JOURNAL OF FINANCIAL AND QUANTITATIVE ANALYSIS Vol. 59, No. 4, June 2024, pp. 1963–1996

doi:10.1017/S0022109023000844

Credit Default Swaps, Fire-Sale Risk, and the Liquidity Provision in the Bond Market

Massimo Massa
INSEAD Finance Department
massimo.massa@insead.edu

Lei Zhang
City University of Hong Kong College of Business Department of Economics and Finance
lzhan29@cityu.edu.hk (corresponding author)

Abstract

We study the effect of credit default swaps (CDSs) on the bond market. Using a comprehensive sample of U.S. corporate bonds, we document that the presence of CDSs significantly increases bond liquidity and reduces yield spreads for investment grade bonds. We show that CDSs influence the bond market by lowering the impact of fire sales of institutional bondholders and facilitating inventory management for bond dealers who absorb fire sale shocks. However, the liquidity provision role of CDSs gets weakened after the CDS Big Bang in 2009, potentially because of the requirement of large upfront payments.

I. Introduction

The 2008–2009 financial crisis has brought to the fore the role of credit derivatives and their implications for the financial markets. The existence of credit default swaps (CDSs) has been considered instrumental to the spread of the crisis (Stulz (2010)). The "indictment" is based on the way credit insurance would affect the debtor–creditor relationship in the case of distress of the borrower. CDS contracts, by protecting the lenders in the case of distress, would reduce their incentives to restructure the debt and monitor the borrowers, thus creating the "empty creditor" problem (Bolton and Oehmke (2011)).

In this article, we focus on an important but unexplored role of CDSs on the underlying bonds: liquidity provision. Practitioners and industry experts alike have indicated that CDSs facilitate bond dealers to provide liquidity for the underlying bonds.[1] In essence, CDSs help to reduce the inventory risk of bond dealers and provide them the opportunity to hold onto their physical bond inventories. This

We thank Joshua Coval, Madhu Kalimipalli, Martin Oehmke, Wenlan Qian, and conference participants at the Western Finance Association 2013 Meeting, the 2013 Singapore Scholars Symposium, and the 2014 SAIF-Moody Credit Market Meeting for their helpful comments and discussions. We thank Hendrik Bessembinder (the editor) and William Maxwell (the referee) for their comments that significantly improved the paper. All remaining errors and omissions are our own.

[1]For example, Jeff Meli, the co-head of fixed-income research at Barclays, said that "The credit default swaps market has contracted 29% to $2.14 trillion of net outstanding positions since Oct. 2008…. The shrinking derivatives market makes it more difficult for bond dealers to hedge, reducing their willingness to own bonds" (http://www.bloomberg.com/news/articles/2013-09-03/dealers-in-debt-pare-commitments-raising-risk-as-new-rules-bite).

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

liquidity provision role of CDSs, if there is any, should be particularly relevant for bonds that are subject to potential fire sales from major bond investors.[2]

Fire sales are especially relevant in the bond market, given that most corporate bonds are traded over the counter, and market liquidity relies on bond dealers' committing risk capital to market making. Regulatory constraints exacerbate this problem by forcing major institutional bond investors to sell in the presence of a drop in market value or a downgrade in bond ratings, and thus, creating significant liquidity deterioration for the bonds. For example, insurance companies are in general regulated to only hold investment grade bonds, and the amount of risk-based capital required by the state regulator is based on the credit quality of their holdings. A negative shock such as a rating downgrade induces these investors to sell the bonds (Ellul, Jotikasthira, and Lundblad (2011)). Moreover, investment commonalities of insurance companies and strategic complementarities of asset managers aggravate such forced sales (Nanda, Wu, and Zhou (2019)).

However, the impact of fire sales will be lower if the liquidity providers (i.e., bond dealers) have more capacity to absorb such sales. We argue that the presence of CDS contracts magnifies such capacity. That is, the availability of CDSs allows liquidity providers to provide liquidity when the underlying bonds are subject to fire sales related liquidity shocks. First, the protection provided by CDSs allows bond dealers to better hedge their inventory holdings and increases their capacity to absorb fire sales shocks on the underlying bonds. Second, CDSs allow liquidity providers to enact CDS-bond basis arbitrage strategies (i.e., *buy* bonds and *buy* CDS protection) reducing the "limits of arbitrage" (Shleifer and Vishny (1997)) in the bond market. Moreover, CDSs will help the bond investors exposed to fire sales by reducing their need to find new capital.[3] This allows investors who are required by regulation to hold high-quality bonds to defer the sales when the bonds are downgraded or lose the investment grade status, which will lower the other players' incentives to front-run such investors, thus, reducing the overall need to rush to sell the bonds.

Overall, these considerations suggest that bonds issued by firms with CDS contracts suffer less fire-sale risk. The lower risk of fire sales should increase bond liquidity. Therefore, we expect the presence of CDS contracts to increase bond liquidity, and such effect to concentrate among investment grade bonds (the ones that are likely to experience forced sales due to regulatory pressures). In contrast, high-yield bonds should be less vulnerable to fire-sale risk. This is due to two reasons: First, high-yield bonds are already held by investors who are not subject to regulatory constraints in terms of the quality of the assets they hold (e.g., hedge

[2]Fire sales may be due to the need of financial intermediaries (e.g., mutual funds) to meet investor withdrawals or to the need to meet suddenly deteriorated regulatory capital ratios (e.g., banks and insurance companies; Bernardo and Welch (2004), Coval and Stafford (2007), Shleifer and Vishny (2011), and Ellul, Jotikasthira, and Lundblad (2011)).

[3]The National Association of Insurance Commissioners (2007) Capital Markets Special Report states that "purchasing CDS helps insurers reduce the credit risk of the bond portfolio, which is one of the major investment assets held by insurance companies. The purchase of CDS can also help insurers to save their risk-based capital and meet regulatory requirements." Indeed, insurance companies use derivatives extensively to hedge risk and ameliorate their performances (Cummins, Phillips, and Smith (2001)).

funds and high-yield mutual funds). Second, the increased default risk induced by CDSs (Subrahmanyam, Tang, and Wang (2014), (2017)) should be more severe among bonds with poor credit quality, for which CDSs may cause a deterioration in bond liquidity by exacerbating information asymmetry of the underlying firm. These considerations bring forward our first hypothesis: The presence of CDS contracts increases bond liquidity for investment grade bonds.

The CDS market in the United States has undergone significant regulatory changes during the past decade, including the CDS Big Bang in 2009 and the advancement of central clearing and post-trade reporting requirements after the Dodd–Frank Act in 2012. Notably, the CDS Big Bang negatively impacted the funding requirements of trading single-name CDS contracts because of the requirement of large upfront payments (especially for protection buyers of investment grade names; Wang, Wu, Yan, and Zhong (2021)).[4] Even though CDS liquidity improved after the Dodd–Frank Act, central clearing and greater post-trade transparency also increased the price of credit protection because of a lower counterparty risk (Loon and Zhong (2014)). This made it more costly for CDS protection buyers (such as banks, insurance companies, and bond dealers) to utilize CDS contracts to save regulatory capital, alleviate fire-sale risk, or manage bond inventory.[5] Therefore, we expect the liquidity provision role of CDSs on the underlying bonds to get weakened after these regulatory changes in the CDS market. This represents our second hypothesis.

We test these hypotheses using a comprehensive sample of U.S. corporate bonds with CDS contracts information over the sample period from 2001 to 2017. We start with an univariate analysis that links bond illiquidity to the availability of CDS contracts. We find opposite results for investment grade bonds and for high-yield bonds: the presence of CDSs reduces illiquidity for investment grade bonds while it increases illiquidity for high-yield bonds. Then, we perform a multivariate analysis in which we control for a battery of bond and issuer characteristics. For investment grade bonds, the presence of CDS contracts reduces the Roll (Amihud) measure of bond illiquidity by a significant 6% (14%) relative to the sample average. For high-yield bonds, instead, the relationship between CDS presence

[4]Most single-name CDS contracts were previously quoted using a par spread, that is, the spread that would cause the present value of a CDS contract to be 0 for both the buyer and seller at the outset of the trade. After the CDS Big Bang, CDS contracts are traded with two fixed coupons of 100 bps and 500 bps. In general, investment grade names will be traded with a fixed coupon of 100 basis points, and high-yield names will be traded with a 500 basis points fixed coupon (Markit (2009)). For example, for an average BBB-rated single-name CDS contract with a par CDS spread of 210 bps, the coupon rate will be set to 100 bps after the CDS Big Bang. Since this coupon rate is 110 bps less than the breakeven rate (210 bps), the CDS protection buyer needs to compensate the seller by paying an upfront fee equal to the present value of 110 bps per year during the life of the CDS contract.

[5]These arguments are consistent with industry anecdote evidence that it indeed became more costly for bond dealers to utilize CDS contracts to manage inventories of investment grade bonds after the CDS Big Bang. For instance, Goldman Sachs released a report in 2015 dissecting the decline in dealer inventories of investment grade corporate bonds: “In our view, the trend declines in dealer inventories reflect the rising cost of hedging and holding corporate bond positions. For example, when single-name CDS were more liquid, dealers could bid aggressively for bonds and use liquid CDS markets to quickly hedge that risk until buyers on the other side of the market could be found” (https://www.businessinsider.com.au/goldman-sachs-on-bond-market-liquidity-2015-11?r=US&IR=T).

and illiquidity remains positive but becomes statistically insignificant. Moreover, within the investment grade category, the effect of lower illiquidity due to the presence of CDSs is concentrated among BBB- and A-rated firms rather than AAA- and AA-rated firms (i.e., the ones that are most subject to fire-sale risk). Overall, these findings document a negative link between the presence of CDS contracts and illiquidity for investment grade bonds, providing strong support for our first hypothesis.

To establish causality, we provide two tests: an exogenous event and an instrumental variable specification. The event is the selling pressure from property and casualty insurance companies following Hurricane Katrina. The property insurance companies exposed to Hurricane Katrina, driven by the need to meet redemption claims, generated a selling pressure of the bonds held by those investors (Massa and Zhang (2021)). These forced sales can only be attributed to supply side shocks (i.e., shocks to the Katrina-exposed property insurance companies) as opposed to firm-specific shocks. We document that the presence of CDS contracts reduced the impact of forced sales on bond liquidity.

The instrumental variable analysis exploits an identification based on the demand for CDS contracts in the market: the level of loan concentration of the banks' lending money to the firm on which the CDSs are written. The intuition is that banks use CDSs to hedge their loan positions. The less diversified their overall loan portfolio is, the higher their incentives are to purchase CDSs for protection (Jarrow (2011)). The instrumental variable analysis confirms the previous findings, displaying a significantly negative relationship between the presence of CDS contracts and bond illiquidity for investment grade bonds.

Next, we examine our second hypothesis investigating how the link between CDS presence and bond illiquidity changed over time as a function of important regulatory changes specific to the CDS market. We consider two key moments: the 2009 CDS Big Bang and the 2012 implementation of the Dodd–Frank Act for CDS dealers.[6]

We find supporting evidence for our second hypothesis by tracking the impact of CDSs on bond illiquidity through these regulatory changes. For investment grade bonds, the impact of CDS on bond illiquidity is significantly negative across different periods, consistent with the overall liquidity provision role of CDSs on the underlying bonds. However, the economic impact becomes much weakened after the CDS Big Bang in 2009 and slightly weakened after the Dodd–Frank Act, in line with our previous analyses based on the regulatory details. For high-yield bonds, the presence of CDSs increases bond illiquidity before the CDS Big Bang (likely due to higher information asymmetry because of the empty creditor problem), while this relationship becomes insignificant after the CDS Big Bang and after the Dodd–Frank Act.

[6]After the Dodd–Frank Act, central clearing became mandatory for index CDS contracts. For single-name CDS contracts, the market participants can either voluntarily clear their trades through a central counterparty or rely on bilateral counterparty arrangements. In addition, Basel III occurred during the same period, after which banks faced considerably higher capital charges with more stringent stress testing requirements for their hedging transactions.

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

Next, we consider two proxies to confirm that the economic channel is related to the ability to deal with fire sales in the bond market. The first proxy relates to the inventory risk of bond dealers. We argue that the presence of CDSs helps reduce the inventory risk of bond dealers (i.e., the use of CDSs allows bond dealers to hedge more efficiently and employ less regulatory capital to manage their inventory). Thus, we examine how CDSs alter the impact of inventory risk of bond dealers on bond illiquidity. We expect the benefit of CDSs to be stronger when the bonds flow to the inventory of bond dealers. Using as a proxy the imbalance between sell and buy of bond institutional investors, we document that CDSs alleviate the impact of inventory risk of bond dealers on illiquidity only before the CDS Big Bang, while playing a less significant role in the following periods.

The second proxy relates to one classic fire sale shock in corporate bonds: the moment when bonds are downgraded from investment grade to high yield (i.e., "fallen angels"). Ellul et al. (2011) find that such a downgrade triggers the forced sales of insurance companies and generates a large liquidity-driven negative effect on the bonds. Nanda et al. (2019) further show that investment commonalities of insurance companies aggravate the fire-sale risk of bonds following a rating downgrade because of regulatory constraints. The results document that downgrades from investment grade to high yield will induce a higher increase in bond illiquidity for bonds without CDS contracts outstanding than for bonds with CDSs. Consistently, this effect is concentrated during the period before the CDS Big Bang.

Overall, these results suggest that CDSs help bond investors and dealers manage their portfolios thus alleviating fire-sale risk and increasing bond liquidity. However, the recent regulatory changes in the CDS market have weakened such a liquidity enhancing role of CDSs in the bond market, which align with recent studies showing that the CDS Big Bang significantly increased the funding requirements of trading single-name CDS contracts (Wang et al. (2021)).

A follow-up question is whether the impact of CDSs on bond liquidity manifests itself in bond prices. We document a significantly negative relationship between the availability of CDS contracts and yield spreads in the case of investment grade bonds. The presence of CDS contracts reduces the option-adjusted spread (asset swap spread) by 7% (8%) relative to the sample average. However, there is no statistically significant relationship for high-yield bonds. Similarly, we also track the relationship between CDS presence and bond yield spreads through different time periods. The negative relation exists throughout the overall period for investment grade bonds, but the economic significance gets weakened after the CDS Big Bang and the Dodd–Frank Act. The patterns are consistent with the previous results on bond illiquidity.

The rest of the article is organized as follows: Section II discusses the contribution of our study to the literature. Section III describes the data and the main variables. Section IV examines how the presence of CDS contracts affects the liquidity of the underlying bonds. Section V addresses the endogeneity concerns. Section VI tracks the liquidity provision role of CDSs through different time periods. Section VII examines the value implication of CDSs on bond yield spreads. Section VIII provides additional robustness checks followed by a brief conclusion.

