measures are computed at the daily and weekly levels. All dependent variables are computed using the Constant Dealer sample described in Table I. All regressions report Newey-West standard errors and include market controls. Tests for statistical differences between changes (relative to the benchmark period) in bank-affiliated dealer and nonbank dealer activity each period are included below the regression results. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. "ns" stands for not significant at a 10% confidence level. Dependent variable sample period (January 2006 to October 2016) averages are shown above the regression results. Panel A reports statistics for bond-level stress based on the occurrence of large block trades (trade size of at least $10 million). Panel B reports statistics for days characterized by market-wide stress based on the Federal Reserve Bank of Cleveland Credit Market Index. A description of the identification of stressful days can be found in Section IV. In Panel B, an [a] indicates that coefficients are statistically different (at the 5% confidence level or better) from control days [–7, –1] prior to the stressful day.

Panel A: Bond-Level Stress: Block Trading

	(1) Block Volume / Total Volume (%)	(2) Time-Weighted Daily Capital / Volume (%)	(3) Overnight Capital / Volume (%)	(4) Weekly Capital / Volume (%)
Dependent Variable Average	15.1	18.2	35.7	24.4
Bank	14.7***	21.1***	47.9***	30.4***
	(0.000)	(0.000)	(0.000)	(0.000)
Crisis × Nonbank	1.4	−1.4	−2.2	−3.2
	(0.104)	(0.410)	(0.463)	(0.192)
Crisis × Bank	−2.5***	−6.8***	−12.7***	−7.7***
	(0.000)	(0.000)	(0.000)	(0.000)
Postcrisis × Nonbank	2.8***	4.3***	9.7***	5.1**
	(0.001)	(0.009)	(0.003)	(0.033)
Postcrisis × Bank	1.5*	−2.9***	−4.2**	−3.7**
	(0.062)	(0.004)	(0.022)	(0.024)
Regulatory × Nonbank	3.7***	4.5***	14.7***	9.3***
	(0.000)	(0.004)	(0.000)	(0.000)
Regulatory × Bank	−1.2	−6.2***	−11.4***	−9.8***
	(0.170)	(0.000)	(0.000)	(0.000)
Volcker × Nonbank	3.0***	2.4	9.3***	3.9*
	(0.000)	(0.101)	(0.001)	(0.090)
Volcker × Bank	−3.0***	−9.8***	−20.3***	−16.3***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	5,430	5,190	5,190	5,190
Adjusted R^2	0.590	0.442	0.504	0.362
Test: Crisis × Nonbank = Crisis × Bank	***	***	***	*
Test: Postcrisis × Nonbank = Postcrisis × Bank	ns	***	***	***
Test: Regulatory × Nonbank = Regulatory × Bank	***	***	***	***
Test: Volcker × Nonbank = Volcker × Bank	***	***	***	***
Market Controls	Yes	Yes	Yes	Yes

(*Continued*)

Table IX—*Continued*

Panel B: Market-Wide Stress: Federal Reserve Bank of Cleveland Credit Market Index

