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Jack Bao, Maureen O'Hara, and Alex Zhou

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The Volcker Rule and Market-Making in Times of Stress[1]

Jack Bao
Federal Reserve Board

Maureen O'Hara
Johnson Graduate School of Management
Cornell University

Xing (Alex) Zhou
Federal Reserve Board

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Abstract

Focusing on downgrades as stress events that drive the selling of corporate bonds, we document that the illiquidity of stressed bonds has increased after the Volcker Rule. Dealers regulated by the Rule have decreased their market-making activities while non-Volcker-affected dealers have stepped in to provide some additional liquidity. Furthermore, even Volcker-affected dealers that are not constrained by Basel III and CCAR regulations change their behavior, inconsistent with the effects being driven by these other regulations. Since Volcker-affected dealers have been the main liquidity providers, the net effect is that bonds are less liquid during times of stress due to the Volcker Rule.

JEL classification: G14, G21, G23, G24, G28

Keywords: Volcker Rule, Corporate Bond Illiquidity, Regulation, Capital Commitment, Dealer Inventory, Market-Making, Financial Crisis

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1. Introduction

Among the many regulatory changes following the financial crisis, few are more controversial than the Volcker Rule. Enacted as part of the Dodd-Frank Act, the Volcker Rule was intended to limit bank risk-taking by restricting or prohibiting certain speculative activities. Critics (for example, Duffie [2012]) contended that an unintended consequence of the Rule could be diminished bond market liquidity, resulting from a reduction in banks' market making activities. Advocates of the Rule disagreed, arguing that non-Volcker affected dealers could compensate for any market making reductions, leaving liquidity essentially unchanged. Recent empirical studies of post-crisis market behavior (e.g., Trebbi and Xiao (2015), Bessembinder, Jacobsen, Maxwell, and Venkataraman (2016), and Dick-Nielsen and Rossi (2016)), however, find conflicting evidence of the effect of regulations on bond market liquidity. In this paper, we focus specifically on the implementation of the Volcker Rule and its impact on bond market liquidity, particularly in times of market stress.

We argue that fully understanding the impact of the Volcker Rule on market liquidity requires understanding how liquidity behaves in the face of severe conditions, or exactly when liquidity is needed most. As shown by recent research, liquidity deterioration was particularly pronounced during the height of the Financial Crisis.[2] Practitioners and policymakers alike have noted that illiquidity in times of market stress may be the more relevant metric for gauging market stability and performance.[3] The main motivation and first major contribution of our paper is to study whether illiquidity is relatively worse in periods of stress after the Volcker Rule was

[2] See Bao, Pan, and Wang (2011), Dick-Nielsen, Feldhutter, and Lando (2012), and Friewald, Jankowitsch, and Subrahmanyam (2012).

[3] See recent comments by Deutsche Banc Research (2016) and testimony by Powell (2016) that even if liquidity is high in normal conditions, it may become more troublesome in periods of stress.

implemented. Motivated by Ellul, Jotikasthira, and Lundblad (2011) who find evidence of forced selling of downgraded bonds induced by regulatory constraints imposed on insurance companies, we use downgrades of corporate bonds to junk as stress events where liquidity is demanded by clients. Focusing on regulation-induced sales has the added advantage of plausibly preventing investors from optimally timing their trades, thereby providing a more reliable estimate of the liquidity conditions that investors face.

Our focus is on a difference-in-differences test comparing the illiquidity of downgraded corporate bonds to a baseline control group both before-and-after the Volcker Rule was implemented. In particular, the first difference is the difference in price impact between a set of bonds recently downgraded to speculative-grade from investment-grade and a set of BB bonds used to control for the general level of illiquidity.[4] The second difference is between the post-Volcker difference and the pre-Volcker difference. Our results show that bond liquidity deterioration around rating downgrades has worsened following the implementation of the Volcker Rule. We find such adverse effects whether we benchmark to the pre-crisis period or to the period just before the Volcker Rule was enacted, and we find that the relative deterioration in liquidity around these stress events is as high during the post-Volcker period as during the Financial Crisis. Given how badly liquidity deteriorated during the financial crisis, this finding suggests that the Volcker Rule may have serious consequences for corporate bond market functioning in stress times.

The second motivation and contribution of our study is to understand how the Volcker Rule induced changes in dealer behavior, and particularly to identify any differential effects on Volcker-affected vs. non-Volcker-affected dealers. Because the Volcker Rule applied only to banks with

[4] Results are similar if we instead use bid-ask spreads.

access to government backstops (such as deposit insurance or Federal Reserve borrowing), other dealers without such access can continue to trade and could, in principle, step in to provide additional liquidity in cases where the lines between permissible market-making and prohibited proprietary trading are blurred.

Using a unique data set with dealer identities, we present evidence that non-Volcker-affected dealers have been providing more liquidity during post-Volcker stress times. In the post-Volcker period, the relative share of dealer-customer trades taken by non-Volcker dealers has increased. Dealers affected by the Volcker Rule see a statistically significant increase in agency trades, or trades in which the dealer has pre-arranged an offsetting trade so as not to have inventory risk. For non-Volcker dealers, we see no such effects on agency trades in the post-Volcker period. We also find that Volcker-affected dealers significantly reduce their capital commitment, while non-Volcker dealers commit more capital in market-making. Combined with our results on the increased illiquidity during the post-Volcker period, these results suggest that while non-Volcker dealers have stepped in (as proponents of the Volcker Rule suggested would happen), opponents of the Volcker Rule were correct in arguing that the change would not be immediate.[5] At least during stress times, this new participation is not yet enough to offset the decreased liquidity in bond market trading.

Finally, a third goal of our research is to disentangle the effects of the Volcker Rule from those of other important regulations on dealer bond market behavior. We do so by focusing particularly on the implementation period as compared to the period just before implementation and also by splitting dealers by their exposure to Basel III. Though most banks' capital ratios are significantly above Basel III minimums, increased Basel III capital requirements along with

[5] See the Federal Register (2014) publication on the Volcker Rule for details of comment letters. Liquidity deterioration was particularly severe during the height of the Financial Crisis.

Comprehensive Capital Analysis and Review (CCAR) requirements may potentially mean that some banks will reduce their market-making activities because of CCAR constraints. These constraints arise from the fact that dealers are required to meet minimum capital requirements in stress scenarios. Thus, to ensure that our results are not driven by banks constrained by the start of Basel III implementation (along with existing CCAR requirements), we split Volcker-affected dealers into those that are CCAR-constrained and those that are not. We find that capital commitment has decreased significantly for dealers that have neither failed CCAR tests nor been given a conditional pass. Thus, our results are unlikely to be driven by banks adjusting their business to remedy failed CCAR tests.

Our paper is most closely related to three recent studies on regulation and liquidity, all of which focus on the general regulatory environment following the global financial crisis. Studying general trends in corporate bond market liquidity, Trebbi and Xiao (2015) argue that liquidity has not deteriorated following post-crisis regulations. Bessembinder, et al. (2016) provide a similar finding, but also add an examination of dealer behavior. They find that while there is little evidence of increases in transactions costs, there is evidence that dealers behave differently as new regulations have been implemented. Dick-Nielsen and Rossi (2016) study liquidity provision around index exclusion events, finding that liquidity has deteriorated post-crisis. All three papers provide evidence of how liquidity and market-making has changed in post-crisis years following the passage of reform rules, but in contrast to these studies, our focus is on isolating the specific effects arising from implementation of the Volcker Rule. Our main results relate to comparing the post-Volcker implementation period to the period just before Volcker implementation, whereas both Bessembinder et al. (2016) and Dick-Nielsen and Rossi (2016) focus on the years prior to

Volcker Rule implementation.[6] Trebbi and Xiao's (2015) sample extends to the end of 2014, but they also do not focus on the Volcker Rule implementation period. Furthermore, our use of the regulatory version of TRACE, with dealer identities, allows us not only to split dealers by those that are directly affected by the Volcker Rule and those that are not, but also to identify which dealers were potentially affected by other regulations such as Basel III and CCAR.

The evidence in our study suggests that there are significant costs to the proprietary trading ban in the Volcker Rule, but it is important to note that we do not do any welfare analysis to assess whether the Volcker Rule is overall net positive or net negative for financial markets and the economy.[7] One obvious potential benefit of the Volcker Rule is the ban of risky trades by institutions that could eventually seek government support if their risky trades led to significant losses. Such analysis requires modeling the trade-off between the social cost to the loss of liquidity in corporate bond markets and the societal benefit of safer banks and is beyond the scope of our study.

The rest of the paper is organized as follows. In Section 2, we discuss the Volcker Rule and its potential impact on market-making in the corporate bond market. In Section 3, we describe our data sources and variable construction. In Section 4, we examine changes in liquidity around times of stress. In Section 5, we examine how the behavior of Volcker-affected and non-Volcker-affected dealers changes with the implementation of the Volcker Rule. We also discuss Basel III and CCAR regulations. Section 6 concludes.

[6] In fact, both papers discuss their results as being related to an anticipation of new regulations. Our results, in contrast, look at the implementation of the Volcker Rule.

[7] There are, of course, costs to not having regulation. For example, Chernobai, Ozdagli, and Wang (2016) show that operational risk events increased during the gradual deregulation of bank holding companies from 1996 to 1999. We are, however, unaware of any studies quantitatively measuring the costs of allowing banks to participate in proprietary trading.