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

II. Literature Review

There has been a growing interest in understanding the impact of CDS contracts on the underlying firm. Despite of a theoretical gloomy view of the CDS-induced empty creditor problem (Thompson (2010), Bolton and Oehmke (2011), and Parlour and Winton (2013)), the empirical evidence regarding the impact of CDSs on the underlying firm is rather mixed. Extant studies have documented that CDSs may reduce loan quality, increase bankruptcy risk, lower bond market efficiency, and reduce firm value (Ashcraft and Santos (2009), Purnanandam (2011), Das, Kalimipalli, and Nayak (2014), Subrahmanyam et al. (2014), (2017), Amiram, Beaver, Landsman, and Zhao (2017), and Narayanan and Uzmanoglu (2018)). Meanwhile, CDSs are also found to stimulate bank credit supply and improve borrowing terms, enabling firms to maintain higher leverage and borrow at longer maturities (Hirtle (2009), Saretto and Tookes (2013)). Bedendo, Cathcart, and El-Jahel (2016) find no evidence that the access to credit insurance favors bankruptcy over a debt workout. Danis and Gamba (2018) examine the impact of CDSs on firm value and conclude that CDSs increase overall firm value.

Several reasons may explain these mixed findings. First, the implication of CDSs may differ through different sample periods. Indeed, the CDS market has undergone significant regulatory changes during the past decade. We therefore examine how the impact of CDSs on underlying bond illiquidity and yield spreads has changed over time and relate our findings to critical regulatory changes in the CDS market. Second, the sample firms may be chosen differently. Depending on the respective research settings, some studies choose the overall sample of publicly traded firms, while a few other studies are based on listed firms with bank loans or public bonds outstanding. Given that our purpose is to examine the impact of CDSs on the bond market, naturally, the sample should be based on publicly traded bonds with and without CDSs outstanding. We therefore focus on a comprehensive sample of bonds included in broad market bond indices that are directly comparable in the eyes of bond investors or bond dealers. Third, the credit market is highly segmented by broad rating categories into investment grade and high-yield names. Even regulatory changes are applied differently between investment grade and high-yield CDS contracts. We therefore investigate how the impact of CDSs may differ for different market segments.

Overall, our study sheds light on the apparent contradiction between the significant growth in the CDS market over the last two decades and the largely negative view of the impact of CDS on the underlying firm. Our results represent direct evidence of the bright side of CDS contracts among investment grade bonds, in line with the fact that the bond market is heavily segmented and major bondholders are subject to the prudent-man rule or the risk-based capital requirement, which mandate them to concentrate their portfolios in investment grade bonds.

Further, we contribute to the literature on fire sales (Bernardo and Welch (2004), Coval and Stafford (2007), and Shleifer and Vishny (2011)) and on forced sales in the corporate bond market in particular (Ellul et al. (2011), Nanda et al. (2019)). We contribute by showing that CDS contracts help reduce the market impact of such selling pressures on the bond market, improving bond liquidity, and reducing yield spreads.

Our findings have important normative and policy implications as well. Even though recent regulatory changes have made CDS contracts more standardized with greater post-trade transparency (Loon and Zhong (2014)), they may also make CDSs more expensive and inflexible to utilize for credit protection buyers (Wang et al. (2021)). Our results suggest that one of the unintended consequences of CDS regulations is a weakened liquidity provision role of CDSs in the bond market, consistent with industry evidence of a rising cost of hedging and holding inventories of investment grade bonds by bond dealers.

III. Data and Variables

We obtain data from multiple sources. We start from a comprehensive sample of corporate bonds included in the ICE BofA US Corporate and High Yield Index compositions from Jan. 2001 to Dec. 2017. The ICE BofA data (previously the Bank of America-Merrill Lynch corporate bond index) cover the majority of rated United States publicly issued corporate bonds and have been used in previous studies (Schaefer and Strebulaev (2008), Acharya, Amihud, and Bharath (2013)). Qualifying bonds must have an investment grade or high-yield rating (based on an average of Moody's, S&P, and Fitch), with a greater than 1 year of remaining maturity, a fixed coupon schedule, and a minimum amount outstanding of $250 million. We require each bond to be included in the index for over 24 months.

We obtain information on major bond characteristics (such as the offering date, maturity date, offering amount, seniority, callability, fungibility, and credit enhancement) from the Mergent Fixed Income Securities Database (FISD). We derive the data on quarterly institutional holdings of corporate bonds from Lipper's eMAXX fixed income database. It contains details of fixed income holdings for United States and European insurance companies, United States, Canadian, and European mutual funds, and leading U.S. public pension funds. We obtain information on the tick-by-tick bond transactions from the Trade Reporting and Compliance Engine database (TRACE). We merge these bond-level data sets using the identifier of bond issue CUSIPs.

We get information on CDS contracts from the Markit CDS database. This data set is the main source of information used in many existing research on CDSs (Ashcraft and Santos (2009), Qiu and Yu (2012)). The CDS spread is the periodic fee that the protection buyer pays to the protection seller in a CDS contract until the contract matures or a credit event occurs.[7] Typically, Markit reports a composite daily CDS spread, which is an average across all the quotes provided by market makers after a series of data cleaning tests. The Markit database also provides identifying information on the reference entity (such as firm name and ticker), the number of dealers providing CDS quotes, and the terms of the CDS contract

[7]The "Restructuring Clause" of a CDS contract specifies the type of credit events that trigger the settlement. In this case, either the protection buyer delivers defaulted bonds to the seller in exchange for the face value of the issue in cash (physical settlement) or the protection seller directly pays the difference between the market value and face value of the issue to the protection buyer (cash settlement). There are four major restructuring clauses (full restructuring, modified restructuring, modified–modified restructuring, and no-restructuring). A detailed discussion of different restructuring clauses can be found in Packer and Zhu (2005).

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

(maturity, currency denomination, and restructuring clauses).[8] We focus on the spreads of all the CDS contracts written on U.S. firms and denominated in U.S. dollars.

Our final combined sample includes 346,741 bond-month observations, among which 81% are investment grade bonds and 19% are high-yield bonds.[9] We consider both major bond characteristics such as bond issue outstanding, bond duration, coupon rate, callability, fungibility, credit enhancement, and bond-level credit rating and major firm characteristics such as equity volatility, equity beta, book size, MTB, book leverage, profitability, cash holding, and dividend payments. The definitions of each variable can be found in the Appendix.

We also include two sets of variables to capture the degree of "hotness" of the issuance. First, there is an "on-the-run" phenomena in corporate bonds similar to Treasury bonds. Investment grade firms issue multiple notes/debentures with different maturities at the same time. In particular, 5-year, 7-year, 10-year, and 30-year bonds are often issued at one time. After issuance, bond trading tends to migrate to these on-the-run bonds. We therefore create four on-the-run indicator variables for each of these maturity levels. Second, given that a lot of bond trading takes place in the first 1–3 months after issuance, we define a newly issued indicator if the bond is issued within the first 3 months.

We focus on the effect of CDS contracts on bond illiquidity. We define CDS_PRESENCE as a dummy variable equal to 1 if the issuing firm has quoted CDS contracts on its bonds in the previous month, and 0 otherwise.[10] We employ two commonly used measures of bond illiquidity based on the transaction level data from TRACE. First, following Bao, Pan, and Wang (2011), we construct the Roll measure of bond illiquidity as the implied bid–ask spread based on the autocovariances of bond price changes: $\text{BOND\_ILLIQUITY} = 2\sqrt{\gamma}$ *(0 if* $\gamma < 0$), where $\gamma = -\text{cov}(\Delta p_t, \Delta p_{t-1})$, and p_t is the log price at time t. Bao et al. (2011) show that the implied bid–ask spread γ is one of the most effective liquidity measures in explaining corporate yield spreads in the cross section. Second, following Dick-Nielsen, Feldhütter, and Lando (2012), we estimate the Amihud measure of bond illiquidity as the price impact of bond trades. For each bond-month, it is defined as the monthly average of $|\Delta p_t|/\text{DVOL}_t$, where p_t is the log price at time t and

[8]Specifically, the maturity of CDS contracts ranges from 6 months up to 30 years, including 6-month, 1-year, 2-year, 3-year, 4-year, 5-year, 7-year, 10-year, 15-year, 20-year, and 30-year maturity contracts.

[9]We use the *monthly* updated bond specific composite rating directly obtained from the ICE BofA index database. The composite rating is calculated as the simple averages of ratings from Moody's, S&P, and Fitch, with 21 levels ranging from AAA to C. We provide a detailed rating correspondence in the Appendix. In our sample, 2% of the bonds are AAA-rated, 7% of the bonds are AA-rated (AA1, AA2, and AA3), 31% of the bonds are A-rated (A1, A2, and A3), 43% of the bonds are BBB-rated (BBB1, BBB2, and BBB3), 11% of the bonds are BB-rated (BB1, BB2, and BB3), 6% of the bonds are B-rated (B1, B2, and B3), and the rest 2% the bonds are rated below (CCC1, CCC2, CCC3, CC, and C). Investment grade bonds refer to the bonds with bond composite rating above or equal to BBB3, while high-yield bonds refer to the bonds with the bond composite rating below BBB3.

[10]In unreported tests, we redefine "CDS presence" only based on the most commonly observed CDS contracts in the market (i.e., CDS contracts with a 5-year maturity and modified restructuring clause). We find that all the results are similar to the reported ones both quantitatively and qualitatively.

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

$DVOL_t$ is the dollar trading volume (in millions) at time t.[11] We require the number of bond transactions to be larger than 10 for each bond-month. Reassuringly, we find that the Roll measure and the Amihud measure of bond illiquidity have a Pearson correlation over 60%.[12]

In addition, we employ two measures of yield spreads widely used by market participants. One is the option-adjusted spread, defined as the number of percentage points that the fair value of the treasury spot curve is shifted to match the present value of the discounted cash flows to the bond's price. The other is the asset swap spread, defined as the number of percentage points that investors receive when subscribing to an interest rate swap in which they exchange the coupons of the bond against a variable LIBOR interest payment as remuneration for the risky proportion of the bond cash flows. These measures are directly obtained from the ICE BofA bond index data set.

TABLE 1

Summary Statistics

Table 1 presents summary statistics of the major variables used in later analysis. The sample period is from Jan. 2001 to Dec. 2017. The data on option-adjusted yield spread, asset swap spread, duration and bond-level credit ratings come from the ICE BofA Corporate and High Yield Index Composition database. Additional bond characteristics including coupon rate, bond offering amount, callability, fungibility, and credit enhancement come from Mergent FISD. We obtain information on bond transactions from the Trade Reporting and Compliance Engine database (TRACE). We get the information on CDS contracts from the Markit CDS database. Firm-level stock return and accounting information come from CRSP and Compustat. For each variable, we report the data frequency, source, number of observations, mean, and standard deviation. The detailed definitions of each variable can be found in the Appendix.

	Frequency	Source	No. of Obs.	Mean	Std. Dev.
Bond Characteristics					
BOND_ILLIQUIDITY (ROLL_MEASURE)	Bond/Month	TRACE	223,315	1.289	1.095
BOND_ILLIQUIDITY (AMIHUD_MEASURE)	Bond/Month	TRACE	223,315	0.454	0.486
OPTION_ADJUSTED_SPREAD (%)	Bond/Month	ICE BofA	346,741	2.033	2.171
ASSET_SWAP_SPREAD (%)	Bond/Month	ICE BofA	346,741	1.728	1.762
INVESTMENT_GRADE	Bond/Month	ICE BofA	346,741	0.813	0.390
OFFERING_AMOUNT	Bond/Month	Mergent FISD	346,741	6.132	0.676
COUPON_RATE	Bond/Month	Mergent FISD	346,741	0.058	0.018
BOND_DURATION	Bond/Month	Mergent FISD	346,741	6.354	4.061
BOND_AGE	Bond/Month	Mergent FISD	346,741	4.259	3.573
CALLABILITY	Bond/Month	Mergent FISD	346,741	0.811	0.391
FUNGIBILITY	Bond/Month	Mergent FISD	346,741	0.640	0.480
CREDIT_ENHANCEMENT	Bond/Month	Mergent FISD	346,741	0.145	0.352
NEWLY_ISSUED_BOND	Bond/Month	Mergent FISD	346,741	0.014	0.118
Firm Characteristics					
CDS_PRESENCE	Firm/Month	Markit	86,217	0.619	0.486
EQUITY_VOLATILITY	Firm/Month	CRSP	86,217	0.020	0.014
EQUITY_BETA	Firm/Month	CRSP	86,217	1.053	0.653
BOOK_SIZE	Firm/Year	Compustat	7,794	9.119	1.337
MTB	Firm/Year	Compustat	7,794	1.263	0.885
BOOK_LEVERAGE	Firm/Year	Compustat	7,794	0.317	0.167
PROFITABILITY	Firm/Year	Compustat	7,794	0.124	0.090
CASH_HOLDING	Firm/Year	Compustat	7,794	0.089	0.102
DIVIDEND_PAYER	Firm/Year	Compustat	7,794	0.745	0.436

[11]Given that the exact amount of trade size from the reported TRACE data is truncated, we assume the trade size to be $1 million ($5 million) if it is reported as "1MM+" ("5MM+").

[12]There are other liquidity proxies proposed in the equity market, such as the trading volume, or the zero-return measure based on the number of days with no price changes (Goyenko, Holden, and Trzcinka (2008)). However, these proxies may not be suitable to study fire-sale risk or liquidity characteristics upon fire sale events. For instance, during late 2008 when Lehman Brothers filed for bankruptcy, there were huge trading volumes and fewer zero-return days in individual stocks. Clearly, this was not an indication that the market or the stock had become more liquid.

We provide the descriptive statistics of variables in Table 1. For each variable, we report the data frequency, source, number of observations, mean, and standard deviation. The average Roll measure of bond illiquidity is 1.289, 1.207 for investment grade bonds, and 1.686 for high-yield bonds. In the case of the Amihud measure, the average bond illiquidity is 0.454, 0.440 for investment grade bonds, and 0.521 for high-yield bonds. The average option-adjusted spread is 2.03%, 1.46% for investment grade bonds, and 4.79% for high-yield bonds. The average asset swap spread is 1.73%, 1.23% for investment grade bonds, and 3.92% for high-yield bonds. On average, among the bond issuers, 62% have CDS contracts outstanding during the sample period. This fraction is higher among investment grade issuers (71%) than among high-yield issuers (42%). Among other variables, the average amount of bond issue outstanding is $586 million, the average bond duration is 6.35 years, the average bond age since issuances is 4.26 years, 81% of the bonds are callable, 64% of the bonds are fungible, and 15% of the bonds have credit enhancement.

IV. CDSs and Bond Illiquidity

In this section, we examine how the presence of CDS contracts affects the liquidity of the underlying bonds. We start with some univariate analysis on bond illiquidity by broad rating categories and by whether there are CDS contracts outstanding of bond issuers (with/without CDS presence). In particular, to account for broad macroeconomic or rating-specific trend that directly affects CDS availability and bond illiquidity, for the univariate tests, we use time-adjusted bond illiquidity and rating-adjusted bond illiquidity. The time-adjusted bond illiquidity is calculated as bond illiquidity minus the sample average illiquidity in the month. The rating-adjusted bond illiquidity is estimated as bond illiquidity minus the sample average bond illiquidity of the same rating category (i.e., investment grade or high yield) in the month.

We report the results in Panel A of Table 2 for the Roll measure of bond illiquidity and Panel B for the Amihud measure of bond illiquidity. We provide *t*-tests to compare the differences in illiquidity between the CDS presence subsample and the no-CDS presence subsample. We find opposite results for investment grade bonds and for high-yield bonds: the presence of CDSs reduces bond illiquidity for investment grade bonds while it increases it for high-yield bonds. The results are robust whether we focus on the Roll measure or the Amihud measure of illiquidity. These findings suggest that the channel of impact of CDSs on the bond market, if there is any, may work very differently for investment grade bonds and for high-yield bonds, indicating that bond market segmentation may play a crucial role with regards to the economic function of CDSs.

Next, we focus on how the presence of CDS affects bond illiquidity in a multivariate setting. We estimate a pooled specification in which bond illiquidity is regressed on a CDS presence dummy and a set of control variables. The dependent variables are our measures of bond illiquidity while the CDS presence dummy ("CDS presence") is a dummy variable equal to 1 if the issuing firm has CDS contracts on its bonds in the previous month, and 0 otherwise.

TABLE 2

CDS Presence and Bond Illiquidity: Univariate Results

Table 2 presents univariate results on bond illiquidity by rating categories and by whether there are CDS contracts outstanding of bond issuers (with/without CDS presence). To account for broad macroeconomic or rating-specific trend that directly affects CDS availability and bond illiquidity, for the univariate tests, we calculate time-adjusted bond illiquidity and rating-adjusted bond illiquidity. The time-adjusted bond illiquidity is calculated as bond illiquidity minus the sample average illiquidity in the month. The rating-adjusted bond illiquidity is estimated as bond illiquidity minus the sample average bond illiquidity of the same rating category (i.e., investment grade or high yield) in the month. In Panel A, we calculate bond illiquidity (Roll measure) as the implied bid–ask spread based on the auto-covariances of bond price changes: $2\sqrt{\gamma}$ (0 if $\gamma<0$), where $\gamma=-\text{cov}(\Delta p_t, \Delta p_{t-1})$ and p_t is the log price at time t. In Panel B, we calculate bond illiquidity (Amihud measure) as the monthly average of $1{,}000\times|\Delta p_t|/\text{DVOL}_t$, where p_t is the log price at time t and DVOL_t is the dollar trading volume at time t. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Time-Adjusted Bond Illiquidity				Rating-Adjusted Bond Illiquidity			
	CDS Presence		Diff.	*t*-Stat.	CDS Presence		Diff.	*t*-Stat.
	Yes	No			Yes	No		
Panel A. Roll Measure								
Investment grade	−0.099	−0.064	−0.034***	−6.54	−0.006	0.030	−0.036***	−6.80
High yield	0.508	0.349	0.159***	12.52	0.038	−0.049	0.086***	6.92
Panel B. Amihud Measure								
Investment grade	−0.024	0.010	−0.034***	−13.32	−0.006	0.028	−0.034***	−13.45
High yield	0.106	0.056	0.050***	10.97	0.019	−0.024	0.043***	9.43

The set of control variables includes major bond characteristics (such as coupon rate, duration, offering amount, callability, fungibility, credit enhancement, newly issued indicator, and on-the-run indicators) as well as firm characteristics (such as equity volatility, equity beta, MTB, book leverage, book size, profitability, cash holding and dividend payment, as well as industry fixed effects, time fixed effects, and credit rating fixed effects).

We report the results in Panels A and B of Table 3. In Panel A, the dependent variable is the Roll measure of bond illiquidity. Columns 1 and 2 are for the subsample of investment grade bonds, whereas columns 3 and 4 are for the subsample of high-yield bonds. In columns 1 and 3, we control for bond characteristics, firm characteristics, the Fama–French 48-industry fixed effects, time fixed effects at the monthly level, and 21 credit rating fixed effects each corresponding to a rating scale from AAA to C. In columns 2 and 4, we include time (year–month) × credit rating fixed effects to further control for the credit rating effects. We include the four on-the-run indicators in all regressions but mute their results in the interest of brevity. All firm-year (month) variables are taken at the end of the previous year (month). Panel B follows the same specifications, whereas the dependent variable is the Amihud measure of bond illiquidity.[13]

The results display a significantly negative relationship between bond illiquidity and the availability of CDS contracts in the case of investment grade bonds. This relation holds across different specifications and is economically sizable. The presence of CDS contracts reduces the Roll (Amihud) measure of bond illiquidity by a significant 6% (14%) relative to the sample average. Notably, after we control for other bond and issuer characteristics, for high-yield bonds, the relationship

[13]We always cluster the standard errors at the issuer level. Not surprisingly, the results become statistically more significant if we cluster the standard errors at the bond level instead of at the issuer level.

TABLE 3

CDS Presence and Bond Illiquidity: Multivariate Results

Table 3 presents multivariate results on the relation between CDS presence on bond illiquidity. In Panel A, the dependent variable is the Roll measure of bond illiquidity defined as the implied bid–ask spread based on the auto-covariances of bond price changes in a month. Columns 1 and 2 are for the subsample of investment grade bonds, whereas columns 3 and 4 are for the subsample of high-yield bonds. In columns 1 and 3, we control for bond characteristics, firm characteristics, industry fixed effects at the Fama–French 48-industry level, time fixed effects at the monthly level, and 21 credit rating fixed effects each corresponding to a rating scale from AAA to C. In columns 2 and 4, we include time (year–month) × credit rating fixed effects to further control for the rating effects. Panel B follows the same specification as in Panel A, whereas the dependent variable is the Amihud measure of bond illiquidity defined as the price impact of bond trading in a month. We always cluster the standard errors at the issuer level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using heteroscedasticity robust standard errors with *t*-statistics given in parentheses.

Panel A. Roll Measure

Dependent Variable: Bond Illiquidity	Investment Grade		High Yield	
	1	2	3	4
CDS_PRESENCE	−0.072***	−0.067***	0.030	0.049
	(−3.27)	(−3.05)	(0.81)	(1.42)
Controls				
OFFERING_AMOUNT	−0.153***	−0.157***	−0.234***	−0.220***
	(−10.30)	(−11.59)	(−7.61)	(−7.34)
COUPON_RATE	−1.688***	−1.455**	−4.149***	−4.310***
	(−2.78)	(−2.43)	(−3.00)	(−3.55)
DURATION	0.080***	0.081***	0.093***	0.104***
	(25.67)	(26.51)	(7.17)	(10.84)
BOND_AGE	0.040***	0.040***	0.030***	0.033***
	(11.89)	(12.36)	(5.51)	(7.07)
CALLABILITY	0.023	0.031	0.093	0.083
	(0.83)	(1.13)	(1.35)	(1.29)
FUNGIBILITY	−0.001	−0.004	−0.016	−0.007
	(−0.08)	(−0.29)	(−0.45)	(−0.23)
CREDIT_ENHANCEMENT	−0.086***	−0.088***	−0.036	−0.025
	(−2.66)	(−2.84)	(−1.02)	(−0.75)
NEWLY_ISSUED_BOND	−0.359***	−0.348***	−0.498***	−0.598***
	(−12.76)	(−13.25)	(−5.27)	(−6.64)
EQUITY_VOLATILITY	12.075***	11.602***	16.720***	15.159***
	(9.44)	(10.81)	(10.63)	(10.84)
EQUITY_BETA	0.002	0.008	−0.017	−0.010
	(0.26)	(0.94)	(−1.35)	(−0.98)
BOOK_SIZE	−0.048***	−0.047***	0.070***	0.050**
	(−4.40)	(−4.34)	(2.88)	(2.26)
MTB	−0.064***	−0.064***	−0.133***	−0.126***
	(−4.81)	(−4.84)	(−2.92)	(−3.03)
BOOK_LEVERAGE	0.072	0.074	0.212	0.143
	(1.03)	(1.08)	(1.16)	(0.90)
PROFITABILITY	−0.172	−0.153	−0.199	−0.155
	(−1.57)	(−1.49)	(−1.37)	(−1.11)
CASH_HOLDING	0.072	0.087	0.443*	0.439**
	(0.86)	(1.03)	(1.80)	(2.00)
DIVIDEND_PAYER	0.026	0.019	0.105**	0.114***
	(0.83)	(0.67)	(2.40)	(3.14)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time FE	Yes	–	Yes	–
Credit rating FE	Yes	–	Yes	–
Time × credit rating FE	–	Yes	–	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	183,829	183,829	39,486	39,486
R^2	0.396	0.413	0.412	0.490

Panel B. Amihud Measure

Dependent Variable: Bond Illiquidity	Investment Grade		High Yield	
	1	2	3	4
CDS_PRESENCE	−0.065***	−0.059***	0.018	0.021
	(−4.07)	(−3.81)	(0.94)	(1.20)
Controls				
OFFERING_AMOUNT	−0.049***	−0.050***	−0.154***	−0.144***
	(−3.57)	(−3.87)	(−10.55)	(−9.66)
COUPON_RATE	−1.035**	−1.076**	−2.339***	−2.332***
	(−2.30)	(−2.32)	(−3.48)	(−4.02)
DURATION	0.020***	0.020***	0.022***	0.025***

(continued on next page)

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

TABLE 3 (continued)

CDS Presence and Bond Illiquidity: Multivariate Results

Panel B. Amihud Measure (continued)

Dependent Variable: Bond Illiquidity	Investment Grade		High Yield	
	1	2	3	4
	(8.95)	(9.33)	(3.84)	(5.52)
BOND_AGE	0.034***	0.034***	0.028***	0.029***
	(11.78)	(11.98)	(7.69)	(8.73)
CALLABILITY	0.016	0.022	−0.004	−0.012
	(0.77)	(1.03)	(−0.08)	(−0.27)
FUNGIBILITY	0.009	0.009	−0.030*	−0.029*
	(0.73)	(0.70)	(−1.82)	(−1.83)
CREDIT_ENHANCEMENT	−0.018	−0.021	−0.008	−0.006
	(−0.78)	(−0.90)	(−0.44)	(−0.34)
NEWLY_ISSUED_BOND	−0.240***	−0.236***	−0.201***	−0.236***
	(−15.64)	(−16.28)	(−5.10)	(−6.64)
EQUITY_VOLATILITY	2.214***	2.146***	2.390***	2.307***
	(3.97)	(3.97)	(4.46)	(4.29)
EQUITY_BETA	0.009*	0.011**	0.000	−0.001
	(1.80)	(2.25)	(0.04)	(−0.19)
BOOK_SIZE	−0.015**	−0.013*	0.029**	0.021*
	(−2.01)	(−1.77)	(2.39)	(1.95)
MTB	−0.029***	−0.028***	−0.057***	−0.056***
	(−3.24)	(−3.31)	(−2.93)	(−3.20)
BOOK_LEVERAGE	0.014	0.014	0.103	0.062
	(0.29)	(0.31)	(1.33)	(0.91)
PROFITABILITY	−0.067	−0.046	0.004	0.008
	(−0.84)	(−0.60)	(0.07)	(0.16)
CASH_HOLDING	0.051	0.068	0.248**	0.263**
	(0.97)	(1.28)	(2.28)	(2.52)
DIVIDEND_PAYER	0.008	0.002	0.037*	0.042**
	(0.42)	(0.12)	(1.88)	(2.33)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time FE	Yes	–	Yes	–
Credit rating FE	Yes	–	Yes	–
Time × credit rating FE	–	Yes	–	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	183,829	183,829	39,486	39,486
R^2	0.324	0.337	0.415	0.474

between CDS presence and bond illiquidity becomes statistically insignificant. This result, robust across different specifications and economically significant, shows that the impact of CDSs on bond liquidity is mostly relevant for investment grade bonds. The fact that there is no effect for high-yield bonds (the ones more subject to bankruptcy and restructuring) provides suggestive evidence that the underlying channel is more liquidity provision for investment grade bonds than the CDS-induced empty creditor problem for high-yield bonds.[14]

Next, we investigate the relation between CDS presence and bond illiquidity within the investment grade category splitting the sample into AAA- and AA-rated firms and A- and BBB-rated firms. The A- and BBB-rated bonds are more likely to experience regulatory constraints induced forced sales by institutional bondholders than AAA- and AA-rated bonds (Nanda et al. (2019)). We report the results in Table 4. Columns 1 and 3 are for the subsample of AAA- and A-rated bonds,

[14]The results for the control variables are largely in line with expectations. For both investment grade and high-yield bonds, bond duration, bond age, and equity volatility are positively related to bond illiquidity, whereas the bond size and issuer MTB are negatively related to it. The newly issued indicator is always negatively related to bond illiquidity. For investment grade bonds, the 5-year on-the-run indicator is strongly negatively related to bond illiquidity.

TABLE 4

CDS Presence and Bond Illiquidity: Within Investment Grade Category

Table 4 presents the results on the relation between CDS presence and bond illiquidity within the investment-grade category but split the sample into AAA- and AA-rated firms, and A- and BBB-rated firms. The dependent variable in columns 1 and 2 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 3 and 4 is the Amihud measure. Columns 1 and 3 are for the subsample of AAA- and AA-rated bonds, whereas columns 2 and 4 are for A- and BBB-rated bonds. In all the specifications, we include industry, credit rating times year–month fixed effects, and cluster the standard errors at the issuer level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using heteroscedasticity robust standard errors with *t*-statistics given in parentheses.

Dependent Variable:	Bond Illiquidity (Roll)		Bond Illiquidity (Amihud)	
	AAA- and AA-Rated Bonds	A- and BBB-Rated Bonds	AAA- and AA-Rated Bonds	A- and BBB-Rated Bonds
	1	2	3	4
CDS_PRESENCE	−0.035	−0.068***	−0.006	−0.062***
	(−0.55)	(−3.00)	(−0.21)	(−3.94)
Controls				
OFFERING_AMOUNT	−0.080***	−0.165***	0.019	−0.059***
	(−3.99)	(−11.19)	(1.21)	(−4.29)
COUPON_RATE	−5.739***	−1.220*	−1.851*	−1.149**
	(−3.71)	(−1.96)	(−1.91)	(−2.27)
DURATION	0.115***	0.078***	0.037***	0.019***
	(13.77)	(25.36)	(7.80)	(8.39)
BOND_AGE	0.058***	0.039***	0.035***	0.035***
	(8.27)	(10.81)	(7.10)	(10.84)
CALLABILITY	0.032	0.012	−0.019	0.021
	(0.98)	(0.34)	(−0.66)	(0.85)
FUNGIBILITY	−0.024	−0.000	−0.030	0.012
	(−0.76)	(−0.03)	(−1.03)	(0.83)
CREDIT_ENHANCEMENT	−0.282*	−0.093***	−0.184**	−0.023
	(−1.98)	(−2.92)	(−2.11)	(−0.98)
NEWLY_ISSUED_BOND	−0.184***	−0.382***	−0.192***	−0.244***
	(−5.16)	(−13.95)	(−11.03)	(−15.12)
EQUITY_VOLATILITY	8.355***	11.747***	1.457	2.166***
	(2.84)	(11.00)	(1.11)	(3.97)
EQUITY_BETA	−0.017	0.007	0.009	0.009*
	(−0.71)	(0.76)	(0.58)	(1.91)
BOOK_SIZE	−0.159**	−0.042***	−0.106**	−0.008
	(−2.21)	(−3.63)	(−2.23)	(−0.98)
MTB	−0.138**	−0.060***	−0.091**	−0.025***
	(−2.12)	(−4.55)	(−2.40)	(−2.94)
BOOK_LEVERAGE	0.778**	0.046	0.376*	−0.008
	(2.59)	(0.68)	(1.85)	(−0.17)
PROFITABILITY	−0.353	−0.134	−0.375	−0.024
	(−0.46)	(−1.31)	(−1.01)	(−0.33)
CASH_HOLDING	0.486**	0.049	0.296***	0.043
	(2.43)	(0.55)	(2.96)	(0.79)
DIVIDEND_PAYER	−0.191	0.022	−0.154*	0.006
	(−1.23)	(0.76)	(−1.91)	(0.32)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time × credit rating FE	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	21,456	162,373	21,456	162,373
R^2	0.543	0.403	0.500	0.328

whereas columns 2 and 4 are for A- and BBB-rated bonds. In line with our expectations, the effect of lower illiquidity due to the presence of CDSs is concentrated among BBB- and A-rated firms rather than AAA- and AA-rated firms (i.e., the ones that are most subject to fire-sale risk).

V. Addressing Endogeneity

The previous results document a significantly negative relationship between the presence of CDS contracts and bond illiquidity for investment grade bonds, providing strong support for our first hypothesis. However, it may not be enough to establish a causal relationship. Indeed, it may be possible that CDS contracts exist in the very firms characterized by some unobserved risk characteristics that also determine bond liquidity. To address this issue, we provide two tests. First, we consider an event that exogenously affects the behavior of institutional investors holding corporate bonds. Then, we provide an instrumental variable specification.

The event is based on Hurricane Katrina (Aug. 23–30, 2005) and the Katrina-exposed property-casualty insurance companies. Hurricane Katrina is the costliest natural disaster in the history of the United States, with total property damage estimated at $81 billion (2005 USD) and almost $40.6 billion of insured losses (Knabb, Rhome, and Brown (2005)).[15] It represents a large exogenous shock to the property and casualty insurance industry. The property insurance companies exposed to Hurricane Katrina, driven by the need to meet redemption claims, generated a selling pressure of the bonds held by those investors (Massa and Zhang (2021)). These forced sales can only be attributed to supply side shocks (i.e., shocks to the Katrina-exposed property insurance companies) as opposed to firm-specific shocks such as rating downgrades.

In this context, we test whether the presence of CDS contracts may help to reduce such impact on bond illiquidity. Following Massa and Zhang (2021), we use the pre-Katrina exposed insurance bond ownership to proxy for the selling pressure of the bonds after the hurricane. First, we identify the set of property and casualty insurance and reinsurance companies that are considered to have high exposure to Hurricane Katrina, based on their 2004 market shares in the states of Louisiana, Mississippi, and Alabama, and whether they have rating or outlook changes immediately after the hurricane. We include the top 10 property insurance companies by their market shares (including both personal and commercial lines) and eight reinsurance companies with negative rating outlook changes. Then, we define the pre-Katrina exposed insurance bond ownership as the par amounts held by property and reinsurance companies with high exposure to Hurricane Katrina at the end of the second quarter of 2005 divided by the amount of bond issue outstanding. Non-exposed bond ownership is defined as the difference between total institutional ownership minus the exposed insurance ownership.[16]

Specifically, we regress the changes in bond illiquidity around Hurricane Katrina, on the pre-Katrina exposed insurance ownership, a "no-CDS presence" indicator as *1-"CDS presence" dummy*, and the interaction between them. We use the "no-CDS presence" dummy in the interaction terms for the convenience of understanding the interaction effects. We focus on the interaction term between the exposed insurance ownership and the "no-CDS presence" dummy. Our hypothesis predicts a positive relationship between the interaction term and the changes in bond illiquidity around Hurricane Katrina.

[15]A special report by Towers Perrin Co. (2005) studying the impact of Hurricane Katrina on the insurance industry estimates the range of privately insured loss to be between $40 and $55 billion.

[16]We exclude bond issuers that may be directly affected by the hurricane, which include life and property (re)insurance companies, and firms headquartered in the states of Louisiana, Mississippi, and Alabama.

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

TABLE 5

CDS Presence and Bond Illiquidity: Hurricane Katrina

Table 5 presents the results on the relation between CDS presence and the change in bond illiquidity during the Hurricane Katrina period from Aug. 2005 to Sept. 2005, through the channel of bond sales by hurricane-exposed property and casualty insurance companies. The data on institutional holdings of corporate bonds are from Lipper's eMAXX fixed income database. We exclude bond issuers that may be directly affected by the hurricane, which include life and property (re)insurance companies, and firms headquartered in the states of Louisiana, Mississippi, and Alabama. We follow Massa and Zhang (2021) to identify exposed property insurance companies. We define exposed insurance bond ownership as the par amounts held by property and reinsurance companies with high exposure to Hurricane Katrina at the end of the second quarter of 2005 divided by the amount of bond outstanding. Non-exposed bond ownership is defined as the difference between total institutional ownership minus the exposed insurance ownership. We focus on the interaction term between the exposed insurance bond ownership and the "No-CDS presence" indicator. In columns 1 and 2, the dependent variable is the change in bond illiquidity based on the Roll measure between Sept. 2005 and Aug. 2005. In columns 3 and 4, the dependent variable is the change in bond illiquidity based on the Amihud measure between Sept. 2005 and Aug. 2005. Columns 1 and 3 are for the subsample of investment grade bonds, whereas columns 2 and 4 are for high-yield bonds. In all the specifications, we include industry fixed effects, credit rating fixed effects, and cluster the standard errors at the issuer level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using heteroscedasticity robust standard errors with *t*-statistics given in parentheses.

	Dependent Variable: Change in Illiquidity			
	Bond Illiquidity (Roll)		Bond Illiquidity (Amihud)	
	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
EXPOSED_INSURANCE_OWNERSHIP	2.157	−44.203	0.934	−12.170
	(0.13)	(−0.82)	(0.13)	(−0.90)
EXPOSED_INSURANCE_OWNERSHIP × NO_CDS_PRESENCE	18.603***	2.774	3.828**	−2.634
	(5.52)	(0.55)	(2.40)	(−0.58)
Controls				
NON_EXPOSED_INSTITUTIONAL_OWNERSHIP	0.035	−0.031	0.004	−0.075
	(0.18)	(−0.10)	(0.07)	(−0.63)
NON_EXPOSED_INSTITUTIONAL_OWNERSHIP × NO_CDS_PRESENCE	−0.173	0.881	−0.284	−0.158
	(−0.45)	(0.96)	(−1.28)	(−0.53)
EXPOSED_INSURANCE_OWNERSHIP × OFFERING_AMOUNT	−0.740	8.633	−0.688	1.853
	(−0.27)	(1.03)	(−0.61)	(1.06)
EXPOSED_INSURANCE_OWNERSHIP × DURATION	0.093	−0.457	0.336*	0.259
	(0.16)	(−0.18)	(1.73)	(0.41)
EXPOSED_INSURANCE_OWNERSHIP × BOND_AGE	0.356	0.160	0.340*	0.282
	(0.82)	(0.08)	(1.80)	(0.46)
EXPOSED_INSURANCE_OWNERSHIP × NEWLY_ISSUED_BOND	−44.462***	−14.531	0.162	5.554
	(−4.53)	(−0.51)	(0.06)	(0.57)
NO_CDS_PRESENCE	−0.010	0.061	0.135	0.207
	(−0.06)	(0.19)	(1.58)	(1.42)
OFFERING_AMOUNT	0.011	0.020	0.020	−0.017
	(0.15)	(0.19)	(0.86)	(−0.39)
DURATION	0.006	−0.033	−0.003	0.004
	(0.57)	(−1.19)	(−0.55)	(0.37)
BOND_AGE	−0.004	0.025	−0.003	0.002
	(−0.31)	(0.81)	(−0.61)	(0.16)
NEWLY_ISSUED_BOND	0.147	−0.717**	−0.020	−0.112
	(1.01)	(−2.39)	(−0.46)	(−0.92)
On-the-run indicators	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	827	271	827	271
R^2	0.097	0.239	0.101	0.263

We report the results in Table 5. In columns 1 and 2, the dependent variable is the change in bond illiquidity based on the Roll measure between Sept. 2005 and Aug. 2005. In columns 3 and 4, the dependent variable is the change in bond illiquidity based on the Amihud measure between Sept. 2005 and Aug. 2005. Columns 1 and 3 are for the subsample of investment grade bonds, whereas columns 2 and 4 are for high-yield bonds. In all the specifications, we include industry fixed effects, credit rating fixed effects, and cluster the standard errors at the issuer level. The results show a significant positive coefficient on the interaction term between the No-CDS dummy and the pre-Katrina exposed insurance ownership. This finding holds for both measures of bond illiquidity. It suggests that in the face of the selling pressure of Katrina-exposed property insurance companies, bonds without CDS contracts experience a larger liquidity deterioration than bonds with CDS presence, supporting our first hypothesis that the presence of CDS contracts reduces the fire sale effect in the bond market.

Next, we consider an instrumental variable specification that uses as instrument the level of loan concentration of the lending banks the bond issuer borrows from. The intuition is that banks use CDSs to hedge their loan positions. The less diversified their overall loan portfolio is, the higher incentives banks have to purchase CDSs for hedging purposes.[17] Therefore, we use the level of loan concentration of the lending banks, from which the bond issuer borrows its bank debt to identify the demand for CDS contracts.[18]

We proceed as follows: First, at the issuer level, we calculate the loan Herfindahl instrument as the minimum loan concentration among all the banks from which the issuer borrows in the last 5 years. We construct banks' loan portfolio concentration using the syndicated loan data from LPC Dealscan. We focus on relatively large bank loans with loan amount more than $100 million. For each bank, we group its existing loans into industry (the Fama–French 48-industry classification) – state pairs. We then calculate the Herfindahl across those pairs as the concentration of the bank's loan portfolio. Finally, we estimate a probit model of the presence of CDS contracts as a function of loan Herfindahl. Then, we calculate the fitted value from the probit model and use it as the instrument (Wooldrige (2001)).

We report the results in Table 6. In column 1, we report the results of the probit model. The dependent variable in columns 2 and 3 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 4 and 5 is the Amihud measure. Columns 2 and 4 are for the subsample of investment grade bonds, whereas columns 3 and 5 are for high-yield bonds. In all the specifications, we include industry, time and credit rating fixed effects, and cluster the standard errors at the issuer level.

The results show a significantly positive relationship between the presence of CDS contracts and the demand for CDS contracts, proxied by the level of loan concentration of the lending banks from which the bond issuer borrows its bank debt. That is, the more concentrated the loan portfolios of the banks are, the higher the probability that the firm has a CDS on its bonds. Moreover, the F-test delivers a Staiger and Stock (1997) statistic of weak instruments above 10. This allows us to

[17]Jarrow (2011) argues that "For financial institutions that originate a large quantity of loans with a particular geographic or industry concentration, the ability to hedge the credit risk of these loans by purchasing a CDS enables the financial institution to eliminate the geographic or industry concentration from their portfolio."

[18]In Supplementary Material, we provide evidence at the bank level that the use of credit derivatives for hedging is significantly positively related to the degree of loan portfolio concentration of the bank, while such a relationship does not exist in the case of interest rate derivatives and foreign exchange derivatives.

TABLE 6

CDS Presence and Bond Illiquidity: Instrumental Variable Results

Table 6 presents the instrumental variable regression results to examine the relation between CDS presence and bond illiquidity. We use the level of geographic and industry concentration of the lending banks, from which the bond issuer borrows its bank debt to identify the demand for CDS contracts, as an instrument for the presence of CDS contracts. Specifically, at the issuer level, we calculate the loan Herfindahl instrument as the minimum loan concentration among all the banks from which the issuer borrows in the last 5 years. We construct banks' loan portfolio concentration based on the syndicated loan data from LPC Dealscan. We focus on relatively large bank loans with loan amount more than $100 million. For each bank, we group its existing loans into industry (the Fama–French 48-industry classification) – state pairs. We then calculate the Herfindahl across those pairs as the concentration of the bank's loan portfolio. In column 1, we run a probit regression of the CDS presence indicator on loan Herfindahl. Then, we calculate the fitted value from column 1 and use it as the instrument for CDS presence in columns 2–5. The dependent variable in columns 2 and 3 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 4 and 5 is the Amihud measure. Columns 2 and 4 are for the subsample of investment grade bonds, whereas columns 3 and 5 are for high-yield bonds. In all the specifications, we include industry, time and credit rating fixed effects, and cluster the standard errors at the issuer level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using heteroscedasticity robust standard errors.

	Dependent Variable				
	CDS Presence	Bond Illiquidity (Roll)		Bond Illiquidity (Amihud)	
	First Stage (Probit Regression)	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4	5
CDS_PRESENCE (instrumented by fitted value from first stage)		−0.470**	−0.421	−0.425**	−0.093
		(−2.20)	(−1.51)	(−2.44)	(−0.80)
LOAN_HERFINDAHL	4.163***				
	(3.31)				
Controls					
OFFERING_AMOUNT	−0.112	−0.163***	−0.247***	−0.055***	−0.146***
	(−1.64)	(−9.60)	(−6.81)	(−3.43)	(−9.15)
COUPON_RATE	−3.059	−2.404***	−4.328**	−1.734***	−3.090***
	(−1.16)	(−3.04)	(−2.53)	(−2.71)	(−3.73)
DURATION	0.013	0.083***	0.095***	0.023***	0.023***
	(1.43)	(22.46)	(6.16)	(8.19)	(3.36)
BOND_AGE	0.050***	0.047***	0.039***	0.040***	0.033***
	(3.91)	(10.90)	(4.14)	(10.51)	(7.95)
CALLABILITY	0.117	0.028	0.142*	0.016	0.019
	(1.19)	(0.82)	(1.76)	(0.60)	(0.34)
FUNGIBILITY	0.100	0.014	0.039	0.028	−0.033
	(1.33)	(0.76)	(0.86)	(1.64)	(−1.52)
CREDIT_ENHANCEMENT	−0.204	−0.069	−0.116	−0.017	−0.020
	(−1.28)	(−1.52)	(−1.36)	(−0.47)	(−0.51)
NEWLY_ISSUED_BOND	0.056	−0.320***	−0.459***	−0.216***	−0.169***
	(0.89)	(−10.24)	(−4.37)	(−12.55)	(−4.18)
EQUITY_VOLATILITY	4.169	12.712***	16.074***	2.398***	2.426***
	(1.62)	(9.03)	(7.98)	(3.65)	(4.01)
EQUITY_BETA	0.111***	0.004	−0.011	0.011	0.002
	(3.40)	(0.35)	(−0.74)	(1.36)	(0.44)
BOOK_SIZE	0.303***	−0.048***	0.090***	−0.014	0.038**
	(4.62)	(−3.04)	(2.58)	(−1.15)	(2.45)
MTB	−0.236***	−0.110***	−0.209***	−0.057***	−0.085***
	(−3.48)	(−5.01)	(−2.69)	(−3.07)	(−3.02)
BOOK_LEVERAGE	1.691***	0.182*	0.497	0.077	0.160
	(3.64)	(1.83)	(1.34)	(0.98)	(1.05)
PROFITABILITY	0.173	−0.156	−0.189	−0.075	0.016
	(0.43)	(−1.24)	(−1.26)	(−0.70)	(0.27)
CASH_HOLDING	0.561	0.079	0.720	0.047	0.181
	(0.73)	(0.66)	(1.57)	(0.52)	(0.91)
DIVIDEND_PAYER	0.209	0.036	0.051	0.023	0.014
	(1.46)	(0.81)	(0.89)	(0.64)	(0.56)
On-the-run indicators	Yes	Yes	Yes	Yes	Yes
Industry FE, time FE, rating FE	Yes	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer	Issuer
No. of obs.	261,457	143,461	27,687	143,461	27,687
R^2	–	0.379	0.411	0.270	0.432

validate the strength of the instrument. Then, we focus on the instrumental variable specification that uses the degree of loan portfolio concentration of the lender as instrument. The results support the previous ones, displaying a significantly negative relationship between CDS presence and both measures of bond illiquidity for investment grade bonds. As before, no statistically significant effect is there for high-yield bonds.[19]

As a robustness check, in the first stage of the IV specification, we include the total amount of bonds outstanding by the issuer. The intuition is that the total amount of bonds outstanding should be positively related to the presence of observing a CDS contract. We find that it is indeed the case, and the second stage results are consistent with the reported ones.[20]

VI. Time Varying Impact of CDSs

We now investigate how the relation between CDS presence and bond illiquidity changed over time. Recent studies have investigated the impact of major regulatory changes on the liquidity and trading quality of the single-name CDS market, including the central clearing and post-trade reporting requirement after the Dodd–Frank Act in 2012 (Loon and Zhong (2014), Narayanan and Uzmanoglu (2018), and Wang et al. (2021)) and the CDS Big Bang in 2009 (Wang et al. (2021)). We therefore track the liquidity provision role of CDSs on the underlying bonds through different time periods, using these two major regulatory events.

The CDS Big Bang happened in Apr. 2009 and involved an increase in CDS standardization. The changes included fixed coupon rates, standard effective dates, determinations committees, and auction settlement changes (Markit (2009)). The standardization of coupons allows for more simplified processing of trades as well as the netting of offsetting CDS positions. The critical implication of trading with fixed coupons is that CDS traders are likely to be required to pay upfront fees. Before the CDS Big Bang, most single-name CDS contracts were quoted using a par spread (i.e., the spread that would cause the present value of a CDS contract to be 0 for both the buyer and seller at the outset of the trade). After the CDS Big Bang, North American CDS contracts are traded with two fixed coupons of 100 bps and 500 bps. In general, investment grade names will be traded with a fixed coupon of 100 basis points, and high-yield names will be traded with a 500 basis points fixed coupon (Markit (2009)).

To better understand the implications of the CDS Big Bang, we examine the average 5-year CDS par spread after Apr. 2009 by rating categories as reported in the Markit data (with available Markit CDS rating). The average reported par spreads for AAA-, AA-, A-, BBB-, BB-, B-, CCC-rated CDS names are 132 bps, 164 bps, 192 bps, 210 bps, 287 bps, 379 bps, and 354 bps, respectively. After the CDS Big Bang, the coupon rates are, respectively, set to 100 bps, 100 bps, 100 bps, 100 bps, 500 bps, 500 bps, and 500 bps. This implies that if, for example, we consider an average BBB-rated single-name CDS contract with a par CDS spread of 210 bps, since its coupon rate (equal to 100 bps after the CDS Big Bang) is 110 bps

[19]One potential concern may be that the geographic and industry loan concentration of banks may be correlated with bond liquidity because of local proximity in bank lending (Hollander and Verriest (2016)). To deal with this concern, we drop local (i.e., headquartered in the same state) firms when we estimate bank portfolio concentration at the bank level and exclude local banks when calculating loan Herfindahl at the issuer level. We report the results in the Supplementary Material. We find similar results compared to the ones reported in the main analyses.

[20]In the interest of brevity, we provide this specification in the Supplementary Material.

less than the breakeven rate (210 bps), the CDS protection buyer will now be asked to compensate the seller by paying an upfront fee equal to the present value of 110 bps per year during the life of the CDS contract. On the other hand, for an average B-rated single-name CDS contract with a par CDS spread of 379 bps, the coupon rate is now 500 bps. In this case, the protection seller needs to compensate the protection buyer by paying an upfront fee equal to the present value of 121 bps per year during the life of the CDS contract.

The upfront payments act as an extra funding requirement that adds to the initial margin required for CDS trades. Wang et al. (2021) find that the average size of such upfront fee is about 4.07% of the notional amount of CDS contracts. This translates into an aggregate monthly upfront fee for CDS trades of approximately $3.87 billion per month between Apr. 2009 to Dec. 2009 (Wang et al. (2021)), and this amount is even after excluding the upfront fees for all offsetting positions. The net effect is a discouragement to use CDSs. That is, the CDS Big Bang reduces the incentives/abilities of potential CDS protection buyers (such as banks, insurance companies, and bond dealers) to utilize CDS contracts to alleviate fire-sale risk, save regulatory capital, or manage bond inventory because of the requirement of large upfront payments. We therefore expect the liquidity provision role of CDS contracts on the underlying bonds to deteriorate after the CDS Big Bang. As illustrated by the previous examples, this effect should be especially pronounced for investment grade bonds. For high-yield bonds, the liquidity provision role of CDSs may have gotten stronger because the protection buyers are likely to receive upfront payments.

The second moment we consider is Dec. 2012, after which more stringent post-trade reporting requirements imposed by the Dodd–Frank Act became effective for CDS dealers, and central clearing became mandatory for index CDS contracts. For single-name CDS contracts, the market participants can either voluntarily clear their trades through a central counterparty or rely on bilateral counterparty arrangements. The implication of central clearing and more stringent post-trade reporting requirements on the liquidity provision role of CDSs on the underlying bonds can be mixed. Loon and Zhong (2014) document that central clearing and greater post-trade transparency improve CDS liquidity and trading activity. However, Loon and Zhong (2014) also show that central clearing increases CDS par spread because of a lower counterparty risk, which makes the upfront fees paid by protection buyers even higher for investment grade bonds after the CDS Big Bang. In addition, the event of Basel III occurred during the same period, after which banks faced considerably higher capital charges with more stringent stress testing requirements for their hedging transactions. Therefore, it is an empirical question regarding how the impact of CDSs on the liquidity of underlying bonds might change after the Dodd–Frank Act.

To track the impact of CDSs on bond illiquidity, we create three period indicators: the Period 1 indicator equal to 1 if the sample period is from Jan. 2002 to Mar. 2009, and 0 otherwise; the Period 2 indicator equal to 1 if the sample period is from Apr. 2009 to Dec. 2012, and 0 otherwise; the Period 3 indicator equal to 1 if the sample period is from Jan. 2013 to Dec. 2017, and 0 otherwise.

We report the results in Table 7. Panel A presents the baseline results. We interact the CDS presence indicator with the Periods 1–3 indicators, respectively.

TABLE 7

CDS Presence and Bond Illiquidity: Tracking Through Time Periods

Table 7 presents the results on tracking the relation between CDS presence and bond illiquidity through difference time periods. We consider important regulatory changes that are specific to the CDS market in the United States. Specifically, we consider Apr. 2009 as a key moment (i.e., the CDS Big Bang) after which CDS contracts became more standardized. We consider Dec. 2012 as another key moment after which more stringent post-trade reporting requirements imposed by the Dodd–Frank Act became effective for CDS dealers, and central clearing became mandatory for index CDS contracts. Thus, we create three period indicators (the Period 1 indicator equal to 1 if the sample period is from Jan. 2002 to Mar. 2009, and 0 otherwise; the Period 2 indicator equal to 1 if the sample period is between from Apr. 2009 to Dec. 2012, and 0 otherwise; the Period 3 indicator equal to 1 if the sample period is between from Jan. 2013 to Dec. 2017, and 0 otherwise). Panel A presents the baseline results. We interact the CDS presence indicator with the Periods 1–3 indicators, respectively. The dependent variable in columns 1 and 2 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 3 and 4 is the Amihud measure of bond illiquidity. Columns 1 and 3 are for the subsample of investment grade bonds, whereas columns 2 and 4 are for the subsample of high-yield bonds. In all the specifications, we include industry, credit rating times year–month fixed effects, and cluster the standard errors at the issuer level. Panel B presents the results on how the presence of CDS contracts may alter the impact of inventory risk of bond dealers on bond illiquidity in different time periods. We use institutional sell–buy imbalance at the end of previous quarter to proxy for the inventory risk of bond dealers. The data on institutional holdings of corporate bonds are from Lipper's eMAXX fixed income database. For each bond-quarter, it is calculated as the ratio of the difference in total institutional selling amount and total institutional buying amount divided by the bond issue outstanding. We focus on the triple interaction term among the institutional sell–buy imbalance, the "No_CDS presence" indicator, and the three period indicators (as defined in Panel A), respectively. We control the double interaction terms to account for the level effects in different time periods. The dependent variable in columns 1 and 2 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 3 and 4 is the Amihud measure of bond illiquidity. Columns 1 and 3 are for the subsample of investment grade bonds, whereas columns 2 and 4 are for the subsample of high-yield bonds. In all the specifications, we include industry, credit rating times year–month fixed effects, and cluster the standard errors at the issuer level. Panel C presents the results on how the presence of CDS contracts may alter the impact of "fallen angel" incidence on the change in bond illiquidity through different time periods. For a bond-month, it is defined as a fallen angel if the bond is downgraded from investment grade to high yield. We focus on the triple interaction terms among the fallen angel indicator, the "No_CDS presence" indicator, and the three period indicators (as defined in Panel A). We control the double interaction terms to account for the level effects in different time periods. The dependent variable in columns 1 and 2 is the change in the Roll measure of bond illiquidity relative to the previous month, whereas the dependent variable in columns 3 and 4 is the change in the Amihud measure of bond illiquidity. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using heteroscedasticity robust standard errors with *t*-statistics given in parentheses.

Panel A. Baseline Results

	Dependent Variable			
	Bond Illiquidity (Roll)		Bond Illiquidity (Amihud)	
	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
CDS_PRESENCE × PERIOD_1	−0.148**	0.391***	−0.146***	0.080
	(−2.48)	(4.22)	(−2.59)	(1.62)
CDS_PRESENCE × PERIOD_2	−0.075*	0.053	−0.062***	0.026
	(−1.78)	(1.04)	(−2.82)	(0.95)
CDS_PRESENCE × PERIOD_3	−0.042*	−0.000	−0.033***	0.010
	(−1.85)	(−0.01)	(−2.62)	(0.54)
Controls				
OFFERING_AMOUNT	−0.157***	−0.224***	−0.049***	−0.145***
	(−11.80)	(−7.48)	(−3.94)	(−9.67)
COUPON_RATE	−1.427**	−4.091***	−1.045**	−2.288***
	(−2.40)	(−3.38)	(−2.29)	(−3.96)
DURATION	0.081***	0.106***	0.020***	0.025***
	(26.37)	(11.12)	(9.22)	(5.57)
BOND_AGE	0.039***	0.034***	0.034***	0.029***
	(12.30)	(7.53)	(12.12)	(8.77)
CALLABILITY	0.030	0.088	0.021	−0.011
	(1.09)	(1.39)	(0.98)	(−0.24)
FUNGIBILITY	−0.006	−0.004	0.007	−0.028*
	(−0.41)	(−0.13)	(0.57)	(−1.80)
CREDIT_ENHANCEMENT	−0.093***	−0.014	−0.027	−0.004
	(−2.96)	(−0.43)	(−1.16)	(−0.23)
NEWLY_ISSUED_BOND	−0.350***	−0.533***	−0.238***	−0.224***
	(−13.20)	(−5.70)	(−15.99)	(−5.96)
EQUITY_VOLATILITY	11.611***	15.056***	2.156***	2.287***
	(10.80)	(10.73)	(4.01)	(4.24)
EQUITY_BETA	0.008	−0.010	0.011**	−0.001
	(0.89)	(−0.97)	(2.26)	(−0.19)
BOOK_SIZE	−0.047***	0.046**	−0.013*	0.020*
	(−4.35)	(2.14)	(−1.79)	(1.90)
MTB	−0.062***	−0.128***	−0.026***	−0.056***
	(−4.68)	(−3.07)	(−2.98)	(−3.21)
BOOK_LEVERAGE	0.073	0.150	0.013	0.063
	(1.05)	(0.95)	(0.27)	(0.92)
PROFITABILITY	−0.162	−0.156	−0.056	0.008
	(−1.59)	(−1.12)	(−0.71)	(0.16)

(continued on next page)

Panel A. Baseline Results (continued)

	Dependent Variable			
	Bond Illiquidity (Roll)		Bond Illiquidity (Amihud)	
	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
CASH_HOLDING	0.083	0.435**	0.064	0.262**
	(0.99)	(2.00)	(1.19)	(2.52)
DIVIDEND_PAYER	0.018	0.109***	0.001	0.041**
	(0.66)	(2.99)	(0.08)	(2.27)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time × credit rating FE	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	183,829	39,486	183,829	39,486
R^2	0.413	0.491	0.338	0.474

Panel B. Dealers' Inventory Risk

	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
INSTITUTIONAL_SELL_BUY_IMBALANCE × NO_CDS_PRESENCE × PERIOD_1	5.187*	−2.924	4.258**	−3.272
	(1.87)	(−0.76)	(2.33)	(−1.62)
INSTITUTIONAL_SELL_BUY_IMBALANCE × NO_CDS_PRESENCE × PERIOD_2	1.079	−4.756*	1.162*	−0.699
	(0.92)	(−1.73)	(1.71)	(−0.58)
INSTITUTIONAL_SELL_BUY_IMBALANCE × NO_CDS_PRESENCE × PERIOD_3	2.096	−1.041	0.477	−0.270
	(1.54)	(−0.35)	(0.78)	(−0.22)
Controls				
INSTITUTIONAL_SELL_BUY_IMBALANCE × PERIOD_1	1.215	9.247***	1.060**	3.779***
	(1.39)	(4.07)	(2.16)	(4.07)
INSTITUTIONAL_SELL_BUY_IMBALANCE × PERIOD_2	2.272***	8.922***	1.673***	3.120***
	(5.13)	(4.79)	(5.56)	(3.29)
INSTITUTIONAL_SELL_BUY_IMBALANCE × PERIOD_3	1.731**	3.595	1.007***	0.715
	(2.13)	(1.55)	(2.65)	(0.74)
NO_CDS_PRESENCE × PERIOD_1	0.171***	−0.362***	0.155***	−0.073
	(2.96)	(−3.98)	(2.81)	(−1.40)
NO_CDS_PRESENCE × PERIOD_2	0.086*	−0.030	0.076***	−0.007
	(1.85)	(−0.52)	(3.24)	(−0.23)
NO_CDS_PRESENCE × PERIOD_3	0.053	−0.000	0.039**	0.011
	(1.45)	(−0.01)	(2.01)	(0.39)
OFFERING_AMOUNT	−0.173***	−0.226***	−0.048***	−0.150***
	(−9.90)	(−5.63)	(−2.98)	(−6.86)
COUPON_RATE	−0.992	−2.241	−1.232**	−1.689**
	(−1.50)	(−1.41)	(−2.11)	(−2.07)
DURATION	0.102***	0.115***	0.031***	0.030***
	(22.74)	(8.32)	(9.18)	(4.35)
BOND_AGE	0.044***	0.032***	0.040***	0.033***
	(11.98)	(4.73)	(11.58)	(7.52)
CALLABILITY	0.039	0.083	0.023	0.003
	(1.39)	(1.23)	(1.00)	(0.07)
FUNGIBILITY	−0.008	0.016	0.020	−0.023
	(−0.43)	(0.40)	(1.04)	(−1.12)
CREDIT_ENHANCEMENT	−0.120***	−0.030	−0.024	−0.008
	(−2.91)	(−0.71)	(−0.70)	(−0.33)
NEWLY_ISSUED_BOND	−0.308***	−0.377***	−0.199***	−0.149***
	(−10.58)	(−4.07)	(−13.49)	(−3.88)
EQUITY_VOLATILITY	12.412***	13.205***	2.442***	2.259**
	(9.13)	(6.26)	(3.39)	(2.43)
EQUITY_BETA	−0.002	−0.012	0.018*	0.004
	(−0.11)	(−0.53)	(1.87)	(0.53)
BOOK_SIZE	−0.050***	0.083***	−0.018*	0.034**
	(−3.68)	(3.21)	(−1.87)	(2.38)
MTB	−0.054**	−0.121*	−0.032*	−0.074**
	(−2.13)	(−1.95)	(−1.92)	(−2.47)
BOOK_LEVERAGE	0.125	0.138	0.043	0.077
	(1.42)	(0.73)	(0.68)	(0.89)
PROFITABILITY	−0.386	−0.295	−0.225	0.021
	(−1.30)	(−1.08)	(−1.15)	(0.15)
CASH_HOLDING	−0.000	0.288	0.051	0.232
	(−0.00)	(0.78)	(0.63)	(1.31)
DIVIDEND_PAYER	0.054	0.013	0.015	0.005
	(1.50)	(0.26)	(0.69)	(0.19)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

(continued on next page)

TABLE 7 (continued)

CDS Presence and Bond Illiquidity: Tracking Through Time Periods

Panel B. Dealers' Inventory Risk (continued)

	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
Time × credit rating FE	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	117,331	23,407	117,331	23,407
R^2	0.406	0.490	0.332	0.478

Panel C. Fallen Angel

Dependent Variable: Change in Illiquidity	Bond Illiquidity (Roll)		Bond Illiquidity (Amihud)	
	1	2	3	4
FALLEN_ANGEL × NO_CDS_PRESENCE × PERIOD_1	0.615***	0.529**	0.260**	0.249*
	(2.69)	(2.10)	(1.99)	(1.88)
FALLEN_ANGEL × NO_CDS_PRESENCE × PERIOD_2	−0.361	−0.364	−0.176	−0.170
	(−1.49)	(−1.56)	(−1.63)	(−1.57)
FALLEN_ANGEL × NO_CDS_PRESENCE × PERIOD_3	−0.079	−0.092	−0.043	−0.044
	(−0.54)	(−0.62)	(−1.51)	(−1.62)
Controls				
FALLEN_ANGEL × PERIOD_1	0.236**	0.096	−0.053	−0.069*
	(2.39)	(0.91)	(−1.33)	(−1.70)
FALLEN_ANGEL × PERIOD_2	0.472**	0.341*	0.037	0.017
	(2.40)	(1.78)	(0.60)	(0.27)
FALLEN_ANGEL × PERIOD_3	0.268**	0.120	0.005	−0.010
	(2.32)	(0.97)	(0.28)	(−0.52)
NO_CDS_PRESENCE × PERIOD_1	0.054	0.055	0.039***	0.039***
	(1.60)	(1.63)	(2.65)	(2.64)
NO_CDS_PRESENCE × PERIOD_2	0.028	0.029	0.013*	0.013*
	(1.19)	(1.23)	(1.78)	(1.78)
NO_CDS_PRESENCE × PERIOD_3	0.001	0.001	−0.001	−0.001
	(0.08)	(0.08)	(−0.20)	(−0.23)
LAGGED_ILLIQUIDITY	−0.608***	−0.608***	−0.348***	−0.348***
	(−67.95)	(−67.92)	(−35.59)	(−35.56)
CHANGE_IN_BOND_RATING		0.072***		0.007
		(5.96)		(1.42)
CHANGE_IN_BOND_DURATION		0.031**		−0.008*
		(2.49)		(−1.76)
CHANGE_IN_EQUITY_VOLATILITY		2.451***		0.525***
		(6.58)		(3.70)
CHANGE_IN_EQUITY_BETA		−0.004*		0.001
		(−1.80)		(0.94)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time × credit rating FE	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	211,348	211,348	211,348	211,348
R^2	0.337	0.338	0.212	0.212

The dependent variable in columns 1 and 2 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 3 and 4 is the Amihud measure of bond illiquidity. For investment grade bonds, the results show that the impact of CDS on bond illiquidity is significantly negative across the three periods, consistent with the overall liquidity provision argument of CDSs on the underlying bonds. However, the economic impact is weakened after the CDS Big Bang in 2009 and slightly weakened after Dodd–Frank in 2012, in line with our previous analyses based on the regulatory details. The results are consistent for the Roll and the Amihud measures of bond illiquidity. For high-yield bonds, the presence of CDSs increases bond illiquidity before the CDS Big Bang (likely due to higher information asymmetry because of the empty creditor problem), while this relationship becomes insignificant after the CDS Big Bang and after Dodd–Frank.

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

Next, we consider two proxies to further confirm whether the economic channel is related to the ability to deal with fire sales in the bond market. The first proxy is linked to the inventory risk of bond dealers. We argue that the liquidity provision role of CDSs is the reduction in the inventory risk of bond dealers (i.e., the use of CDSs allows bond dealers to hedge more efficiently and employ less regulatory capital to manage their bond inventory). This implies that the presence of CDS contracts should alter the impact of inventory risk of bond dealers on bond illiquidity, with the benefits of CDSs to be stronger when the bonds flow to the inventory of bond dealers. We proxy for the latter using the imbalance between the sell and buy of the institutional investors. The intuition is that when the imbalance is higher (i.e., institutional investors sell more than they buy) the dealers should absorb this imbalance and inflate their inventories.

More specifically, to proxy for the inventory risk of bond dealers, we use the previous quarter's institutional sell–buy imbalance. For each bond quarter, the imbalance is calculated as the ratio of the difference in total institutional selling amount and total institutional buying amount divided by the bond issue outstanding. The data on institutional holdings of corporate bonds are from Lipper's eMAXX fixed income database. Our focus variable is the interaction term between the institutional sell–buy imbalance and the "No-CDS presence" dummy. The "No-CDS presence" indicator equals 1 if the bond issuer has No-CDS contracts in the previous month, and 0 otherwise. We use the "No-CDS presence" dummy in the interaction terms for the convenience of interpreting coefficients relative to the level effects.

We report the results in Panel B of Table 7. The dependent variable in columns 1 and 2 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 3 and 4 is the Amihud measure of bond illiquidity. Columns 1 and 3 are for the subsample of investment grade bonds, whereas columns 2 and 4 are for the subsample of high-yield bonds. We focus on the triple interaction term among the institutional sell–buy imbalance, the "No-CDS presence" indicator, and the three period indicators (as defined in Panel A), respectively. We control the double interaction terms to account for the level effects in different periods.

The results display a positive relationship between institutional sell–buy imbalance and bond illiquidity. This is not surprising because bond dealers would face higher inventory risks after absorbing a large amount of inventory holdings. These effects are more than doubled for bonds in which No-CDS contracts are outstanding. The results remain the same when we include the interaction terms of the institutional sell–buy imbalance with other bond characteristics.[21] These results imply that CDSs allow bond dealers to hold onto their physical bond inventories by keeping their risk profile neutral, thus increasing their capacity to absorb fire sale-related shocks. We also find consistent evidence that CDSs significantly alter the impact of inventory risk of bond dealers on bond illiquidity only in the first period before the CDS Big Bang, while playing a less significant role in the following two periods. This pattern is consistent for both measures of bond illiquidity.

[21] In unreported analyses, we add additional interaction terms of the institutional sell–buy imbalance with firm risk characteristics such as equity volatility and equity beta, and the results remain the same.

The second proxy relies on one classic fire sale shock in the bond market: the moment when bonds are downgraded from investment grade to high yield (i.e., "fallen angels"). Ellul et al. (2011) show that such a downgrade triggers the forced sales of insurance companies and generates a large liquidity-driven negative effect on the bonds. Nanda et al. (2019) further show that investment commonalities of insurance companies aggravate the fire-sale risk of bonds following a rating downgrade because of regulatory constraints. In line with their findings, we find that in our sample, there is a significant 4% decrease in institutional bond ownership around the quarter of such downgrade (a 9% decrease relative to the ownership before the downgrade). In contrast, the average drop in institutional bond ownership around downgrades without crossing the investment grade/high-yield threshold is only 1%.

We expect that downgrades from investment grade to high yield will induce a higher increase in illiquidity for bonds without CDSs outstanding than for bonds with CDSs. This effect should be concentrated in the first period before the CDS Big Bang. We verify this prediction by regressing the Fallen Angel indicator, the No-CDS presence indicator, and the interactions with the period breakdowns. For a given bond-month, we define the fallen angel indicator as a dummy equal to 1 in the month in which the bond is downgraded from investment grade to high yield, and 0 otherwise. The "No-CDS" indicator equals 1 if the bond issuer has No-CDS contracts in the previous month, and 0 otherwise. We focus on the triple interaction terms among the fallen angel indicator, the "No-CDS presence" indicator, and the three period indicators (as defined in Panel A of Table 7). We control the double interaction terms to account for the level effects in different periods.

We report the results in Panel C of Table 7. The dependent variable in columns 1 and 2 is the change in the Roll measure of bond illiquidity relative to the previous month, whereas the dependent variable in columns 3 and 4 is the change in the Amihud measure of bond illiquidity. The results show a strong positive impact of being a Fallen Angel in the absence of CDSs on both illiquidity, and this effect is, in line with our expectations, concentrated in the first period before the CDS Big Bang, and it is not significant in the following two periods. These results suggest that the impact of CDSs on the underlying bonds is concentrated in the period in which their usage was more flexible and less costly, providing further evidence of the liquidity provision role of CDSs to alleviate the impact of fire sales for investment grade bonds.

VII. CDS Presence and Bond Yield Spreads

The previous results bring forward the question of whether the impact of CDSs on bond illiquidity manifests itself in bond prices. Bao et al. (2011) find that bond illiquidity helps to explain a large component of individual yield spreads in the cross section. However, Culp, Nozawa, and Veronesi (2018) find that bond market illiquidity and corporate frictions do not seem to explain the observed credit spreads.

To investigate this issue, we estimate a pooled specification in which the bond yield spread is regressed on the CDS presence dummy and a set of control variables. We report the results in Table 8. Panel A presents the baseline results. In columns

TABLE 8

Value Implication: CDS Presence and Bond Yield Spreads

Table 8 presents multivariate results on the relation between CDS presence and bond yield spreads. Panel A presents the baseline results. We employ two popular yield spread measures used by market participants, obtained directly from the ICE BofA bond index membership database. In columns 1 and 2, the dependent variable is the option-adjusted spread, whereas in columns 3 and 4, the dependent variable is the asset swap spread. Columns 1 and 3 are for the subsample of investment grade bonds, whereas columns 2 and 4 are for high-yield bonds. Panel B presents the results on tracking the relation between CDS presence and bond yield spread through difference time periods as identified in Table 7. We interact the CDS presence indicator with the Periods 1–3 indicators, respectively. In all the specifications, we include industry and credit rating times year–month fixed effects. We cluster the standard errors at the issuer level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using heteroscedasticity robust standard errors with *t*-statistics given in parentheses.

Panel A. Baseline Results

Dependent Variable:	Option-Adjusted Spread		Asset Swap Spread	
	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
CDS_PRESENCE	−0.106***	−0.076	−0.098***	−0.077
	(−4.51)	(−0.91)	(−4.44)	(−1.14)
Controls				
OFFERING_AMOUNT	−0.011	0.035	−0.014	0.039
	(−0.82)	(0.50)	(−1.07)	(0.76)
COUPON_RATE	10.081***	22.806***	13.675***	24.978***
	(17.33)	(8.05)	(19.91)	(10.26)
DURATION	0.055***	0.048***	0.079***	0.085***
	(26.85)	(2.63)	(34.19)	(5.48)
BOND_AGE	−0.003	0.019	0.002	0.023***
	(−1.23)	(1.52)	(0.55)	(2.61)
CALLABILITY	−0.057**	0.147	−0.091***	0.014
	(−2.22)	(1.15)	(−3.75)	(0.14)
FUNGIBILITY	−0.009	0.054	−0.009	0.049
	(−0.65)	(0.63)	(−0.64)	(0.74)
CREDIT_ENHANCEMENT	−0.034	0.026	−0.033	−0.029
	(−1.17)	(0.19)	(−1.28)	(−0.28)
NEWLY_ISSUED_BOND	−0.059***	−0.383***	−0.047***	−0.331***
	(−3.66)	(−2.95)	(−3.20)	(−3.42)
EQUITY_VOLATILITY	33.614***	60.582***	27.146***	40.928***
	(14.55)	(15.20)	(15.30)	(17.55)
EQUITY_BETA	0.038**	−0.008	0.040***	0.006
	(2.49)	(−0.20)	(2.96)	(0.23)
BOOK_SIZE	−0.085***	−0.078	−0.071***	−0.099**
	(−5.68)	(−1.38)	(−5.06)	(−2.14)
MTB	−0.078***	−0.553***	−0.074***	−0.539***
	(−4.55)	(−5.25)	(−4.75)	(−5.42)
BOOK_LEVERAGE	0.391***	1.145***	0.345***	0.912***
	(4.41)	(2.90)	(4.28)	(2.97)
PROFITABILITY	−0.772***	−0.682***	−0.658***	−0.475***
	(−3.64)	(−3.18)	(−3.54)	(−2.73)
CASH_HOLDING	−0.111	0.772	−0.068	0.661
	(−0.96)	(1.40)	(−0.66)	(1.51)
DIVIDEND_PAYER	0.039	0.174	0.027	0.159*
	(0.97)	(1.60)	(0.75)	(1.94)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time × credit rating FE	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	281,972	64,769	281,972	64,769
R^2	0.708	0.733	0.747	0.712

Panel B. Tracking Through Time Periods

Dependent Variable:	Option-Adjusted Spread		Asset Swap Spread	
	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
CDS_PRESENCE × PERIOD_1	−0.154***	0.382**	−0.137***	0.203*
	(−4.08)	(2.55)	(−4.19)	(1.88)
CDS_PRESENCE × PERIOD_2	−0.121***	−0.195*	−0.103**	−0.139
	(−2.65)	(−1.70)	(−2.26)	(−1.50)
CDS_PRESENCE × PERIOD_3	−0.070**	−0.287**	−0.071***	−0.212**
	(−2.44)	(−2.40)	(−2.66)	(−2.03)

(continued on next page)

TABLE 8 (continued)

Value Implication: CDS Presence and Bond Yield Spreads

Panel B. Tracking Through Time Periods (continued)

Dependent Variable:	Option-Adjusted Spread		Asset Swap Spread	
	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4
Controls				
OFFERING_AMOUNT	−0.010	0.029	−0.014	0.036
	(−0.78)	(0.42)	(−1.05)	(0.70)
COUPON_RATE	10.087***	23.270***	13.680***	25.275***
	(17.25)	(8.12)	(19.87)	(10.29)
DURATION	0.055***	0.052***	0.079***	0.087***
	(26.81)	(2.90)	(34.25)	(5.69)
BOND_AGE	−0.004	0.024**	0.001	0.026***
	(−1.36)	(1.97)	(0.46)	(2.99)
CALLABILITY	−0.058**	0.174	−0.092***	0.030
	(−2.29)	(1.34)	(−3.82)	(0.30)
FUNGIBILITY	−0.010	0.073	−0.009	0.060
	(−0.72)	(0.86)	(−0.69)	(0.92)
CREDIT_ENHANCEMENT	−0.038	0.025	−0.036	−0.029
	(−1.26)	(0.19)	(−1.37)	(−0.28)
NEWLY_ISSUED_BOND	−0.061***	−0.322**	−0.048***	−0.293***
	(−3.75)	(−2.53)	(−3.29)	(−3.12)
EQUITY_VOLATILITY	33.639***	60.102***	27.166***	40.631***
	(14.59)	(15.31)	(15.34)	(17.66)
EQUITY_BETA	0.038**	−0.013	0.040***	0.004
	(2.50)	(−0.32)	(2.96)	(0.13)
BOOK_SIZE	−0.083***	−0.090	−0.070***	−0.107**
	(−5.63)	(−1.60)	(−5.02)	(−2.31)
MTB	−0.076***	−0.560***	−0.072***	−0.544***
	(−4.45)	(−5.32)	(−4.67)	(−5.46)
BOOK_LEVERAGE	0.389***	1.209***	0.344***	0.951***
	(4.41)	(3.03)	(4.28)	(3.08)
PROFITABILITY	−0.773***	−0.653***	−0.659***	−0.457***
	(−3.62)	(−3.09)	(−3.52)	(−2.67)
CASH_HOLDING	−0.114	0.839	−0.070	0.702
	(−0.98)	(1.53)	(−0.68)	(1.61)
DIVIDEND_PAYER	0.038	0.158	0.026	0.149*
	(0.94)	(1.46)	(0.73)	(1.82)
On-the-run indicators	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time × credit rating FE	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer
No. of obs.	281,972	64,769	281,972	64,769
R^2	0.708	0.734	0.747	0.712

1 and 2, the dependent variable is the option-adjusted spread, whereas in columns 3 and 4, the dependent variable is the asset swap spread. Columns 1 and 3 are for the subsample of investment grade bonds, whereas columns 2 and 4 are for high-yield bonds. All firm-year (month) variables are taken at the end of the previous year (month). The set of control variables are the same as before, including major bond and issuer characteristics, as well as the Fama–French 48-industry fixed effects, time fixed effects at the year–month-level and credit rating fixed effects at the bond issue level. The fact that we control extensively for measures of credit risk (i.e., bond-level credit rating (from AAA to C) times year–month fixed effects, equity volatility, equity beta, and firm leverage) helps to make sure that our results are not driven by the fundamental changes in the default risk of the bond issuer.

The results show a significantly negative relationship between the availability of CDS contracts and yield spreads in the case of investment grade bonds. This holds robust across different specifications and is economically sizable. The presence of CDS contracts reduces the option-adjusted spread (asset swap spread) by

https://doi.org/10.1017/S0022109023000844 Published online by Cambridge University Press

7% (8%) relative to the sample average. However, there is no statistically significant relationship for high-yield bonds.[22]

Similarly, we also examine the impact of CDS presence on bond yield spreads through different time periods. Panel B of Table 8 presents the results on tracking the relation between CDS presence and bond yield spread through different time periods as identified in Table 7. Specifically, we interact the CDS presence indicator with the Periods 1–3 indicators, respectively. We find that the negative relation exists throughout the overall period for investment grade bonds, but the economic significance gets weakened after the CDS Big Bang and the Dodd–Frank Act. These patterns are consistent with the previous results on bond illiquidity.

VIII. Additional Robustness Checks

In this section, we utilize additional features of the Markit CDS data set to further evaluate the impact of CDSs on bond liquidity. First, we concentrate on the difference in bond illiquidity between long-term bonds and short-term bonds for *the same bond issuer* and relate it to the difference in the presence of long-term maturity CDS contracts and short-term maturity CDS contracts. The advantage of this specification is that, by focusing on the bonds issued by the same firm, we can identify the liquidity component between long-term and short-term bonds.

We therefore link the differences in bond illiquidity between long-term bonds and short-term bonds of the same issuer, to the differences in the presence of long-term and short-term maturity CDS contracts. We use the sample average bond time-to-maturity (9 years) as the cutoff to define long-term and short-term bonds. We define the long-term CDS presence as an indicator equal to 1 if the issuer has CDS contracts outstanding of 10-, 15-, 20-, and 30-year maturity, and 0 otherwise. We define the short-term CDS presence as an indicator equal to 1 if the issuer has CDS contracts outstanding of 1-, 2-, 3-, 4-, 5-, and 7-year maturity, and 0 otherwise.

The results strongly support the liquidity provision role of CDSs on the underlying bonds.[23] For investment grade bonds, the long-term CDS presence in excess of the short-term CDS presence reduces the difference in Roll (Amihud) bond illiquidity between long-term bonds and short-term bonds by 12% (25%) relative to the sample average differences. Consistent with previous findings, no significant effect is observed for high-yield bonds. Given that we focus on long-term and short-term bonds of the same issuer, this result suggests that the presence of CDS contracts effectively increases bond liquidity.

Second, we focus on the subsample of bonds issued by firms with CDS contracts trading in the market. Specifically, we link the *depth* of CDS contracts to bond illiquidity. Following Qiu and Yu (2012), we use the number of dealers providing CDS quotes as a proxy for the depth of CDS contract. The Markit data only provide information on the number of dealers in the 5-year maturity CDS contracts. Therefore, we define CDS composite depth as the log number of dealers

[22]The results for the control variables are largely in line with expectations. For both investment grade and high-yield bonds, the coupon rate is positively related to bond yield spreads, supporting a tax-based explanation. Consistent with Campbell and Taksler (2003), equity volatility and leverage are positively related to yield spreads, while MTB and profitability are negatively related to yield spreads.

[23]In the interest of brevity, we report these results in the Supplementary Material.

in the CDS contracts with 5-year maturity. Given that the CDS depth measure is directly related to the market liquidity of CDS contracts, we focus on the instrumental variable regression, with CDS depth instrumented by the loan Herfindahl defined in the same way as in Table 4.

We report the results in Table 9. The results make two points. First, they show that the loan portfolio concentration also significantly explains the degree of depth

TABLE 9

Robustness Check: CDS Depth and Bond Illiquidity

In Table 9, we perform another robustness check, by focusing the subsample of bonds issued by firms with CDS contracts trading in the market. Specifically, we link the depth of CDS contracts to bond illiquidity. Following Qiu and Yu (2012), we use the number of dealers providing CDS quotes as a proxy for the depth of CDS contract. We define CDS composite depth as the log number of dealers in the CDS contracts with 5-year maturity. We focus on the instrumental variable regression, with CDS depth instrumented by the loan concentration of the lending banks. We construct the instrument based on the loan Herfindahl defined in the same way as in Table 4. Column 1 presents the results of first-stage regression. The dependent variable in columns 2 and 3 is the Roll measure of bond illiquidity, whereas the dependent variable in columns 4 and 5 is the Amihud measure. Columns 2 and 4 are for the subsample of investment grade bonds, whereas columns 3 and 5 are for high-yield bonds. In all the specifications, we include industry, time and credit rating fixed effects, and cluster the standard errors at the issuer level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using heteroscedasticity robust standard errors with *t*-statistics given in parentheses.

Dependent Variable:	CDS Depth	Bond Illiquidity (Roll)		Bond Illiquidity (Amihud)	
	First Stage	Investment Grade	High Yield	Investment Grade	High Yield
	1	2	3	4	5
CDS_PRESENCE (instrumented)		−0.371***	−0.012	−0.284***	0.174
		(−5.23)	(−0.02)	(−6.87)	(0.45)
LOAN_HERFINDAHL	0.786***				
	(3.22)				
Controls					
OFFERING_AMOUNT	−0.010	−0.158***	−0.342***	−0.045***	−0.185***
	(−0.92)	(−9.49)	(−6.21)	(−2.86)	(−7.38)
COUPON_RATE	0.699	−2.716***	−6.736**	−1.468***	−5.076***
	(1.65)	(−3.72)	(−2.20)	(−2.87)	(−3.43)
DURATION	−0.000	0.087***	0.112***	0.024***	0.028***
	(−0.13)	(22.75)	(5.64)	(8.66)	(3.35)
BOND_AGE	0.002	0.044***	0.030***	0.036***	0.031***
	(1.14)	(11.21)	(3.41)	(11.55)	(7.20)
CALLABILITY	0.013	0.044	0.199**	0.013	0.093*
	(0.92)	(1.38)	(2.42)	(0.56)	(1.73)
FUNGIBILITY	0.030**	0.021	0.075	0.026	−0.047
	(2.40)	(1.13)	(1.24)	(1.55)	(−1.59)
CREDIT_ENHANCEMENT	−0.048*	−0.094*	−0.028	−0.059	0.034
	(−1.78)	(−1.78)	(−0.30)	(−1.53)	(0.62)
NEWLY_ISSUED_BOND	0.003	−0.332***	−0.672***	−0.228***	−0.228***
	(0.25)	(−10.27)	(−5.71)	(−13.25)	(−5.55)
EQUITY_VOLATILITY	1.516***	14.341***	14.570***	3.834***	2.318***
	(3.36)	(8.34)	(6.14)	(5.42)	(2.80)
EQUITY_BETA	0.026***	−0.003	−0.008	0.009	0.008
	(2.80)	(−0.26)	(−0.34)	(1.35)	(0.97)
BOOK_SIZE	0.147***	0.009	0.095	0.025**	0.017
	(10.96)	(0.60)	(0.89)	(2.42)	(0.29)
MTB	0.031*	−0.044**	−0.174***	−0.009	−0.105***
	(1.69)	(−2.08)	(−3.10)	(−0.62)	(−4.08)
BOOK_LEVERAGE	0.311***	0.314***	0.145	0.168**	0.096
	(3.68)	(2.77)	(0.36)	(2.22)	(0.55)
PROFITABILITY	0.078	−0.140	−0.274	0.026	−0.034
	(0.64)	(−1.56)	(−0.69)	(0.38)	(−0.16)
CASH_HOLDING	−0.072	−0.078	−0.426	−0.091	−0.146
	(−0.61)	(−0.57)	(−0.62)	(−0.92)	(−0.57)
DIVIDEND_PAYER	0.126***	0.056	−0.012	0.031	−0.030
	(2.84)	(1.15)	(−0.07)	(0.96)	(−0.31)
On-the-run indicators	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes	Yes
Clustering	Issuer	Issuer	Issuer	Issuer	Issuer
R^2	0.622	0.387	0.464	0.304	0.464
No. of obs.	197,790	112,679	14,933	112,679	14,933

of the CDS market. This evidence clearly shows that the demand for CDS contracts is indeed related to the banks' need to rely on credit derivatives for hedging purposes. The Staiger and Stock (1997) tests of weak instrument are comfortably passed. Second, the results display a significantly negative relationship between the CDS depth and both proxies of bond illiquidity for investment grade bonds. Consistent with the previous findings, no effect is observed for high-yield bonds.[24]

IX. Conclusion

We study the effect of CDSs on the corporate bond market. We argue that the presence of CDSs facilitate liquidity providers to provide liquidity at the very moment when bonds are subject to such fire sale related liquidity shocks. Using a comprehensive sample of U.S. corporate bonds with CDS contracts information, we find that the presence of CDSs significantly increases bond liquidity and reduces yield spreads for investment grade bonds.

We use an exogenous event that triggers forced sales induced by the selling pressure of exposed property insurance companies following Hurricane Katrina, and find that the presence of CDS contracts lowers the impact of forced sales by reducing the drop in bond liquidity. We also find consistent results using an instrumental variable identification that pins down the demand for CDS contracts. We further show that an important channel for CDSs to influence the bond market is to lower the impact of fire sales of institutional bondholders and facilitate inventory management for bond dealers who absorb fire sale shocks.

Moreover, we track the impact of CDSs on bond liquidity through different time periods, and find that the recent regulatory changes in the CDS market have weakened such a liquidity enhancing role of CDSs in the bond market. These results have important policy implications, suggesting that even though the recent regulatory changes have made CDS contracts more standardized, they may reduce the abilities of potential protection buyers to utilize CDS contracts to effectively manage bond inventory and save regulatory capital.

Appendix. Variable Definitions

BOND_ILLIQUIDITY (ROLL_MEASURE): For each bond-month, defined as the implied bid–ask spread based on the auto-covariances of bond price changes: $2\sqrt{\gamma}$ (0 if $\gamma < 0$), where $\gamma = -\text{cov}(\Delta p_t, \Delta p_{t-1})$ and p_t is the log bond price ("clean price") at time t. We use the tick-by-tick transaction data from TRACE to calculate the price changes. We require the number of bond transactions to be larger than 10 for each bond-month.

BOND_ILLIQUIDITY (AMIHUD_MEASURE): For each bond-month, defined as the monthly average of $1{,}000 \times |\Delta p_t| / \text{DVOL}_t$, where p_t is the log price at time t and DVOL_t is the dollar trading volume (in millions) at time t. We use the tick-by-

[24]Similarly, for a robustness check, we drop local (i.e., headquartered in the same state) firms when we estimate bank portfolio concentration at the bank level and exclude local banks when calculating loan Herfindahl at the issuer level. The results are similar to the ones reported in the main analyses. We report these results in the Supplementary Material.

tick transaction data from TRACE to calculate the price changes. Given that the exact amount of trade size from the TRACE data is truncated, we assume the trade size to be $1 million ($5 million) if it is reported as "1MM+" ("5MM+"). We require the number of bond transactions to be larger than 10 for each bond-month.

OPTION_ADJUSTED_SPREAD: Number of percentage points that the fair value of the treasury spot curve is shifted to match the present value of the discounted cash flows to the bond's price. For securities with embedded options, such as callability, a log normal short interest rate model is used to evaluate the present value of the securities' potential cash flows. In this case, the option-adjusted spread is equal to the number of percentage points that the short interest rate tree must be shifted to match the discounted cash flows to the bond's price.

ASSET_SWAP_SPREAD: Number of percentage points that investors receive when subscribing to an interest rate swap in which they exchange the coupons of the bond against a variable LIBOR interest payment as remuneration for the risky proportion of the bond cash flows.

COUPON_RATE: Interest rate paid on a bond as a percentage of the issuing amount (par value).

DURATION: Average maturity of a bond's cash flows.

OFFERING_AMOUNT: Logarithm of dollar amount of bond issuing outstanding.

CALLABILITY: Indicator variable equal to 1 if the bond is callable. A callable bond gives the issuer the right to early redemption at a given price (redemption price) or a given date (call date).

FUNGIBILITY: Indicator variable equal to 1 if the bond is fungible. Fungible bonds can be "reopened" in the future by increasing the total amount outstanding of the issue.

CREDIT_ENHANCEMENT: Indicator variable equal to 1 if the bond has credit enhancements (e.g., guarantees, letters of credit, and so forth).

BOND_AGE: Number of years since the bond issuing date.

NEWLY_ISSUED_BOND: Indicator variable equal to 1 if a bond-month is within the first 3 months after the bond issuance.

ON_THE_RUN_INDICATORS: Four indicator variables equal to 1 if a bond has an offering maturity of 5 years, 7 years, 10 years, and 30 years at the time of bond issuance, respectively.

BOND_RATING_FIXED_EFFECTS (ISSUE_LEVEL): Twenty-one credit rating indicators, each corresponding to the current month composite rating (simple averages of ratings from Moody's, S&P, and Fitch) from AAA to C. Investment grade bonds refer to the bonds with bond composite rating above or equal to BBB3. High-yield bonds refer to the bonds with the bond composite rating below BBB3. The detailed correspondence is given below, together with the sample percentage of each rating category.

CDS_PRESENCE: Indicator variable equal to 1 if the issuing firm has quoted CDS contracts on its bonds, and 0 otherwise.

NO_CDS_PRESENCE: Defined as 1-*"CDS presence."*

EQUITY_VOLATILITY: For each stock-month, the standard deviation of daily stock returns in the month.

Numeric	Composite	Moody's	S&P	Fitch	Sample Percentage %
		Investment Grade Bonds			
1	AAA	Aaa	AAA	AAA	2.08
2	AA1	Aa1	AA+	AA+	0.26
3	AA2	Aa2	AA	AA	1.69
4	AA3	Aa3	AA−	AA−	3.86
5	A1	A1	A+	A+	6.81
6	A2	A2	A	A	14.18
7	A3	A3	A−	A−	9.85
8	BBB1	Baa1	BBB+	BBB+	14.63
9	BBB2	Baa2	BBB	BBB	17.67
10	BBB3	Baa3	BBB−	BBB−	10.50
		High-Yield Bonds			
11	BB1	Ba1	BB+	BB+	4.25
12	BB2	Ba2	BB	BB	3.55
13	BB3	Ba3	BB−	BB−	3.12
14	B1	B1	B+	B+	2.29
15	B2	B2	B	B	1.77
16	B3	B3	B−	B−	1.77
17	CCC1	Caa1	CCC+	CCC+	0.92
18	CCC2	Caa2	CCC	CCC	0.45
19	CCC3	Caa3	CCC−	CCC−	0.17
20	CC	Ca	CC	CC	0.13
21	C	C	C	C	0.04

EQUITY_BETA: For each stock-month (i, t), we estimate the factor loadings by running the following regression:

$$r_{i,s} - r_{f,s} = a_{i,t-1} + \beta_{i,t-1}\left(r_{m,s} - r_{f,s}\right) + \varepsilon_{i,s},$$

where we use the previous 180 days as the estimation period, and we require a minimum of 90 observations for each regression. The dependent variable is the daily return of firm i at day s less the risk-free rate $r_{f,s}$. The independent variable is the excess return of market portfolio over the risk-free rate $(r_{m,s} - r_{f,s})$.

MARKET_VALUE_OF_ASSETS: Stock price (PRCC_F) × shares outstanding (CSHO) + short-term debt (DLC) + long-term debt (DLTT) + preferred stock liquidation value (PSTKL) – deferred taxes and investment tax credits (TXDITC).

MTB_RATIO: Market value of assets/book assets (AT).

BOOK_LEVERAGE: Total debt/market value of assets, where the total debt is long-term debt (DLTT) + short-term debt (DLC).

FIRM_SIZE: Log (book assets) (AT).

PROFITABILITY: Operating income before depreciation (OIBDP)/book assets (AT).

CASH_HOLDING: Cash and short-term investments (CHE)/book assets (AT).

DIVIDEND_PAYER: an indicator variable equal to 1 if the firm pays cash dividends in the year.

INDUSTRY_FIXED_EFFECTS: Fama–French 48-industry indicators.

Supplementary Material

To view supplementary material for this article, please visit http://doi.org/10.1017/S0022109023000844.

References

Acharya, V. V.; Y. Amihud; and S. Bharath. "Liquidity Risk of Corporate Bond Returns: Conditional Approach." *Journal of Financial Economics*, 110 (2013), 358–386.

Amiram, D.; W. H. Beaver; W. R. Landsman; and J. Zhao. "The Effects of Credit Default Swap Trading on Information Asymmetry in Syndicated Loans." *Journal of Financial Economics*, 126 (2017), 364–382.

Ashcraft, A. B., and J. A. C. Santos. "Has the CDS Market Lowered the Cost of Corporate Debt?" *Journal of Monetary Economics*, 564 (2009), 514–523.

Bao, J.; J. Pan; and J. Wang. "The Illiquidity of Corporate Bonds." *Journal of Finance*, 66 (2011), 911–946.

Bedendo, M.; L. Cathcartl; and L. El-Jahel. "Distressed Debt Restructuring in the Presence of Credit Default Swaps." *Journal of Money, Credit and Banking*, 48 (2016), 165–201.

Bernardo, A., and I. Welch. "Liquidity and Financial Market Runs." *Quarterly Journal of Economics*, 119 (2004), 135–158.

Bolton, P., and M. Oehmke. "Credit Default Swaps and the Empty Creditor Problem." *Review of Financial Studies*, 24 (2011), 2617–2655.

Campbell, J. Y., and G. B. Taksler. "Equity Volatility and Corporate Bond Yields." *Journal of Finance*, 58 (2003), 2321–2350.

Coval, J., and E. Stafford. "Asset Fire Sales (and Purchases) in Equity Markets." *Journal of Financial Economics*, 86 (2007), 479–512.

Culp, C. L.; Y. Nozawa; and P. Veronesi. "Option-Based Credit Spreads." *American Economic Review*, 108 (2018), 454–488.

Cummins, J. D.; R. D. Phillips; and S. D. Smith. "Derivatives and Corporate Risk Management: Participation and Volume Decisions in the Insurance Industry." *Journal of Risk and Insurance*, 68 (2001), 51–91.

Danis A., and A. Gamba. "The Real Effects of Credit Default Swaps." *Journal of Financial Economics*, 127 (2018), 51–76.

Das, S.; M. Kalimipalli; and S. Nayak. "Did CDS Contracts Improve the Market for Corporate Bonds?" *Journal of Financial Economics*, 111 (2014), 495–525.

Dick-Nielsen, J.; P. Feldhütter; and D. Lando. "Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis." *Journal of Financial Economics*, 103 (2012), 471–492.

Ellul, A.; C. Jotikasthira; and C. T. Lundblad. "Regulatory Pressure and Fire Sales in the Corporate Bond Market." *Journal of Financial Economics*, 101 (2011), 596–620.

Goyenko, R. Y.; C. W. Holden; and C. A. Trzcinka. "Do Liquidity Measures Measure Liquidity?" *Journal of Financial Economics*, 92 (2008), 153–181.

Hirtle, B. "Credit Derivatives and Bank Credit Supply." *Journal of Financial Intermediation*, 18 (2009), 125–150.

Hollander, S., and A. Verriest. "Bridging the Gap: The Design of Bank Loan Contracts and Distance." *Journal of Financial Economics*, 119 (2016), 399–419.

Jarrow, R. A. "The Economics of Credit Default Swaps." *Annual Review of Financial Economics*, 3 (2011), 235–257.

Knabb, D. R.; R. J. Rhome; and D. P. Brown. "Tropical Cyclone Report on Hurricane Katrina (23–30 August 2005)." Working Paper, National Hurricane Center (2005).

Loon, Y. C., and Z. K. Zhong. "The Impact of Central Clearing on Counterparty Risk, Liquidity, and Trading: Evidence from the Credit Default Swap Market." *Journal of Financial Economics*, 112 (2014), 91–115.

Markit. *The CDS Big Bang: Understanding the Changes to the Global CDS Contract and North American Conventions*. London: Markit Group Ltd, (2009).

Massa, M., and L. Zhang. "The Spillover Effects of Hurricane Katrina on Corporate Bonds and the Choice Between Bank and Bond Financing." *Journal of Financial and Quantitative Analysis*, 56 (2021), 885–913.

Nanda V.; W. Wu; and X. Zhou. "Investment Commonality Across Insurance Companies: Fire Sale Risk and Corporate Yield Spreads." *Journal of Financial and Quantitative Analysis*, 54 (2019), 2543–2574.

Narayanan, R., and C. Uzmanoglu. "Credit Default Swaps and Firm Value." *Journal of Financial and Quantitative Analysis*, 53 (2018), 1227–1259.

National Association of Insurance Commissioners. *Capital Markets Special Report 110715*. Kansas City, MO: The Center for Insurance and Policy (2007).

Packer, F., and H. Zhu. "Contractual Terms and CDS Pricing." *BIS Quarterly Review*, 1 (2005), 89–100.

Parlour, C. A., and A. Winton. "Laying Off Credit Risk: Loan Sales Versus Credit Default Swaps." *Journal of Financial Economics*, 107 (2013), 25–45.

Purnanandam, A. "Originate-to-Distribute Model and the Subprime Mortgage Crisis." *Review of Financial Studies*, 24 (2011), 1881–1915.
Qiu, J., and F. Yu. "Endogenous Liquidity in Credit Derivatives." *Journal of Financial Economics*, 103 (2012), 611–631.
Saretto, A., and H. Tookes. "Corporate Leverage, Debt Maturity, and Credit Default Swaps: The Role of Credit Supply." *Review of Financial Studies*, 26 (2013), 1190–1247.
Schaefer, S., and I. Strebulaev. "Structural Models of Credit Risk are Useful: Evidence from Hedge Ratios on Corporate Bonds." *Journal of Financial Economics*, 90 (2008), 1–19.
Shleifer, A., and R. W. Vishny. "The Limits of Arbitrage." *Journal of Finance*, 52 (1997), 35–55.
Shleifer, A., and R. W. Vishny. "Fire Sales in Finance and Macroeconomics." *Journal of Economic Perspectives*, 25 (2011), 29–48.
Staiger, D., and J. Stock. "Instrumental Variables Regression with Weak Instruments." *Econometrica*, 65 (1997), 557–586.
Stulz, R. M. "Credit Default Swaps and the Credit Crisis." *Journal of Economic Perspectives*, 24 (2010), 73–92.
Subrahmanyam, M.; D. Y. Tang; and S. Q. Wang. "Does the Tail Wag the Dog? The Effect of Credit Default Swaps on Credit Risk." *Review of Financial Studies*, 27 (2014), 2927–2960.
Subrahmanyam, M.; D. Y. Tang; and S. Q. Wang. "Credit Default Swaps, Exacting Creditors and Corporate Liquidity Management." *Journal of Financial Economics*, 124 (2017), 395–414.
Thompson, J. "Counterparty Risk in Financial Contracts: Should the Insured Worry About the Insurer." *Quarterly Journal of Economics*, 125 (2010), 1195–1252.
Towers Perrin Corporation. "Hurricane Katrina: Analysis of the Impact on the Insurance Industry." Towers Perrin (2005), 1–35.
Wang X.; Y. Wu; H. Yan; and Z. Zhong. "Funding Liquidity Shocks in A Quasi-Experiment: Evidence from the CDS Big Bang." *Journal of Financial Economics*, 139 (2021), 545–560.
Wooldridge, J. M. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: The MIT Press (2001).