	(1) Time-Weighted Daily Capital / Volume (%)	(2) Time-Weighted Daily Capital ($ Millions)	(3) Overnight Capital / Volume (%)	(4) Overnight Capital ($ Millions)	(5) Weekend Capital / Volume (%)	(6) Weekend Capital ($ Millions)
Dependent Variable Average	8.5	407.1	16.2	773.5	15.9	4,582.7
Bank	3.8***	803.2***	7.2***	1,491.8***	6.4***	9,132.3***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Crisis × Nonbank	0.6	−31.6[a]	1.0	−71.8[a]	0.6	−276.3
	(0.454)	(0.296)	(0.559)	(0.231)	(0.615)	(0.339)
Crisis × Bank	−1.2*	−244.5***	−1.6	−415.8***	0.0	−2,552.0***
	(0.089)	(0.000)	(0.225)	(0.000)	(0.993)	(0.000)
Postcrisis × Nonbank	2.9**	44.8	6.5**	91.0	3.6**	812.5*
	(0.050)	(0.254)	(0.041)	(0.241)	(0.021)	(0.058)
Postcrisis × Bank	0.3	104.2	2.0	294.1	−0.2	1,618.3***
	(0.766)	(0.314)	(0.361)	(0.118)	(0.823)	(0.005)
Regulatory × Nonbank	1.3	34.8	2.7	57.8	4.1***	371.1
	(0.183)	(0.361)	(0.180)	(0.444)	(0.002)	(0.397)
Regulatory × Bank	−2.8***	−76.1	−5.2***	−108.0	−3.0**	−1,149.0
	(0.005)	(0.376)	(0.005)	(0.516)	(0.016)	(0.258)
Volcker × Nonbank	−1.4*	123.9***	−2.9*	227.7***	−0.2	1,065.7***
	(0.056)	(0.000)	(0.066)	(0.000)	(0.839)	(0.003)
Volcker × Bank	−6.2***	−54.1	−12.1***,[a]	−103.2	−8.1***	−1,135.3**
	(0.000)	(0.403)	(0.000)	(0.391)	(0.000)	(0.050)
Observations	172	172	172	172	172	172
Adjusted R^2	0.349	0.906	0.332	0.899	0.624	0.937
Test: Crisis × Nonbank = Crisis × Bank	**	***	ns	***	ns	***
Test: Postcrisis × Nonbank = Postcrisis × Bank	*	ns	ns	ns	**	*
Test: Regulatory × Nonbank = Regulatory × Bank	***	ns	***	ns	***	**
Test: Volcker × Nonbank = Volcker × Bank	***	***	***	***	***	***
Market Controls	Yes	Yes	Yes	Yes	Yes	Yes

(column (3)) is 9.3% for nonbank dealers who completed block trades, while the decrease for bank-affiliated dealers who completed block trades is 20.3%. Each of these changes between the benchmark period and the Volcker period is large relative to the full sample average of 35.7%.

The results are quite uniform across measures of capital commitment, indicating that not only did nonbank dealers increase the proportion of total volume accounted for by large block trades, but they also committed more capital relative to block volume during the recent period as compared to the benchmark period. In contrast, bank-affiliated dealers' block trading volume and capital commitment relative to block volume declined.

B. Portfolio Time-Series Regressions for Market-Wide Stressful Days

In Panel B of Table IX, we report results of time-series regressions that focus on aggregate capital commitment across dealers in the Constant Dealer sample on days characterized by market-wide stress. We estimate identical time-series regressions for control days, which are one to seven days prior to the identified stress days. The resulting coefficient estimates are suppressed to conserve space, but we indicate by use of a superscript a when stressful day coefficients statistically differ (p-value < 0.05) from the corresponding coefficient on control days. In each case where such a divergence is detected, the point estimates indicate lower capital commitment on stress days as compared to same-period control days.

The empirical results in Panel B of Table IX are consistent when focusing on daily time-weighted capital commitment, overnight capital commitment, and weekly capital commitment, and show that the following conclusions hold, after allowing for changes in control variables. First, we find that bank-affiliated dealers committed much greater amounts of capital as compared to nonbank dealers on stressful days during the benchmark period. Overnight capital as a percentage of trading volume, for example, was 7.2% higher for bank-affiliated dealers on stressful days during the benchmark period.

Second, while there was no significant change in nonbank dealers' stressful day capital commitment during the financial crisis, bank-affiliated dealers significantly reduced their stressful day dollar capital commitment during the crisis. The reduction in capital commitment during the crisis for bank-affiliated dealers is significantly larger than nonbank dealers for four of the six capital commitment measures. Thus, the results support the view that bank-affiliated dealers withdrew market-making capital on the stressful days that occurred during the financial crisis to a greater extent than did nonbank dealers.

Third, when comparing results for the recent Volcker period to the benchmark period, we find that nonbank dealers have significantly increased their dollar capital commitment on stressful days, while bank-affiliated dealers have modestly decreased their capital commitment. For nonbank dealers, the increase in stressful day capital commitment (e.g., $228 million in overnight capital, column (4)) is explained by a commensurate increase in stressful day trading activity as compared to the benchmark period, as the coefficient estimate on capital commitment relative to volume is not statistically significant at the 5% level for any of the three measures.

For bank-affiliated dealers, however, we observe a decline in capital commitment relative to trading volume on stressful days during the Volcker period as compared to the benchmark period. For example, bank-affiliated dealers' overnight capital commitment relative to volume on stressful days declined by 12.1% (column (3)) during the Volcker period.