2. Potential Impact of the Volcker Rule on the Corporate Bond Market

As part of the Dodd-Frank Act, passed July 21, 2010, section 13 (the "Volcker Rule") was added to the Bank Holding Company Act of 1956. Section 13 generally prohibits banking entities from engaging in proprietary trading or having ownership or relationships with hedge funds and private equity funds. Implementation of section 13, however, was not immediate and followed a laborious process. On January 18, 2011, the Financial Stability Oversight Council (2011) released a study of its recommendations for implementing section 13. The Treasury, Board of Governors, FDIC, and SEC worked with the CFTC in formulating a proposal before releasing a version for comments in the Federal Register (2011) in November 2011. In December 2013, final regulations were issued, and final regulations with details of market participants' comments were released in the Federal Register (2014) on January 31, 2014. On April 1, 2014, the Volcker Rule became effective with banks of at least $50 billion in trading assets required to report some quantitative metrics starting July 2014. By July 21, 2015, large banks were required to be fully compliant with the Volcker Rule. During the conformance period, banks were required to make good faith efforts to conform to the new rules.[8] Hence, we expect to already see some effects of the Volcker Rule starting in April 2014.

Other research (e.g., Bessembinder et al. (2016) and Dick-Nielsen and Rossi (2016) has argued that anticipation of new regulation implementation could lead to earlier changes in dealer behavior. Though we expect the impact to be the greatest once the implementation period requires dealers to begin reporting metrics on market-making activity, our tests do not preclude the possibility of some changes in dealer behavior prior to rule implementation. In particular, our tests

[8] See Federal Reserve Board (2016).

are designed to gauge the additional impact of Volcker Rule implementation, mainly benchmarking to the period just before implementation.

The intent of the Volcker Rule is to prohibit banking entities with access to the discount window at the Federal Reserve or to FDIC insurance from engaging in risky proprietary trading. It is important to keep in mind that not all financial firms are covered. For example, an Oliver Wyman and SIFMA (2011) study lists Cantor Fitzgerald & Co., Daiwa Capital Markets, Jefferies & Co., and Nomura as explicitly not covered. It is also the case that not all trading activities are precluded. Recognizing that some activities are necessary for the market to function normally, the Volcker Rule includes an explicit set of permitted activities. The most relevant one for this paper, and arguably the most controversial, is a provision that permits market-making. Essentially, affected dealers can trade securities in a way to facilitate client-driven transactions, but cannot transact in a way intended to make profits based on the price appreciation of securities.

A major difficulty in implementing the market-making exception is distinguishing allowed market-making from prohibited proprietary trading. The Financial Stability Oversight Council (2011) proposed a number of principles to distinguish between the two. Among these are that market-making should have rapid inventory turnover with the vast majority of profits from bid-ask spreads rather than profits from inventory appreciation. Proprietary trading is likely to have more modest turnover with significant profits from inventory appreciation. The FSOC also proposed a number of metrics including measures of inventory aging, customer-initiated trade ratios, and revenue from customer-initiated flows. The final law requires establishment of an internal compliance program and the reporting of seven sets of metrics: (1) Risk and Position Limits and Usage, (2) Risk Factor Sensitivities, (3) Value-at-Risk and Stress VaR, (4)

Comprehensive Profit and Loss, (5) Inventory Turnover, (6) Inventory Aging, and (7) Customer Facing Trade Ratio.

Critics of the Volcker Rule noted many gray areas in the rule and further argued that ambiguity in how the rule would be enforced was likely to be detrimental to market liquidity. Furthermore, though the intent of market-making and proprietary trading may be different, observationally, they are difficult to distinguish. In fact, some argued that proprietary trading could be deemed "risky market-making." Duffie (2012) writes, "… an attempt to separate 'legitimate and acceptable' market-making from 'speculative and risky' market-making is not productive, in my opinion." Duffie and other commenters suggested that the Volcker Rule could be particularly problematic in illiquid markets such as corporate bond markets. Duffie notes that whereas the average half-life of order imbalance in equities is three days, for investment grade corporate bonds it is roughly two weeks. Thus, metrics based on measures such as inventory aging and inventory turnover could be particularly problematic for market-making in corporate bonds. Furthermore, dealers who fear violating the Volcker Rule could be unable to properly manage inventory. One of the guidelines for the Volcker Rule is meeting "near-term customer demand." But absent perfect predictions about future customer demand, market makers may be hesitant to acquire bonds in advance of a predicted spike in customer demand.

The final rule also presents complications for fulfilling customer demand because of the required internal compliance metrics. The Federal Register (2014) notes that trades exceeding internal limits "should not be permitted simply because it responds to customer demand." Instead, a banking entity is required to have escalation procedures that include "demonstrable analysis and approval." Such regulations mean that market makers will find it particularly difficult to respond to large sells in the market.

One initial proposal that was dropped in the final rule was a requirement for detailed revenue attribution. This included identifying revenue attributable to the bid-ask spread as opposed to price appreciation. While the final rule no longer has such a requirement, it does have a profit and loss attribution requirement that focuses on revenue generation patterns. Abnormal patterns could raise a red flag and lead to further review. Given the illiquid nature and infrequent trading patterns in corporate bonds, this could potentially cause issues for market makers, particularly when a significant subset of its bonds has a severe order imbalance.

In summary, Volcker Rule requirements have the potential to impact the behavior of dealers covered by the rule and lead to less liquid markets. Ambiguity as to what is legal market-making and what is prohibited proprietary trading may exacerbate the problem by pushing dealers toward more conservative trading strategies. New rules favoring customer-facing trades may discourage dealers from using the interdealer market, while inventory-based metrics may lead dealers to reduce their inventory exposure. Perhaps most pertinent to our study, the requirement that dealers set internal limits may result in dealers being unable to respond to increased customer demands during times of stress. With all of these theoretical reasons why the Volcker Rule may damage corporate bond liquidity, particularly in times of stress, we turn to assessing whether the empirical evidence is consistent with these concerns.

3. Data and Sample Description

To examine how the Volcker Rule has affected corporate bond liquidity in stress periods, we focus on bond trading around times when a bond was downgraded from investment-grade to speculative-grade. Insurance companies, the dominant investors in the corporate bond market, face regulatory restrictions when investing in the corporate bond markets. The National Association of Insurance Commissioners (NAIC) classifies corporate bonds into six risk categories (NAIC1 to

NAIC6) based on their credit ratings, and requires insurance companies to maintain a higher level of capital when investing in bonds in a higher risk category.[9] In addition, insurance companies are usually required to invest no more than 20% of their assets in bonds below NAIC2, i.e., speculative-grade bonds. Ellul, Jotikasthira, and Lundblad (2011) find that rating downgrades to speculative-grade can trigger fire sales in the bond market since greater capital requirements and other regulatory constraints prompt widespread divestment by insurance companies. Such regulation-induced fire sales generate high demand for liquidity, and can cause substantial price pressure in the absence of adequate liquidity provision.

We obtain the rating history file from Mergent's Fixed Income Securities Database (FISD) for the period from January 2006 to March 2016. This data file provides the announcement date of rating actions by the three largest rating agencies: Standard & Poor's (S&P), Moody's, and Fitch. We focus on fixed coupon corporate bonds with semi-annual coupon payments, $1000 par amount, and fixed maturity. These bonds are issued in U.S. Dollars by U.S. firms in the following three broad FISD industry groups: Industrial, Finance, and Utility. We exclude from our sample the following bonds: convertible or putable bonds, private placements, asset-backed issues, and issues which are part of a unit deal. Since rating agencies differ with respect to the timing of rating actions, we follow Ellul, Jotikasthira, and Lundblad (2011) and define the rating change event as the date of downgrade from investment-grade to speculative-grade announced by the first acting rating agency.

We then extract data from FINRA's TRACE database on corporate bond transactions during the one month following each rating downgrade. These data provide detailed information

[9] Bonds rated AAA, AA, A are in NAIC risk category 1 (NAIC1). NAIC2-NAIC5 correspond to BBB, BB, B and CCC rated bonds respectively. Bonds rated CC or lower belong to NAIC 6. The capital charge for NAIC1 to NAIC6 is 0.4%, 1.3%, 4.6%, 10%, 23% and 30%, respectively.

on all secondary market transactions in the downgraded bond, including bond CUSIP, trade execution date and time, trade price and quantity, a buy or sell indicator, an indicator for agency or principal trade, and an indicator for inter-dealer trade. In addition, the data also contain information on dealers for each trade and, in the case of inter-dealer trades, both sides of the trade. Our version of TRACE is the regulatory version of TRACE, which has dealer identities. The standard version of TRACE, while including flags for dealer-customer and interdealer trades, does not identify the dealer(s) involved in a trade. Knowing dealer identities allows us to separately analyze liquidity provision by Volcker-affected and non-Volcker-affected dealers. Lastly, for each of the rating downgrades in our sample, we obtain characteristics information, including total par amount outstanding, issuance date and maturity date, from Mergent FISD.

To examine bond liquidity during stress times, we estimate the average price impact during the one-month post-downgrade period in the spirit of Amihud (2002):

$$PriceImpact_i = \frac{1}{(N_i-1)}\sum_{t=2}^{N_i}\frac{(P_{i,t}-P_{i,t-1})}{Q_{i,t}},$$

where $P_{i,t}$ and $Q_{i,t}$ represent the price (per \$1000 of par value) and par amount (in thousands) of the t-th trade in bond i, and N_i represents the total number of trades during the one month following the downgrade of bond i.[10] In calculating the price impact measure, we exclude the following transactions: when-issued, cancelled, subsequently corrected, reversed trades, and exclude inter-dealer trades. Following Bessembinder, Kahle, Maxwell, and Xu (2009) and Ronen and Zhou (2013), we remove trades with \$100,000 or less in par amount to avoid the substantial noise that these small trades introduce into prices.

[10] Because we have transaction-level data with trade direction, we modify our calculation of the Amihud (2002) measure to use transaction-level data (as in Dick-Nielsen, Feldhutter, and Lando (2012)) and also use signed trades rather than using absolute changes in prices. As in Amihud (2002), which is based on the theoretical model of Kyle (1985), we aim to capture liquidity by using the response of price to order flow.

Table 1 presents our final sample of rating downgrades after matching FISD's rating history file with FINRA's TRACE data. A total of 687 bonds by 218 firms were downgraded from investment grade to speculative-grade during the period from January 2006 to March 2016. Moody's acted first in 375 bonds, followed by S&P, which downgraded 247 bonds, and then Fitch who acted first for the remaining 89 bonds. Out of the 687 bonds, 356 were downgraded by one notch, and 157 were downgraded by two notches. The remaining 174 bonds were downgraded by three or more notches.

We divide our sample period into five sub-periods: Pre-crisis Period (January 1, 2006 – June 30, 2007), Crisis Period (July 1, 2007 – April 30, 2009), Post-crisis Period (May 1, 2009 – July 20, 2010), Post-Dodd Frank Period (July 21, 2010 – March 31, 2014), and Post-Volcker Period (April 1, 2014 – March 31, 2016). We focus on comparing bond liquidity during the Post-Volcker Period with that during the other four sub-periods prior to the effective date of the Volcker Rule.[11] The designations of the four pre-Volcker sub-periods are generally consistent with existing studies (e.g., Dick-Nielsen, Feldhutter, and Lando (2012), and Bessembinder et. al. (2016)).[12]

As pointed out by Trebbi and Xiao (2015), using exact dates of regulatory policies to study the impact of regulation on market liquidity is potentially complicated by anticipatory or delayed responses by market participants. For example, bank dealers might have become more conservative in market-making in anticipation of the rule prohibiting proprietary trading. In addition, regulators gave market participants over one year to fully comply with the Volcker Rule. Thus, using the effective date of the Volcker rule allows us to capture only partial effects of the Volcker Rule on bond liquidity and biases against finding results. The complete effects (including

[11] Since our focus is on examining bond liquidity during the one-month following each downgrade, we exclude those downgrade events that happened during the last month in each of the five sub-periods.
[12] The regulatory period that other papers study largely coincides with the period we classify as the Post-Dodd Frank Period.

both implementation and anticipation-related actions) could be larger than our empirical methodology captures.

Table 1 shows how the distribution of sample of rating downgrades across the five sub-periods. A total of 182 bonds were downgraded during the post-Volcker Period. The number of downgraded bonds increases from 114 for the Pre-Crisis Period to 210 for the Crisis Period, and then declines to 68 and 113 for the Post-Crisis Period and Post-Dodd Frank Period, respectively.

4. Liquidity around Stress Events

Studying the effect of Volcker Rule on corporate bond liquidity during stress times is challenging since liquidity of the bond market might have changed over time for reasons unrelated to the post-crisis regulations. To account for the potential influence of such time trends, we use a difference-in-differences methodology by first comparing the price impact in the BB bonds newly downgraded from BBB with that in the existing BB bonds, and then examine how their differences have change from the Pre-Volcker periods to the Post-Volcker Period. Specifically, for each downgrade event, we calculate the average *PriceImpact* in bonds which were rated BB by the acting rating agency during the same one-month period, labeled as $PriceImpactControl_i$. $PriceImpactDiff_i$ is the first difference and is defined as the difference in *PriceImpact* between the downgraded bond *i* and other BB bonds during the same one-month period

$$PriceImpactDiff_i = PriceImpact_i - PriceImpactControl_i.$$

We then compare *PriceImpactDiff* over different periods.

4.1. Univariate Analysis of Price Impact Measures

Table 2 shows that the average $PriceImpactDiff_i$ is 0.016 during the Post-Volcker Period. This is substantially higher than the mere 0.003 during the Pre-Crisis period. It is also higher than the 0.007 and 0.011 for the Post-Dodd Frank Period and the Post-Crisis Period, and

only slightly smaller than the 0.018 for the Crisis Period. To benchmark these numbers, consider two trades at \$1000 and \$1016 (per \$1000 in face value), respectively. Suppose that the second trade is for \$1,000,000 in face value. This gives a price impact measure of (1016 – 1000)/1000 = 0.016.

The changes in $PriceImpactDiff_i$ across sub-periods mainly reflect changes in $PriceImpact_i$ of the downgraded bonds, rather than those of the BB bonds in the control sample. For our sample of downgraded bonds, $PriceImpact_i$ was 0.007 during the Pre-Crisis Period. It jumped to 0.03 during the Crisis-Period, but has since declined to 0.021 in the Post-Crisis Period, and further to 0.015 in the Post-Dodd Frank Period. However, following the implementation of the Volcker Rule, the trend of declining price impact reversed: $PriceImpact_i$ increased to 0.024, higher than any of the Pre-Volcker sub-periods except for the Crisis Period. This finding is intriguing given that $PriceImpactControl_i$ did not change from the Post-Dodd Frank Period to the Post-Volcker Period. In fact, the changes in $PriceImpactControl_i$ over time for the control sample of BB bonds not in stress are consistent with that documented in Bessembinder et al. (2016). In sum, bond liquidity around stress events have deteriorated since the Volcker Rule took effect.

4.2. Regression Analyses

To check the statistical significance of the changes in $PriceImpactDiff_i$ from the pre-Volcker sub-periods to Post-Volcker Period, and also to control for the influences of other factors on bond liquidity during stress times, we conduct regression analyses in this section to further study the Volcker Rule effect on corporate bond liquidity.

We create four dummy variables for the four sub-periods after the Pre-Crisis Period: Crisis, Post-Crisis, Post-Dodd Frank, and Post-Volcker. Crisis takes the value of one if a rating

downgrade occurred during the Crisis Period, and it takes the value of zero otherwise. The other three sub-period dummies are created in a similar way. We then regress $PriceImpactDiff_i$ on the four sub-period dummies, and a host of control variables.

First, although all our sample bonds were downgraded from investment grade to speculative-grade, they differ from each other in terms of both pre-downgrade rating and the number of notches downgraded. Since such differences can affect bond trading following the downgrade announcement, and hence the *PriceImpactDiff*$_i$ measure, we include as control variables *Previous Rating* and Δ*Rating*, which refer to the rating of the bond prior to the downgrade and the number of notches by which it was downgraded, respectively. Second, we control for bond characteristics, including (the log of) number of years since issuance (*Log Age*), number of years until maturity (*Log Time to Maturity*), and total par amount outstanding (*Log Amount Outstanding*). Lastly, we include into the regressions several variables that capture general market conditions during the same one-month period following each downgrade. These variable include aggregate market index returns, such as the return to the S&P 500 Index (*SP500 Index Return*), the return to the Barclays Capital U.S. Investment-Grade Corporate Bond Index (*IV Bond Index Return*) and the Barclays Capital U.S. High-Yield Corporate Bond Index (*HY Bond Index Return*). We also include changes in market volatilities, such as the change in CBOE stock market volatility index (Δ*VIX*), the change in the volatility of the Barclays Capital U.S. Investment-Grade Corporate Bond Index (Δ*IV Bond Volatility*) and the Barclays Capital U.S. High-Yield Corporate Bond Index (Δ*HY Bond Volatility*), and the change in 3 month LIBOR rate (Δ*3M LIBOR*). Changes in market volatilities and interest rates are calculated by comparing the one-month following a downgrade

to the one-month prior to the downgrade.[13] Since bonds issued by the same firm are usually downgraded at the same time, we cluster the standard errors at the firm level.

Column I of Table 4 presents the result from this regression analysis. We find that bond characteristics affect the $PriceImpactDiff_i$ measure, with older bonds and bonds with longer time-to-maturity experiencing lower liquidity following their downgrade, while larger issues enjoy higher liquidity. *Previous Rating* and *Rating Change* do not have a significant impact on the $PriceImpactDiff_i$, and neither do the macro-economic variables.

More importantly, the coefficient for all four sub-period dummies are positive and significant at the 5% level, suggesting that bond liquidity around stress events has significantly deteriorated since the beginning of financial crisis. Consistent with the summary information presented in Table 2, the magnitude of the coefficient for sub-period dummies first declines monotonically from Crisis to Post-Dodd Frank, but then increases from Post-Dodd Frank to Post-Volcker. Tests on the differences in the coefficients on sub-period dummies show that the coefficient for Post-Volcker is significantly higher than that for Post-Dodd Frank, and it is not statistically significantly different from that for Crisis and Post-Crisis. These results suggests that bond liquidity around stress events has worsened following the implementation of the Volcker Rule, and it has deteriorated to a level similar to that during the financial crisis.

To confirm that the increase in $PriceImpactDiff_i$ for Post-Volcker is mainly driven by higher price impact for the downgrade bonds, rather than lower price impact for BB bonds, we run the regression by using either $PriceImpact_i$ or $PriceImpactControl_i$ as the dependent variables. These results are presented in Columns II and III, respectively. For the sample of downgraded bonds, Post-Volcker has a significantly higher coefficient than Post-Dodd Frank. The coefficient

[13] For ease of reference, we also provide a definition of all of these independent variables in Table 3.

for Post-Volcker is not statistically different from Crisis and Post-Crisis. These results mirror those from using $PriceImpactDiff_i$ as the dependent variable. Meanwhile, for the sample of BB bonds not experiencing any rating changes, there is no significant difference in the coefficients for Post-Volcker and Post-Dodd Frank, both statistically and economically. Taken together, these results are consistent with Volcker Rule degrading liquidity in the bond market around times of stress.

4.3. Robustness Checks

We conduct three tests to examine the robustness of our results on post-Volcker bond liquidity changes. First, we investigate the sensitivity of our results to an alternative measure of liquidity, *Realized Spread*. Second, we study whether using the compliance date instead of the effective date of the Volcker Rule affects our results. And finally, we use a matched sample approach to conduct the difference-in-differences test.

4.3.1 Alternative Liquidity Measure

Measuring liquidity in financial markets is challenging. The fact that most bonds do not trade often makes it even hard to measure liquidity in the bond market as almost all the existing bond liquidity measures rely on transaction data.[14] The reliability of these liquidity measures varies with the amount of trades used in estimation. In this section, we estimate a measure of *Realized Spread* which has relatively low requirements on trade frequency. Specifically, for each downgraded bond, we first calculate the daily *Realized Spread* by taking the difference between volume weighted average customer buy prices (Ask) and volume weighted average customer sell prices (Bid) during the one-month following the downgrade. To avoid the noise embedded in small trades, we exclude trades with $100,000 or less in par amount. We then average the daily spread across days within the one-month period to get an event level estimate: $RealizedSpread_i$.

[14] One notable exception is Mahanti et al. (2008) who propose a latent liquidity measure for corporate bond by using the holding-weighted average turnover rate of bond portfolio of each fund that holds the bond.

For each downgrade event, we also calculate the average *RealizedSpread* in bonds which were rated BB by the acting rating agency during the same one-month period. We then subtract the average BB bond *RealizedSpread* from that of the downgraded bond to get a $SpreadDiff_i$ measure.

We regress $SpreadDiff_i$ on the four sub-period dummies and all the control variables and the results are presented in Column I of Table 5. The coefficients for sub-period dummies declines from 0.166 for Crisis to 0.066 for Post-Crisis, and further to 0.051 for Post-Dodd Frank. However, the downward trend of *RealizedSpread* reverses following the implementation of the Volcker Rule. The coefficient of Post-Volcker is 0.09, which is higher than that for the Post-Dodd Frank at the 10% level. Therefore, liquidity as captured by *RealizedSpread* also seems to have deteriorated post-Volcker.

4.3.2 Alternative Definition of Post-Volcker Period

The final Volcker Rule became effective April 1, 2014, but the compliance date for banks to fully conform their proprietary trading activities to the Volcker Rule was July 21, 2015. To examine how any lagged reaction of market participants to regulation during the gap between the effective date and compliance date affects our results, we use the compliance date of the Volcker Rule to redefine Post-Volcker period. Specifically, Post-Dodd Frank period now is from July 21, 2010 to July 20, 2015 and Post-Volcker period is from July 21, 2015 to March 31, 2016. The other sub-periods are defined as earlier.

Column II of Table 5 again provides evidence of deteriorating liquidity following Volcker Rule. The coefficient of Post-Volcker is 0.026, more than double that of Post-Dodd Frank (0.011) and the different is statistically significant at the 10% level. Also similar to the results from using the Final Rule Effective date to define Post-Volcker, the coefficient of Post-Volcker is not significantly different from that of Crisis and Post-Crisis.

4.3.3 Alternative Approach for the Difference-in-Differences Test

In examining how liquidity in downgraded bonds has changed over time, we compare each downgraded BB bond with a sample of BB bonds not experiencing any recent rating changes. Although both downgraded bonds and bonds in the control group have the same rating, they can differ in other key attributes, which could affect their liquidity. To account for this possibility, we use a matched sample approach by comparing each downgraded BB bond with a sub-sample of the BB bonds that are similar to the downgraded BB bond in terms of time-to-maturity, total par amount outstanding, and age.

Specifically, we first segment BB bonds in the control group into three time to maturity categories: short-term (maturing within one year), medium-term (with time to maturity greater than one year by no more than seven years), and long-term (maturing over seven years). Within each maturity category, we further segment bonds into three size categories: small issue, medium issue, and large issue, using $0.5 Billion and $1.5 Billion in total par amount outstanding as the cutoffs. Finally, we divide bonds within each size category into new issues and seasoned issues, depending on whether its time since issuance is greater than one year. Therefore, we form a total of eighteen bond groups in the control sample based on time to maturity, amount outstanding, and age. We then calculate *PriceImpactDiff* for each downgraded bond by taking the difference between the *PriceImpact* of the downgraded bond and the average *PriceImpact* of BB bonds from the matching group during the same one-month period.

Column III of Table 5 shows that using the matched sample approach has little impact on our results. We continue to observe that following Volcker Rule, the marginal deterioration in bond liquidity during stress times is as severe as during the financial crisis period.

5. Dealer Behavior Around Stress Events

In this section, we study how the behavior of dealers has changed around Volcker Rule implementation and, importantly, compare the behavior of Volcker-affected dealers and non-Volcker-affected dealers. In Subsection 5.1, we discuss how we identify whether a dealer is Volcker-affected and in Subsections 5.2 and 5.3, we document the change in behavior across the two groups over time. Finally, we discuss other regulations in Subsection 5.4.

5.1 Identifying Volcker-Affected Dealers

A key issue is identifying which broker-dealers are subject to the Volcker Rule. This is a non-trivial task as full lists of Volcker-affected institutions are not published. In a study of the Volcker Rule, Oliver Wyman and SIFMA (2011) provide a list of 21 liquidity providers and whether they categorize as affected by the Volcker Rule.[15] Of these 21 banks, they identify four (Cantor Fitzgerald & Co., Daiwa Capital Markets, Jefferies & Co., and Nomura) that are not affected by the Volcker Rule. Among those affected are major bank holding companies such as Goldman Sachs and Morgan Stanley. However, this list is far from complete as TRACE data identifies hundreds of dealers transacting in the bond market.

To determine whether other broker-dealers are covered by the Volcker Rule, we follow the principle that the Volcker Rule was designed to prevent institutions with access to government backstops from participating in proprietary trading. The two most prominent backstops mentioned in the Federal Register (2014) discussion of the Volcker Rule are FDIC insurance and access to the Fed's discount window. We start with the broker-dealers on the Oliver Wyman and SIFMA (2011) list and add to it the top 300 broker-dealers in terms of trading volume; together, these broker-dealers account for 97% of total bond market trade volume. We then search both the FDIC's database of FDIC-insured banking institutions and the National Information Center's

[15] We reproduce this list in Table 6.

institution database to see which of the 300 broker-dealers were subject to the Volcker Rule. The former is relatively straightforward. If a broker-dealer, or more likely an affiliate (i.e., a commercial bank with the same parent holding company) is listed as having FDIC insurance, we code it as Volcker-affected. The latter is more complicated as the NIC database contains "banks and other institutions for which the Federal Reserve has a supervisory, regulatory, or research interest…" Thus, not all institutions in the database are necessarily Volcker-affected. We look for institutions coded as National Banks, State Member Banks, Bank Holding Companies, and Financial Holding Companies and treat these as Volcker-affected. Among the main types of institutions in the NIC database that we do not treat as Volcker-affected are Securities Broker/Dealers and Domestic Entity Other. As a third source, we search the Federal Reserve Board's Resolution Plans website (https://www.federalreserve.gov/bankinforeg/resolution-plans.htm) to identify large bank holding companies under Fed supervision that must submit a living will.[16] Combining results from our manual search with the list in Oliver Wyman and SIFMA (2011) results in approximately 45% of the top dealers being determined to be Volcker-affected.

5.2 Dealer Trading Activities

We start by documenting basic dealer trading patterns around downgrade-to-speculative ("stress") events in Table 7. In the month following a downgrade, the average turnover of downgraded bonds is close to 40% in the Post-Volcker period, higher than any of the other four periods in our sample. It is also much higher than the 9% monthly turnover of BB bonds during the Post-Volcker period, consistent with significant selling by insurance companies in the period just after downgrades to speculative-grade. However, the proportion of total trading volume that

[16] Living wills are mandated by Dodd-Frank to prevent taxpayer bailouts in the future. Thus, the fact that regulators require a living will suggests that these are institutions with government backstops.

is dealer-customer (as opposed to interdealer), 62%, is roughly in line with the other periods of our sample.

Of perhaps more interest, we compare Volcker-affected and non-Volcker-affected dealers in the other panels of Table 7. Our focus is on the proportion of dealer-customer trading handled by Volcker vs. non-Volcker dealers and also the dealers' use of agency trading. The underlying evidence in Ellul, Jotikasthira, and Lundblad (2011) is that around stress events, some institutional investors (e.g., insurance companies) sell bonds due to regulatory constraints. Dealers then intermediate these trades, and potentially hold inventory in bonds when selling demand exceeds buying demand. Both the proportion of customer-dealer trades and the percentage of agency trades address how dealers react to customer demands.

Volcker-affected dealers tend to be larger than non-Volcker dealers and handled 93% of dealer-customer volume around stress events in the pre-crisis period. Over our sample period, we see a gradual decline in the share of dealer-customer volume handled by Volcker-affected dealers. By the Post-Volcker period, non-Volcker dealers were handling almost one quarter of the dealer-customer volume. Though the increasing volume handled by non-Volcker dealers is consistent with Volcker-affected dealers scaling back their market-making due to the Volcker Rule, we cannot rule out the explanation that there has been a gradual time series change in the dealer business that has led the smaller, non-Volcker dealers to take a greater share of dealer-customer volume.

Next, we turn to how agency trading has changed over time for Volcker and non-Volcker dealers. Agency trading occurs when a dealer has lined-up a counterparty to immediately offset a trade with a customer. For example, if an insurance company decides to sell a downgraded bond, a dealer in an agency trade would line-up another customer (or dealer) to purchase the bond. In

such a case, dealers do not commit capital or take on any inventory risk. A principal trade, in contrast, involves dealers taking on one side of a trade without pre-existing knowledge that they will be able to unwind the trade quickly. We follow Harris (2015) and Bessembinder et al. (2016) and define a trade as an agency trade if it is offset by another trade in the opposite direction within one minute.

Our empirical results indicate that Volcker-affected dealers have increased the proportion of their total volume that is done on an agency basis. Pre-crisis, only 12% of the volume traded by Volcker-affected dealers was in agency trades. This number jumped to a little over 15% with the onset of the Financial Crisis and stayed fairly flat until jumping again to almost 23% with enforcement of the Volcker Rule. The sudden jump in the proportion of volume done as agency trades is suggestive of a causal effect of the Volcker Rule on Volcker-affected dealers' willingness to hold bonds on their balance sheet without pre-arranging an offsetting trade. Non-Volcker dealers, in contrast, have seen a decline in the proportion of trades that they do on an agency basis. During the Pre-Crisis Period, almost half of the trades done by non-Volcker dealers around stress events were done as agency trades. By the Post-Volcker Period, this percentage had dropped to 29%.

To more formally study the changes in agency trades across time for Volcker and non-Volcker-affected dealers, we run a regression of proportion of trades that are agency trades on period dummies and controls. Our base regression is,

$$
\begin{aligned}
&Proportion\ of\ agency\ volume_i \\
&= \beta_0 + \beta_1 Crisis + \beta_2 Post - Crisis + \beta_3 Post - Dodd\ Frank \\
&+ \beta_4 Post - Volcker + \gamma X + \epsilon,
\end{aligned}
$$

where the unit of observation is a stress event, the dependent variable is the proportion of volume done by either Volcker or non-Volcker dealers done on an agency basis, and the omitted period dummy is the Pre-Crisis Period. X represents a vector of control variables that are the same as defined in Table 3 and used in Table 4. Our variable of interest is β_4, which directly measures the difference in the proportion of volume done on an agency basis between the Post-Volcker Period and the Pre-Crisis Period. Also of interest is the difference between β_4 and the coefficients on the other sub-period dummies.

The regression results are presented in Table 8. In the first column, the dependent variable is the proportion of agency trading done by Volcker Rule affected dealers after stress events. The coefficient on the Post-Volcker dummy is 0.133, indicating a 13 percentage point increase in volume done on an agency basis relative to the pre-crisis period. This change is slightly larger than the 11 percentage point increase without controls in Table 7. Importantly, we also see that the coefficient on the Post-Volcker dummy is also significantly larger than for the other periods in our sample. The Post-Dodd Frank period has a statistically significant coefficient of 0.046, indicating a 4.6 percentage point increase in agency trades compared to the Pre-Crisis Period, but also much smaller than the Post-Volcker Period. The nine percentage point increase in agency trading from the Post-Dodd Frank Period to the Post-Volcker Period is both statistically and economically significant.

In the second column of Table 8, we re-run our agency trade regression, but instead consider the proportion of trades done on an agency basis by non-Volcker-affected dealers. While the coefficients on all of the sub-period dummies are negative and the amount of agency trading done by non-Volcker dealers is smaller (in magnitude) during the Post-Volcker Period as compared to any other period, we do not find any statistical significance. In particular, unlike

Volcker-affected dealers, we do not find a sharp jump in the proportion of agency trading for non-Volcker dealers upon implementation of the Volcker Rule. If anything, we find the opposite, at least in terms of point estimates. Our results are consistent with the Volcker Rule inducing Volcker-affected dealers to shift from principal to agency trading as a way to avoid inventory imbalance.

5.3 Dealer Capital Commitment

A more direct measure of dealers' willingness to hold inventory imbalances is the time-weighted capital commitment. In the one month following a stress event, we calculate for each dealer the absolute deviation from starting inventory. The intuition is that if a dealer starts with a particular desired inventory level, the first purchase moves the dealer above this desired inventory level, but a following sell will again move the dealer back towards the desired inventory level. The actual desired inventory level is unobservable, so our implicit assumption is that the starting level of inventory is optimal. To calculate how far a dealer is from the starting inventory level, we simply take the accumulated buys and subtract the accumulated sells from the starting point. To calculate the time-weighted capital commitment, we then average the absolute distance from the starting inventory, weighting by the amount of time the inventory level is held.

While our measure is similar to the dealer capital commitment measure in Bessembinder et al. (2016), it is important to note that we measure capital commitment over the course of a month while they construct a daily measure. Their measure implicitly assumes that the starting point at each day is the optimal inventory, whereas our monthly measure allows for inventory to continue to move away from optimal inventory over the course of a few days. In particular, if a dealer has purchased a large volume of a bond in a day and has not sold this volume to another customer or

dealer, the dealer still has significant capital commitment the next day. Once we calculate bond-dealer level capital commitment, we sum across dealers for a given stress event.

In Table 9, we report regressions of time-weighted dealer capital commitment on sub-period dummies and controls separately for Volcker-affected and non-Volcker-affected dealers, similar to our proportion of agency volume regressions. The units for time-weighted dealer capital commitment are the number of bonds, with each bond being $1000 in face value. In the first column, we find that dealer capital commitment by Volcker-affected dealers has declined in all periods relative to the pre-crisis period. Dealer capital commitment is roughly $10 million in face value lower on average for a downgraded bond during the Crisis, Post-Crisis, and Post-Dodd Frank periods as compared to the Pre-Crisis period.[17] For the Post-Volcker Period, this decline is $20 million in face value relative to the Pre-Crisis Period. The lower capital commitment for the Post-Volcker Period is also statistically larger for the Volcker Period than it is for the Crisis, Post-Crisis, and Post-Dodd Frank periods. Thus, while there is a large and sudden drop in capital commitment from the Pre-Crisis to the Crisis Period, there is also a large and sudden drop from the Post-Dodd Frank Period to the Post-Volcker Period, suggesting that there was a significant shift in Volcker-affected dealers around the implementation of the Volcker Rule. Column II of Table 9 considers whether capital commitment has changed for non-Volcker dealers. Our results indicate that capital commitment has actually increased for non-Volcker dealers during the Post-Volcker period, in contrast to Volcker-affected dealers.

5.4 Capital Commitment and Basel III

[17] As a benchmark, the average capital commitment of Volcker-affected dealers in BB-rated bonds during non-stress periods is $6 million. For non-Volcker dealers, it is $1.6 million.

A potential concern in trying to isolate a Volcker Rule implementation effect is that, in the post-crisis period, a number of reforms were passed to regulate the finance industry. In particular, the Comprehensive Capital Analysis and Review (CCAR) process began in 2011, requiring bank holding companies (BHCs) to submit capital plans to the Federal Reserve. The capital plan requires that the BHC is able to maintain minimum capital requirements even under stress scenarios, providing a stiff test of a BHC's regulatory capital. The punishment for not passing a CCAR test is that the BHC is not allowed to make capital distributions unless the Federal Reserve indicates in writing that it allows the distribution.[18] Each year, the Federal Reserve publishes a list of BHCs that have either failed their CCAR tests or received only a conditional pass.

In January 2014, the start of Basel III implementation went into effect, adding additional capital requirements above what was required in Basel II. In conjunction with CCAR regulations, this potentially made banks more capital constrained and may have caused BHCs to change their market-making businesses.[19] To test the hypothesis that it was the combination of Basel III and CCAR that is driving our results on dealers, we split dealers into those that were CCAR-constrained and those that were not. We classify any bank that failed a CCAR test or was given a conditional pass in 2014 or 2015 as CCAR-constrained.[20] If BHCs change their market-making behavior in response to changing capital requirements, then we would expect CCAR-constrained banks to lower their capital commitment more than BHCs that were able to pass their CCAR tests.

In Table 10, we find that both dealers that passed the CCAR tests and dealers that failed or conditionally passed the CCAR test had lower capital commitment in the Volcker Rule

[18] Historically, the Federal Reserve has continued to allow failed BHCs to continue capital distributions at the same rate as in the past. Effectively, the main constraint is that these BHCs cannot increase their capital distributions.
[19] We thank Darrell Duffie for suggesting the CCAR linkage to us.
[20] BHCs receiving a conditional pass are required to remediate deficiencies and resubmit a new capital plan later in the year. Thus, such BHCs would have similar incentives to BHCs that fail CCAR tests.

implementation period as compared to the Post-Dodd Frank Period. However, the decline in capital commitment is higher for the dealers that passed CCAR tests (roughly $4.5 million) than for dealers that failed or conditionally passed CCAR tests (roughly $2.6 million), a result at variance with the prediction above.[21] Hoarding capital to pass the CCAR test is thus not supported as an explanation for decreased dealer capital commitment in bond trading.

6. Conclusion

In this paper, we study the impact of Volcker Rule implementation on corporate bond illiquidity and dealer behavior. Our main finding is that the Volcker Rule has a deleterious effect on corporate bond liquidity and dealers subject to the Rule become less willing to provide liquidity during stress times. While dealers not affected by the Volcker Rule have stepped in to provide liquidity, we find that the net effect is a less liquid corporate bond market. We also rule out that the effects are due to the implementation of Basel III in conjunction with CCAR requirements.

Our study focuses on events where investment-grade bonds are downgraded to speculative-grade to capture plausible events of forced selling. Using these stress events, we find that downgraded bonds exhibit a larger price impact of trading than a control group of BB bonds. More importantly, the relative level of the excess price impact is larger after the Volcker Rule is implemented than the period just before the Volcker Rule is implemented. Indeed, we find the disturbing result that illiquidity in stress periods is now approaching levels see during the financial crisis.

[21] It is possible that the BHCs that passed their CCAR tests chose to change their capital commitment in anticipation of Basel III, prior to the actual implementation, whereas the BHCs that failed did not. Nevertheless, this also predicts that if BHCs commit less capital to try to pass CCAR tests, we should still see stronger declines in capital commitment during the Volcker implementation period for those BHCs that failed CCAR tests, relative to those BHCs that passed CCAR tests.

Examining individual dealer behavior allowed us to rule out the possibility that our results are driven simply by time series changes in dealer behavior. We find that following Volcker Rule implementation Volcker-affected dealers are less involved in dealer-customer trades, use a greater proportion of agency trades, and are less willing to commit capital. Non-Volcker dealers pick-up a greater proportion of dealer-customer trades and do not have statistically significant changes in their use of agency trades or willingness to commit capital. Splitting Volcker-affected dealers into those who have failed CCAR tests in 2014 and 2015 and those who have not, we find that capital commitment among downgraded bonds has decreased more for dealers that passed CCAR tests, a result inconsistent with a Basel III explanation for decreased bond market liquidity. Overall, our results show that the Volcker Rule has had a real effect on dealer behavior, with significant effects only on those dealers affected by the Volcker Rule and not all bond dealers.

Table 1: Sample Description

This table provides a description of the corporate bonds downgraded from investment grade to speculative-grade by one of three major credit rating agencies (S&P, Moody's, and Fitch) over the period from January 1, 2006 to March 31, 2016. Data on historical rating changes by the three major rating agencies are obtained from Mergent's Fixed Income Securities Database (FISD). We use the date of announcement by the rating agency who acted first to define the downgrade event. We divide the full sample period into five sub-periods: Pre-crisis Period (January 1, 2006 – June 30, 2007), Crisis Period (July 1, 2007 – April 30, 2009), Post-crisis Period (May 1, 2009 – July 20, 2010), Post-Dodd Frank Period (July 21, 2010 – March 31, 2014), and Post-Volcker Period (April 1, 2014 – March 31, 2016). For the full sample period and each of the sub-periods, we present the number of bonds downgraded and number of firms whose bonds were downgraded. We report the number of bonds in which S&P, Moody's, or Fitch was the first to take action. Note that multiple rating agencies can downgrade a bond on the same day. We also report the number of bonds that were downgrade by one notch, by two notches, and by three or more notches (which are in the "**other**" column) respectively.

	# of Bonds	**# of Firms**	**by S&P**	**by Moody's**	**by Fitch**	**by One Notch**	**by Two Notches**	**others**
full sample period								
January 1, 2006 – March 31, 2016	687	218	247	375	89	356	157	174
by sub-periods								
Pre-crisis Period (January 1, 2006 – June 30, 2007)	114	45	36	50	37	54	17	43
Crisis Period (July 1, 2007 – April 30, 2009)	210	57	105	100	8	97	80	33
Post-crisis Period (May 1, 2009 – July 20, 2010)	68	16	3	61	4	46	3	19
Post-Dodd Frank Period (July 21, 2010 – March 31, 2014)	113	45	51	41	33	64	28	21
Post-Volcker Period (April 1, 2014 – March 31, 2016)	182	55	52	123	7	95	29	58

Table 2: Univariate Analysis of Corporate Bond Liquidity Following Downgrades

This table analyzes the liquidity of a bond during the one-month following its downgrade from investment-grade to speculative-grade over the period from January 1, 2006 to March 31, 2016. We measure bond liquidity by using a price impact measure, *PriceImpact* = $(P_t - P_{t-1})/Q_t$, where P_t and Q_t refers to the price (per $1000 of par value) and par amount (in thousands) of the trade at time *t* respectively. Retail-sized trades, i.e., those with par amount less than $100,000 are excluded from calculation in order to avoid the noise they tend to carry as suggested by Bessembinder et al. (2009). We first calculate the *PriceImpact* measure for each trade, and then average it across the trades within the one-month following each downgrade to get an event level estimate. For each downgrade event, we also calculate the average $PriceImpact$ in bonds which were rated BB by the acting rating agency during the same one-month period, and is labelled as *PriceImpactControl*. *PriceImpactDiff* is the difference in *PriceImpact* between the downgraded bond and other BB bonds. We divide the full sample period into five sub-periods: Pre-crisis Period (January 1, 2006 – June 30, 2007), Crisis Period (July 1, 2007 – April 30, 2009), Post-crisis Period (May 1, 2009 – July 20, 2010), Post-Dodd Frank Period (July 21, 2010 – March 31, 2014), and Post-Volcker Period (April 1, 2014 – March 31, 2016). Since our focus is on examining bond liquidity during the one-month following each downgrade, we exclude those downgrade events that happened during the last month in each of the sub-periods. We test whether $PriceImpactDiff$ for each sub-period is statistically different from zero and report the *p*-value. We also conduct tests on the differences in the $PriceImpact$ liquidity measures between two sub-periods and report the *p*-value. Since bonds issued by the same firm are usually downgraded at the same time, we cluster the standard errors at the firm level.

	PriceImpact	PriceImpact Control	PriceImpact Diff	p-value	Number of Bonds	Number of Firms
Pre-crisis Period	0.007	0.004	0.003	0.062	114	45
Crisis Period	0.030	0.012	0.018	0.000	210	57
Post-crisis Period	0.021	0.011	0.011	0.129	68	16
Post-Dodd Frank Period	0.015	0.008	0.007	0.000	113	45
Post-Volcker Period	0.024	0.008	0.016	0.007	182	55

Table 3: Independent Variable Definitions

This table provides detailed definitions of independent variables used in the tables below. Dependent variables are defined in the respective tables that they are used in.

Variable	Definition
Crisis	Dummy variable equal to 1 for July 1, 2007 to April 30, 2009 and 0 otherwise.
Post-crisis	Dummy variable equal to 1 for May 1, 2009 to July 20, 2010 and 0 otherwise.
Post-Dodd Frank	Dummy variable equal to 1 for July 21, 2010 to March 31, 2014 and 0 otherwise.
Post-Volcker	Dummy variable equal to 1 for April 1, 2014 to March 31, 2016 and 0 otherwise.
Previous Rating	The rating of a downgraded bond before the downgrade from investment-grade to speculative-grade. A numeric value is assigned to each notch of credit rating, with 1, 2, 3, 4 … denoting AAA, AA+, AAA, AA- … respectively.
ΔRating	The number of notches that a bond was downgraded.
Age	The log of the number of years since issuance for a bond.
Time-to-Maturity	The log of the number of years to maturity for a bond.
Amount Outstanding	The log of the total amount outstanding in $thousands.
S&P 500 Index Return	The return of the S&P 500 over the one-month post-downgrade period. It is expressed in decimal form.
IV Bond Index Return	The return to the Barclays Capital U.S. Investment-Grade Corporate Bond Index over the one-month post-downgrade period. It is expressed in decimal form.
HY Bond Index Return	The return to the Barclays Capital U.S. High-Yield Corporate Bond Index over the one-month post-downgrade period. It is expressed in decimal form.
ΔVIX	The change in CBOE stock market volatility index from the one-month pre-downgrade period to the one-month post-downgrade period.
ΔIV Bond Volatility	The change in the standard deviation of the Barclays Capital U.S. Investment-Grade Corporate Bond Index Return from the one-month pre-downgrade period to the one-month post-downgrade period. It is expressed in decimal form.
ΔHY Bond Volatility	The change in the standard deviation of the Barclays Capital U.S. High-Yield Corporate Bond Index Return from the one-month pre-downgrade period to the one-month post-downgrade period. It is expressed in decimal form.
Δ3M LIBOR Change	The change in the 3 month LIBOR rate (in percentage) from the one-month pre-downgrade period to the one-month post-downgrade period.

Table 4: Corporate Bond Liquidity Following Downgrades

This table analyzes how corporate bond liquidity evolves during the period from January 1, 2006 to March 31, 2016, especially following the effective date of Volcker rule. The dependent variables for Columns I – III are *PriceImpactDiff*, *PriceImpact*, and *PriceImpactControl*, respectively. *PriceImpact* is price impact of trading in a downgraded bond in the month after the downgrade. *PriceImpactControl* is the average price impact for BB-rated corporate bonds in same horizon as *PriceImpact*. *PriceImpactDiff* is the difference between *PriceImpact* and *PriceImpactControl*. The primary independent variables of interest are dummy variables for Crisis, Post-crisis, Post-Dodd Frank, and Post-Volcker. Detailed definitions of all of the independent variables are provided in Table 3. Since bonds issued by the same firm are usually downgraded at the same time, we cluster the standard errors at the firm level.

	I. PriceImpactDiff		**II. PriceImpact**		**III. PriceImpactControl**	
	Estimate	**p-value**	**Estimate**	**p-value**	**Estimate**	**p-value**
Intercept	-0.024	0.339	-0.001	0.491	0.022	0.000
Crisis	0.017	0.003	0.022	0.000	0.006	0.000
Post-crisis	0.016	0.024	0.024	0.002	0.007	0.000
Post-Dodd Frank	0.010	0.010	0.013	0.001	0.004	0.000
Post-Volcker	0.021	0.002	0.025	0.000	0.004	0.000
Previous Rating	-0.002	0.361	-0.004	0.252	-0.002	0.000
ΔRating	0.001	0.348	0.000	0.405	0.000	0.176
Log Age	0.005	0.015	0.005	0.014	0.000	0.213
Log Time to Maturity	0.008	0.010	0.008	0.014	0.000	0.142
Log Amount Outstanding	-0.016	0.000	-0.016	0.000	-0.001	0.018
SP500 Index Return	0.006	0.477	-0.002	0.493	-0.008	0.227
IV Bond Index Return	-0.021	0.460	-0.031	0.443	-0.010	0.347
HY Bond Index Return	-0.152	0.299	-0.182	0.267	-0.030	0.015
ΔVIX	-0.001	0.242	-0.001	0.201	0.000	0.142
ΔIV Bond Volatility	0.313	0.457	1.163	0.345	0.850	0.009
ΔHY Bond Volatility	0.146	0.476	-0.500	0.418	-0.645	0.004
Δ3M LIBOR	-0.015	0.251	-0.012	0.300	0.003	0.024
Number of Observations	687		687		687	
R^2	0.079		0.079		0.079	
Post-Volcker vs Crisis		0.296		0.384		0.062
Post-Volcker vs Post-crisis		0.315		0.454		0.000
Post-Volcker vs Post-Dodd Frank		0.037		0.040		0.477

Table 5: Robustness Checks on Liquidity Following Downgrades

This table presents results from robustness checks of the analyses on bond liquidity changes following the implementation of the Volcker Rule. In Column I, we use an alternative measure, Spread, to capture bond liquidity. For each downgraded bond, we first calculate daily *Spread* by taking the difference between volume weighted average customer buy prices (Ask) and volume weighted average customer sell prices (Bid) during the one-month following the downgrade. We then average the daily spread across days within the month to get an event level estimate. For each downgrade event, we also calculate the average *Spread* in bonds which were rated BB by the acting rating agency during the same one-month period. We then subtract the average BB bond *Spread* from that of the downgraded bond to get a *SpreadDiff* measure. This is the dependent variable for the regression in Column I. In Column II, we used the compliance date for banks to conform their proprietary trading activities and investments in and relationships with non-legacy covered funds under the Volcker Rule, which is July 21, 2015, to define Post-Volcker period. Specifically, Post-Dodd Frank period is from July 21, 2010 to July 20, 2015 and Post-Volcker period is from July 21, 2015 to March 31, 2016. The other sub-periods during our sample are defined as earlier. In Column III, we compare each downgraded bond to the average of other BB rated bonds with similar time to maturity, amount outstanding, and age when calculating the *PriceImpactDiff* measure. We first segment bonds into three time to maturity categories: short-term (maturing within one year), medium-term (with time to maturity greater than one year by no more than seven years), and long-term (maturating over seven years). Within each maturity category, we further segment bonds into three size categories: small issue, medium issue, and large issue, using $0.5 Billion and $1.5 Billion in total par amount outstanding as the cutoffs. Finally, we divide bonds within each size category into new issues and seasoned issues, depending on whether its time since issuance is greater than one year. Therefore, we form a total of eighteen bond groups based on time to maturity, amount outstanding, and age. We then calculate $PriceImpactDiff$ for each downgraded bond by taking the difference between the *PriceImpact* of the downgraded bond and the average $PriceImpact$ of BB bonds from the matching group during the same one-month period. Downgrade events that happened during the last month in each of the newly defined sub-periods are excluded since the one-month following those downgrades overlapped with the next sub-period. The dependent variable in Column II is *PriceImpactDiff* as in Table 4. The primary independent variables of interest are dummy variables for Crisis, Post-crisis, Post-Dodd Frank, and Post-Volcker. Detailed definitions of all of the independent variables are provided in Table 3 Since bonds issued by the same firm are usually downgraded at the same time, we cluster the standard errors at the firm level.

	I. Measuring Liquidity by Spread		II. Use Compliance Date to Define Post-Volcker		III. Use Matched Bonds to Calculate PriceImpactDiff	
	Estimate	**p-value**	**Estimate**	**p-value**	**Estimate**	**p-value**
Intercept	-0.229	0.165	-0.033	0.285	-0.035	0.266
Crisis	0.166	0.002	0.016	0.003	0.013	0.013
Post-crisis	0.066	0.152	0.017	0.020	0.013	0.061
Post-Dodd Frank	0.051	0.156	0.011	0.007	0.008	0.028
Post-Volcker	0.090	0.056	0.026	0.007	0.019	0.004
Previous Rating	0.008	0.349	-0.001	0.418	-0.001	0.450
ΔRating	-0.022	0.004	0.001	0.353	0.000	0.462
Log Age	-0.009	0.292	0.005	0.013	0.005	0.023
Log Time to Maturity	0.076	0.002	0.008	0.008	0.008	0.006
Log Amount Outstanding	-0.004	0.433	-0.017	0.000	-0.015	0.000
SP500 Index Return	-0.328	0.186	0.016	0.436	0.013	0.443
IV Bond Index Return	-0.440	0.375	-0.071	0.368	-0.006	0.489
HY Bond Index Return	0.932	0.152	-0.176	0.269	-0.158	0.286
ΔVIX	0.007	0.145	-0.001	0.198	-0.001	0.221
ΔIV Bond Volatility	10.592	0.221	-0.009	0.499	-0.096	0.487
ΔHY Bond Volatility	-21.171	0.025	0.336	0.445	0.705	0.382
Δ3M LIBOR	0.105	0.101	-0.018	0.223	-0.020	0.184
Number of Observations	647		687		687	
R^2	0.058		0.079		0.074	
Post-Volcker vs Crisis		0.050		0.196		0.212
Post-Volcker vs Post-crisis		0.283		0.217		0.255
Post-Volcker vs Post-Dodd Frank		0.075		0.070		0.034

Table 6: Major Liquidity Providers in the Corporate Bond Market and Volcker Rule

This table provides a list of 21 major securities dealers and whether they are subject to the Volcker Rule. Dealers affected by the Volcker Rule are prohibited from participating in proprietary trading, but have a market-making exception. Non-affected dealers are not subject to bans on proprietary trading or market-making.
Source: "The Volcker Rule restrictions on proprietary trading: Implications for the US corporate bond market" presentation by Oliver Wyman and SIFMA.

Dealers Affected by Volcker Rule	Dealers Not Affected by Volcker Rule
Bank of Nova Scotia	Cantor Fitzgerald & Co.
Barclays Capital	Daiwa Capital Markets Americas
BMO Capital Markets	Jefferies & Company
BNP Paribas Securities	Nomura Securities International
Citigroup Global Capital Markets	
Credit Suisse Securities (USA)	
Deutsche Bank Securities	
Goldman, Sachs & Co.	
HSBC Securities (USA)	
J.P. Morgan Securities	
Merrill Lynch, Pierce, Fenner & Smith	
Mizuho Securities USA	
Morgan Stanley & Co.	
RBC Capital Markets	
RBS Securities	
SG Americas Securities	
UBS Securities	

Table 7: Trading Activity by Dealers Affected by Volcker Rule and those not affected by Volcker Rule

This table presents summary information on trading activities by dealers affected by Volcker rule and those not affected by Volcker rule during each of the five sub-periods between January 1, 2006 to March 31, 2016: Pre-crisis Period (January1, 2006 – June 30, 2007), Crisis Period (July 1, 2007 – April 30, 2009), Post-crisis Period (May 1, 2009 – July 20, 2010), Post-Dodd Frank Period (July 21, 2010 – March 31, 2014), and Post-Volcker Period (April 1, 2014 – March 31, 2016). *All Trade* refers to the aggregate trade volume by all dealers, including both inter-dealer trade and dealer-customer trade, during the one-month following each rating downgrade. To control for the effect of issue size on trade volume, we first divide the aggregate one-month trade volume for each downgrade event by the total par amount outstanding of the downgraded bond, and then average it across bonds within each sub-period. We report the percent of Dealer-Customer trade volume out of the total trade volume for all dealers (*D-C Trade*), as wells as for dealers affected by Volcker rule and those not affected by Volcker rule separately. In addition, for the two groups of dealers, we also report their respective share of the total dealer-customer trade volume (*Share of Total D-C Trade*), and the percentage of their dealer-customer trade that is effectively agent trade (*Dealer Agency Trade*). We classify a trade as being effectively agent if it offset by another trade that occurred within one minute with the same trade size by the same dealer but with opposite trade direction. This one-minute algorithm is similar to that used in Harris (2015) and Bessembinder et al. (2016).

	Full Sample		**Dealers Affected by Volcker**			**Dealers Not Affected by Volcker Rule**		
	All Trade	**D-C Trade (%)**	**D-C Trade (%)**	**Share of Total D-C Trade (%)**	**Dealer Agency Trade (%)**	**D-C Trade (%)**	**Share of Total D-C Trade (%)**	**Dealer Agency Trade (%)**
Pre-crisis Period	0.300	65.601	77.428	93.371	12.104	22.119	6.629	46.404
Crisis Period	0.277	70.037	83.295	89.117	15.413	37.803	10.883	45.326
Post-crisis Period	0.219	62.324	75.958	84.569	15.543	29.192	15.431	35.779
Post-Dodd Frank Period	0.306	53.913	67.224	79.728	15.965	33.063	20.272	33.118
Post-Volcker Period	0.383	62.032	75.608	76.297	22.709	48.722	23.703	29.403

Table 8: Volcker Rule and Agency Trades

This table analyzes how dealers' willingness to arrange trades on a principal basis change following Volcker Rule. We first estimate for each dealer the proportion of dealer-customer trade volume completed on effectively agent basis (expressed in decimals) during the one-month following each downgrade. For each downgrade, we divide the active dealers into two groups: those affected by Volcker rule and those that were not. We then average the percent of agency trade across dealers within each dealer group, and use them as the dependent variables in Columns I and II. The primary independent variables of interest are dummy variables for Crisis, Post-crisis, Post-Dodd Frank, and Post-Volcker. Detailed definitions of all of the independent variables are provided in Table 3 Since bonds issued by the same firm are usually downgraded at the same time, we cluster the standard errors at the firm level.

	I. Dealers Affected by Volcker Rule		**II. Dealers Not Affected by Volcker Rule**	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	0.219	0.163	-0.041	0.454
Crisis Period	0.030	0.176	-0.026	0.361
Post-crisis Period	0.037	0.199	-0.062	0.175
Post-Dodd Frank Period	0.046	0.049	-0.048	0.232
Post-Volcker Period	0.133	0.000	-0.077	0.114
Previous Rating	-0.016	0.223	0.035	0.147
ΔRating	-0.011	0.086	0.017	0.087
Log Age	0.016	0.083	0.026	0.078
Log Time to Maturity	0.006	0.384	-0.008	0.391
Log Amount Outstanding	-0.035	0.006	-0.020	0.209
SP500 Index Return	-0.164	0.280	-0.627	0.110
IV Bond Index Return	-0.520	0.292	1.421	0.226
HY Bond Index Return	0.688	0.117	-0.821	0.232
ΔVIX	-0.002	0.232	-0.008	0.114
ΔIV Bond Volatility	4.730	0.386	-2.517	0.451
ΔHY Bond Volatility	20.346	0.004	3.674	0.409
Δ3M LIBOR	-0.082	0.105	0.016	0.431
Number of Observations	687		687	
R^2	0.073		0.031	
Post-Volcker vs Crisis		0.003		0.212
Post-Volcker vs Post-crisis		0.019		0.375
Post-Volcker vs Post-Dodd Frank		0.003		0.266

Table 9: Dealer Capital Commitment around Volcker Rule Implementation

This table analyzes how dealers' willingness to commit their own capital to bond trading changes following Volcker rule. During the one-month following a bond's downgrade, we first calculate for each dealer, the absolute value of a dealer's accumulated principal buy volume and accumulated principal sell volume at the time of each of the dealer's trades in the downgraded bond (in thousands of dollars of face value). We then average the absolute difference between accumulated buys and accumulated sells across trades within the one-month for each dealer, weighting each observation by the time for which the capital is committed. Trades that were not offset prior to day end hence received larger weight in the capital commitment calculation. For each downgrade, we divide the active dealers into two groups: those affected by Volcker rule and those that were not. We then aggregate each dealer's capital commitment measure within each dealer group, and use them as the dependent variables in Columns I and II. The primary independent variables of interest are dummy variables for Crisis, Post-crisis, Post-Dodd Frank, and Post-Volcker. Detailed definitions of all of the independent variables are provided in Table 3. Since bonds issued by the same firm are usually downgraded at the same time, we cluster the standard errors at the firm level.

	I. Dealers Affected by Volcker Rule		II. Dealers Not Affected by Volcker Rule	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	45675.140	0.030	6371.760	0.003
Crisis Period	-9025.310	0.003	-617.660	0.012
Post-crisis Period	-11231.500	0.000	609.720	0.023
Post-Dodd Frank Period	-12891.800	0.000	1879.880	0.000
Post-Volcker Period	-20127.890	0.000	2131.810	0.000
Previous Rating	-894.800	0.337	-391.460	0.029
ΔRating	1371.910	0.025	-117.810	0.099
Log Age	-5690.310	0.000	-321.400	0.034
Log Time to Maturity	4250.750	0.002	50.050	0.387
Log Amount Outstanding	16734.870	0.000	966.710	0.000
SP500 Index Return	55463.810	0.004	3324.580	0.072
IV Bond Index Return	38394.350	0.301	-13601.550	0.162
HY Bond Index Return	-149809.210	0.000	-8738.820	0.085
ΔVIX	-589.090	0.033	-42.560	0.110
ΔIV Bond Volatility	-528626.130	0.269	-94993.340	0.214
ΔHY Bond Volatility	633910.390	0.166	33231.020	0.348
Δ3M LIBOR	2868.600	0.232	-721.820	0.161
Number of Observations	687		687	
R^2	0.472		0.031	
Post-Volcker vs Crisis		0.000		0.000
Post-Volcker vs Post-crisis		0.000		0.068
Post-Volcker vs Post-Dodd Frank		0.000		0.086

Table 10: Capital Commitment by Volcker Affected Dealers: The Effect of CCAR Testing

This table analyzes how CCAR regulations affect capital commitment among Volcker affect dealers. During the one-month following a bond's downgrade, we first calculate for each dealer, the absolute value of a dealer's accumulated principal buy volume and accumulated principal sell volume at the time of each of the dealer's trades in the downgraded bond (in thousands of dollars of face value). We then average the absolute difference between accumulated buys and accumulated sells across trades within the one-month for each dealer, weighting each observation by the time for which the capital is committed. Trades that were not offset prior to day end hence received larger weight in the capital commitment calculation. For each downgrade, we divide the Volcker affected dealers into two groups: those who passed the CCAR testing in both 2014 and 2015, and those either failed or conditionally passed the CCAR test in at least one year. We then aggregate each dealer's capital commitment measure within each dealer group, and use them as the dependent variables in Columns I and II. The primary independent variables of interest are dummy variables for Crisis, Post-crisis, Post-Dodd Frank, and Post-Volcker. Detailed definitions of all of the independent variables are provided in Table 3. Since bonds issued by the same firm are usually downgraded at the same time, we cluster the standard errors at the firm level.

	I. Volcker Affected Dealers who Passed the CCAR Test		II. Volcker Affected Dealers who Failed/Conditionally Passed the CCAR Test	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	21561.340	0.065	23872.770	0.027
Crisis Period	-4255.380	0.022	-5114.490	0.001
Post-crisis Period	-7449.130	0.000	-4186.190	0.008
Post-Dodd Frank Period	-6207.900	0.002	-7171.690	0.000
Post-Volcker Period	-10732.840	0.000	-9816.140	0.000
Previous Rating	368.070	0.382	-1240.680	0.138
ΔRating	808.620	0.035	588.190	0.039
Log Age	-3098.010	0.001	-2670.770	0.000
Log Time to Maturity	2146.430	0.014	2300.440	0.000
Log Amount Outstanding	12345.580	0.000	4428.690	0.000
SP500 Index Return	45166.660	0.000	10757.080	0.153
IV Bond Index Return	11309.940	0.415	33251.730	0.185
HY Bond Index Return	-104937.140	0.000	-46102.670	0.019
ΔVIX	-481.870	0.004	-101.680	0.277
ΔIV Bond Volatility	153290.210	0.393	-636766.770	0.071
ΔHY Bond Volatility	279028.120	0.239	377606.390	0.118
Δ3M LIBOR	3094.440	0.107	-336.950	0.433
Number of Observations	683		683	
R^2	0.420		0.369	
Post-Volcker vs Crisis		0.002		0.000
Post-Volcker vs Post-crisis		0.020		0.000
Post-Volcker vs Post-Dodd Frank		0.003		0.007

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