Further, the decrease in bank-affiliated dealers' dollar overnight capital commitment on stressful days during the Volcker period is significantly greater than their decrease on control days during the Volcker period. In contrast, nonbank dealers' capital commitment on stressful days during

the Volcker period does not differ significantly from that on control days.[34]

In Section III, we find that nonbank dealers have increased their market share and capital commitment in recent years, while bank-affiliated dealers have decreased their market share and capital commitment. Here, we find that the same pattern holds on stressful days, and is more notable on days made stressful for individual dealers as indicated by block trades. Further, the data show no tendency for nonbank dealers to exit the market on stressful days, either during the financial crisis or thereafter.

VIII. Conclusion

Concerns that liquidity in the corporate bond markets is deteriorating are widespread. We conduct a comprehensive analysis of corporate bond trading over the 2006 to 2016 period and obtain a number of findings relevant in evaluating these concerns. We first show that, despite a temporary increase during the financial crisis, customer trade execution costs are on average nearly unchanged from 2006 to 2016. Thus, the evidence for customer trade execution costs, obtained over a relatively long time series, does not indicate systematic degradation of corporate bond liquidity in recent years.

However, execution costs for completed trades do not capture the search costs that customers may have experienced in locating counterparties or the costs associated with trades that were desired but not consummated. We thus conduct a broader analysis that indicates that the secondary market for corporate bonds is evolving in a manner that may point to more difficult trading conditions. The commitment of capital by dealers to absorb customer order imbalances is relatively important in markets, such as corporate bonds, characterized by infrequent transactions and search costs. We find that measures of dealers' capital commitment, trading volume relative to amounts outstanding, average trade size, and frequency of large block trading were not only degraded during the financial crisis, but these measures in general did not revert to precrisis levels in the years after the financial crisis abated.

Dealer capital commitment is potentially affected by postcrisis banking regulations such as the Volcker Rule and Basel III. To assess this possibility, we measure capital commitment and market quality separately for bank-affiliated and nonbank dealers. The results indicate that, while nonbank dealers were relatively unimportant during the precrisis period, they have steadily increased their market share, the proportion of their volume attributable to block trades, and their levels of capital commitment in recent years, even while

[34] For robustness, we study two additional measures of stressful days and present the results in Internet Appendix Tables IA.VII and IA.VIII. First, we focus on days in which customer trading volume in a particular bond is unusually high. Second, we construct a composite stress index, separately for high-yield and investment-grade bonds, by combining information from the Cleveland Fed Credit Stress Index with measures of bond market returns, the VIX equity volatility index, and returns to the Wilshire 5000 stock index. Each of these analyses confirms our main conclusions here.

bank-affiliated dealers have reduced their willingness to accommodate block trades and to commit capital to absorb customer order imbalances. Results for days subject to market-wide stress mirror those for the overall sample, and in the case of block trades are generally stronger than the full sample results.

Decreased dealer capital commitment could also result from decreased search costs associated with the growth in electronically facilitated trading, or from increased competition from corporate bond ETFs and mutual funds. We document that both banks and nonbank dealers reduced capital commitment as a percentage of volume traded in the portion of the market where electronically facilitated trades are most likely to occur. These results support that electronic venues have reduced search costs and the need for dealer intermediation services in some segments of the corporate bond market. However, electronically facilitated trading still represents a relatively small share of the overall market, and in the broader market where electronic venues are less important the data show that bank-affiliated dealers have reduced their capital commitment while nonbank dealers have increased their capital commitment.

On balance, the results support the Duffie (2012) prediction that bank-specific regulations enacted in the wake of the financial crisis, including the Volcker Rule and the Basel III Accords, will reduce the ability or willingness of bank-affiliated dealers to provide liquidity to the corporate bond markets. However, it is important to note that we do not assess the net welfare effect of the Volcker Rule. In particular, we do not evaluate the effect of the Volcker Rule on macroeconomic stability. Further, we document that nonbank dealers have partially supplanted bank-affiliated dealers, and that electronically intermediated trading, while still small, is growing in importance. It may be the case that the corporate bond market can function effectively even with reduced commitment by bank-affiliated dealers. It will be of particular interest to learn whether nonbank dealers and electronic trading sufficiently offset reductions in bank-affiliated dealer commitment in the future.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix.