Dissecting Bond Volatility[†]

Jie Cao, Tarun Chordia, and Linyu Zhou

Abstract

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	Cao	**Chordia**	**Zhou**
Voice:	852-3943-7757	1-404-727-1620	852-3943-7437
Fax:	852-2603-6586	1-404-727-5238	852-2603-6586
E-mail:	jiecao@cuhk.edu.hk	Tarun.Chordia@emory.edu	lyzhou@link.cuhk.edu.hk
Address:	Department of Finance Chinese University of Hong Kong Hong Kong	Goizueta Business School Emory University Atlanta, GA 30322	Department of Finance Chinese University of Hong Kong Hong Kong

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Abstract

This paper documents a positive cross-sectional relation between returns and lagged idiosyncratic volatility (IVOL) in the corporate bond market. The relation is stronger following periods of low funding liquidity due to a funding liquidity driven decrease in returns and its subsequent reversal. Three exogenous shocks – (i) the Volcker Rule which restricted the participation of dealers in the corporate bond market in 2014, (ii) the Global Financial Crisis of 2008, and (iii) the COVID-19 crisis of 2020, are used to establish causality between funding liquidity and the positive IVOL-return relation.

Keywords: Corporate bonds, idiosyncratic volatility, financial intermediaries, Volcker Rule, COVID-19

JEL Classifications: G10, G11, G12, E44

1. Introduction

The relation between return and volatility has been extensively studied. The Intertemporal Capital Asset Pricing Model (ICAPM) of Merton (1973) suggests a positive relation between the conditional expected excess return and the conditional variance in market portfolios. The evidence is, however, mixed.[1] In the cross-section, Ang, Hodrick, Xing, and Zhang (2006) show that stocks with high sensitivity to innovations in market volatility have low returns. More surprising is the cross-sectional relation between idiosyncratic volatility (IVOL) and returns.

In a world with rational, homogenously informed, mean-variance agents, the Capital Asset Pricing Model (CAPM) of Sharpe (1964), Lintner (1965), and Mossin (1966) says that the only risk that is priced is the covariance between an asset's return and that of the market. On the other hand, Levy (1978), Tinic and West (1986), and Merton (1987) derive a positive relation between IVOL and expected returns when investors hold under-diversified portfolios. While the evidence is, once again mixed,[2] a majority of studies report a negative IVOL-return relation. The negative IVOL-return relation is inconsistent with theory and is considered a puzzle, viz., the IVOL puzzle.

While there is a vast literature investigating the IVOL puzzle in stocks, the topic has been relatively under-explored in corporate bonds even though the size of the US corporate bond market is non-trivial and the issuance of corporate bonds is at a much larger scale. On one hand, given that stocks and bonds are contingent claims on cash flows for the same firm, bond returns, like those of stocks, should also be impacted by IVOL. On the other hand, bonds and stocks are

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[1] French, Schwert, and Stambaugh (1987), Campbell and Hentschel (1992), Ghysels, Santa-Clara, and Valkanov (2005), and Lundblad (2007) document a positive relation while Nelson (1991) and Glosten, Jagannathan, and Runkle (1993) report a negative relation between the conditional expected returns and the market. Yu and Yuan (2011) find a positive relation during low sentiment periods only. Chan, Karolyi, and Stulz (1992) find no relation.

[2] Fama and MacBeth (1973), Bali, and Cakici (2008), Huang, Liu, Rhee, and Zhang (2010), and Bali, Cakici, and Whitelaw (2011) find no relation between IVOL and stock returns. Fu (2009) finds a positive relation. Others including Ang, Hodrick, Xing, and Zhang (2006, 2009), Guo and Savickas (2010), and Jiang, Xu, and Yao (2009) report a negative IVOL-return relation not only in the US stock market, but also in international markets.

different in many respects including risk characteristics, contractual stipulations, and investment clientele. Hence, bond returns may react differently to IVOL than stock returns or they may not react at all.

Chung, Wang, and Wu (2019) report that bond IVOL is positively priced in the cross-section. However, Bai, Bali, and Wen (2021) find that IVOL defined with respect to their bond factors (Bai, Bali, and Wen (BBW, 2019)) has no significant explanatory power for future bond returns after controlling for systematic risk. In this paper, we investigate the conditional relation between corporate bond returns and lagged IVOL. We follow Chung, Wang, and Wu (2019) to define bond IVOL as the residual volatility in rolling regressions of daily bond excess returns on Fama and French (FF, 1993) five factors plus ΔVIX over past 6-month with the sample from 2002 to 2019 and confirm the positive relation between IVOL and expected returns. The IVOL-return relation is robust to factor adjusted returns using the FF factors or the BBW factors.

Funding liquidity impacts the IVOL-return relation. We condition on funding liquidity which is proxied by the intermediary capital ratio (ICR) of He, Kelly, and Manela (2017). More specifically, we condition on funding illiquidity defined as (1-ICR). A low intermediary capital ratio, high (1-ICR), indicates high marginal value of wealth and low funding capacity for intermediation and, hence, high funding illiquidity. The interaction term IVOL*(1-ICR) is positively related to next month return suggesting that the IVOL-return relation is stronger in the presence of funding illiquidity. The reason for this positive impact of lagged IVOL on returns following periods of high funding illiquidity is as follows. During periods of high funding illiquidity high IVOL bonds earn lower returns which are then reversed in the subsequent period.

To establish causality, we conduct three separate tests based on three separate exogenous shocks for identification, (i) the implementation of the Volcker Rule in 2014, (ii) the Global

Financial Crisis (GFC) in 2008, and (iii) the COVID-19 (COVID) crisis in 2020. We now discuss each in turn.

The Volcker Rule, which was implemented as of April 1, 2014, prohibits banks from using their own accounts for short term proprietary trading. This reduced the market making activities of banks and led to a deterioration in intermediary funding liquidity (Bao, O'Hara, and Zhou (2018); Wang, Zhang, and Zhang (2020)). Hence, we expect the impact of funding illiquidity on the IVOL-return relation to be stronger after the Rule and this is precisely what we see. The positive IVOL-return relation is strengthened following periods of low funding liquidity after the implementation of the Volcker Rule.

Next, we examine the cross-sectional impact of funding liquidity on corporate bonds. Specifically, we examine the IVOL-return relation around downgrades from investment grade (IG) to non-investment grade (NIG). The IG to NIG downgrade triggers widespread selling pressure from insurance companies who face capital constraints in terms of the funds that can be allocated to NIG bonds (Ambrose, Cai, and Helwege (2008); Ellul, Jotikasthira, and Lundblad (2011); Nanda, Wu, and Zhou (2019)). The IVOL-return effect is indeed stronger for the IG to NIG downgraded bonds after the implementation of the Volcker Rule.

The GFC of 2008 and the COVID of 2020 provide us a laboratory for two additional difference-in-differences tests. When funding liquidity is constrained during both crises, high IVOL bonds earn lower returns. Subsequently, when the Federal Reserve loosens monetary policy, the high IVOL bonds rebound and earn higher returns. The results from both exogenous shocks provide causal evidence of a positive IVOL-return relation following periods of low funding liquidity.

Overall, we provide robust evidence that, unlike in the case of stocks, lagged corporate bond IVOL is positively related to excess and risk-adjusted returns, especially following periods of low funding liquidity. Three exogenous shocks provide identification for the claim that low funding liquidity causes an initial contemporaneous decline in high IVOL bond returns followed by a subsequent reversal.

Finally, we reconcile our findings with those in Bai, Bali, and Wen (2021) who find no significant impact of lagged bond IVOL on returns once systematic volatility is controlled for. It is the methodology used to compute IVOL that gives rise to the different results while the factor model used has no impact. The frequency of returns at which IVOL is computed, daily versus monthly, is what matters. The IVOL series is too smooth due to a slowly evolving IVOL when estimated using past monthly as opposed to daily bond return data.

2. Data and Variables

This section introduces the data and key variables used in the empirical analyses.

2.1. Corporate bond data

Corporate bond data is obtained from the enhanced Trade Reporting and Compliance Engine (TRACE) database.[3] Enhanced TRACE includes more transactions than the standard TRACE database in disseminating both sides of the inter-dealer trade. Besides, enhanced TRACE reports the actual trade which is more accurate than the capped value in the standard database (Bessembinder, Maxwell, and Venkataraman (2006)). We match the enhanced TRACE with the

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[3] The National Association of Insurance Commissioners (NAIC) database also includes daily prices, but it covers only a part of the market with fewer observations and transactions only by the buy-and-hold insurance companies. We focus on the TRACE data.

Mergent FISD database using the complete 9-digit CUSIP. The FISD database contains bond issue- and issuer-specific information, such as coupon rate, interest payment frequency, issue date, maturity date, issue size, and bond rating. The sample period is from July 2002 to December 2019.

First, we clean the data following the procedure in Dick-Nielsen (2014) to minimize data reporting errors by removing all transactions marked as cancellations, corrections, and reversals, as well as their matched original trades. Agency transactions that may raise concerns of double counting are also deleted. Following Bai, Bali, and Wen (2019), we apply several more filters to remove bonds that (i) are not listed or traded in the US public market; (ii) are structured notes, mortgage-backed, asset-backed, agency-backed, or equity-linked securities; (iii) are convertible; (iv) trade under \$5 or above \$1,000; (v) have a floater or odd frequency of coupon payments; and (vi) have less than one year to maturity. We eliminate bond transactions that (vii) are labeled as when-issued, locked-in, or have special sales conditions; (viii) are recorded as having a settlement period of more than two days; and (ix) have a trading volume less than \$10,000.

Following Bessembinder, Kahle, Maxwell, and Xu (2009), we compute bond daily prices as the trading volume-weighted average of intraday prices to minimize the effect of bid-ask spreads in prices and reflect bond prices more accurately. For bond returns on any day t, we need the bond to trade on day t as well as on day $t-1$. To obtain monthly bond returns, we use the last observation during the last five trading days of each month as bond's month-end price. If there is no observation during the last five trading days, the month-end bond price is set to be missing.

The raw daily or monthly return at time t for an individual corporate bond i is

$$r_{i,t} = \frac{P_{i,t} + AI_{i,t} + C_{i,t}}{P_{i,t-1} + AI_{i,t-1}} - 1 \tag{1}$$

where $P_{i,t}$ is either the daily or the month-end price for day or month t and $P_{i,t-1}$ is the previous day's or month's price. $AI_{i,t}$ is the accrued interest and $C_{i,t}$ is the coupon payment, if any, from the end of month or day $t-1$ to the end of month or day t.[4] Bond i's excess return at month t is, $R_{i,t} = r_{i,t} - r_{f,t}$, where $r_{f,t}$ is the risk-free rate proxied by one-month Treasury bill rate.

2.2. Bond idiosyncratic / systematic volatility (IVOL/ SVOL) and bond characteristics

Following Chung, Wang, and Wu (2019), we use the past 6-month daily returns and estimate the sample total variance of bond i in month t as:

$$\sigma_{i,t}^2 = \frac{1}{n-1}\sum_{t=1}^{n}\left(R_{i,t} - \overline{R_\iota}\right)^2 \quad (2)$$

where R_{it} is bond i's daily excess return in month t. $\overline{R_\iota} = \frac{1}{n}\sum_{t=1}^{n} R_{i,t}$ is the sample average of daily excess returns over the past six months. Idiosyncratic volatility (IVOL) for bond i in month t is the standard deviation of return residuals $\epsilon_{i,t}$ from a time-series regression of daily excess returns on the Fama and French (1993) five factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX over the past six months,[5]

$$R_{it} = \alpha_i + \beta_{1,i}\, MKT_t + \beta_{2,i}\, SMB_t + \beta_{3,i}\, HML_t + \beta_{4,i}\, TERM_t + \beta_{5,i}\, DEF_t + \beta_{6,i}\, \Delta VIX_t + \epsilon_{i,t} \quad (3)$$

The systematic volatility (SVOL) for bond i is the standard deviation of predicted returns estimated using equation (3). A bond-month observation is included in the sample if it has at least 24 daily bond return observations in the past 6-month rolling window.

Bond characteristics are obtained from the Mergent FISD database. Rating is assigned a number corresponding to the symbol rating provided by Moody's and Standard & Poor's (S&P).[6]

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[4] Computing accrued interest requires the bond coupon size, coupon frequency, and day count convention. If the coupon frequency is missing, we assume it is semiannual. If the day count convention is missing, we assume it is 30/360.

[5] Daily TERM factor is the daily return difference between ICE BofA AAA US Corporate Index Total return and 1-month T-bill rate. Daily DEF factor is daily return difference between ICE BofA BBB US Corporate Index Total return and ICE BofA AAA US Corporate Index Total return at daily frequency retrieved from FRED. Other daily factors are retrieved from Ken French's website.

[6] Bond's rating is the average of ratings provided by S&P and Moody's when both are available or the rating provided by one of the two rating agencies when only one rating is available.

A numerical score of one refers to a rating of AAA rating by S&P and Aaa by Moody's while a score of 21 refers to C for both S&P and Moody's. Investment-grade bonds have scores lower than 10 while non-investment-grade (high-yield) bonds have ratings above 10. A larger number indicates lower rating and higher credit risk or lower credit quality. Bond illiquidity (ILLIQ) is the auto-covariance of bond daily log price change multiplied by -1 as defined in Bao, Pan, and Wang (2011). RET1 is the bond return in past 1-month. Bond momentum (MOM) is cumulative monthly return over past 6-month, skipping the most recent month. Maturity is the years to maturity. Age denotes years since issuance and Coupon is the coupon rate. Size is the logarithm of offering amount (in thousands) of the bond.

2.3. Descriptive statistics

After merging enhanced TRACE and Mergent FISD datasets, the final sample includes 1,108,893 bond-month observations for 41,012 bonds issued by 4,601 firms from July 2002 to December 2019. Panel A of Table 1 reports the time-series averages of the cross-sectional summary statistics, for monthly returns, bond IVOL, SVOL, and the bond characteristics. The average sample mean (median) excess return is 0.61% (0.38%) per month with a standard deviation of 4.51%. The average rating is 9.06 (equivalently, BBB for S&P or Baa for Moody's), time-to-maturity is 9.27 years, time-since-issuance is 4.30 years, and issue size is $312 million. Bond IVOL has a sample average of 1.12% with a standard deviation of 1.29%. Bond SVOL is generally lower than IVOL, with a sample average of 0.50% and standard deviation of 0.56%.

Panel B of Table 1 reports the average correlations of bond IVOL, SVOL and the characteristics. The bond IVOL and SVOL correlation is 0.82. Also, compared to IVOL, SVOL has lower correlations with bond characteristics like rating, coupon and bond size, consistent with its role as a measure of systematic risk. IVOL is moderately correlated with rating, ILLIQ, and coupon with correlations of 0.39, 0.57, and 0.30 respectively, indicating that bonds with the higher credit risk, lower liquidity, higher coupon rate have, on average, higher idiosyncratic volatilities. Size is negatively correlated with bond IVOL with a correlation of -0.43, indicating smaller bond IVOL for larger bonds.

3. The Impact of Funding Illiquidity on Bond IVOL-Return Relation

In this section, we first confirm the significantly positive cross-sectional relation between lagged IVOL and future bond returns documented by Chung, Wang, and Wu (2019). We then extend their findings by examining the conditional IVOL-return relation. We condition on a proxy for intermediary funding liquidity, under the rationale that trading is dominated by institutions in the corporate bond market and hence the capacity of financial intermediaries to provide liquidity may play an important role in the pricing of bond IVOL.

3.1. The replication of bond IVOL-return relation

In this section, we study the overall cross-sectional relation between bond IVOL and future returns. Each month, we sort the sample by IVOL into equal-weighted (EW) and value-weighted (VW) quintile portfolios. Quintile IVOL,1 (IVOL,5) consists of bonds with the lowest (highest) IVOL. IVOL,5-1 is the difference between the highest and lowest quintiles. The holding period is one month and the portfolios are rebalanced monthly. Panel A of Table 2 reports the average bond IVOL, monthly excess returns of EW and VW portfolios for each quintile and the difference between the highest and lowest quintiles. The average returns are in percent per month and Newey-West (1987) t-statistics with three lags are reported in parenthesis.

The average bond excess return for VW portfolios in quintile IVOL,1 is 0.23% per month, and it increases monotonically to 1.20% per month in quintile IVOL,5. Excess returns for EW and VW portfolios are essentially the same. The difference in the average monthly excess returns between the highest and lowest IVOL quintiles is a significant 97 basis points (bps) per month. Moreover, the significantly positive difference between the highest and lowest IVOL bonds is largely due to the bonds in the highest IVOL quintile. The last six columns report average bond characteristics, including the bond credit rating, age, maturity, illiquidity (ILLIQ), bond size and value-at-risk (VaR).[7] Age, maturity, and illiquidity increase monotonically while size decreases with IVOL, consistent with signs of the correlations in Panel B of Table 1. Bonds with higher IVOL on average have a worse rating and a more negative VaR, i.e., higher downside risk.

Since the bond characteristics vary with IVOL, we now run Fama-MacBeth regressions to examine the cross-sectional relation between IVOL and excess returns while controlling for the characteristics. Panel B of Table 2 reports the time-series averages of the slope coefficients (multiplied by 100), average adjusted-R^2, and the total number of bond-month observations. The t-statistics are based on Newey-West standard errors with three lags. All independent variables are winsorized at the 0.5% level and standardized by the cross-sectional standard deviation each month, so that the regression coefficients can be interpreted as the premiums per unit of standard deviation. Besides excess returns, we follow Brennan, Chordia, and Subrahmanyam (1998) to construct two additional risk-adjusted returns as dependent variables. Monthly bond returns are risk adjusted using the Fama and French (FF, 1993) five factors as well as the Bai, Bali, and Wen (BBW, 2019)

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[7] We follow Bai, Bali, and Wen (2019) to define (VaR) as the second lowest monthly return over the past 36 months as a measure of a bond's downside risk.

four factors. The methodology is described in detail in the appendix.[8]

In addition to the above bond characteristics, bond rating, illiquidity, maturity, age, coupon and bond size, we also control for lagged one-month bond returns (RET1) given the evidence of short-term reversals (Bali, Subrahmanyam, and Wen (2021)) and bond momentum (MOM) over past 6-month skipping the most recent month (Jostova, Nikolova, Philipov, and Stahel (2013)).[9] We also include a bond's systematic volatility (SVOL) as an additional control. We will use these bond-level variables as controls through the rest of the paper. IVOL is significantly and positively related to the next month excess and risk-adjusted returns. For instance, in column (2), a one standard deviation increase in IVOL is associated with an increase of 22 bps per month (2.64% per year) in the next month excess returns, even after controlling for SVOL. In columns (4) and (6), the increase in the monthly risk-adjusted returns amounts to 20 and 21 bps when the risk adjustment is done using the FF and the BBW factors, respectively.

Overall, the results in Table 2 confirm the finding in Chung, Wang, and Wu (2019) that bond IVOL is positively priced in the cross-section of corporate bond returns.

3.2. The impact of intermediary funding illiquidity on bond IVOL-return relation

Given the fact that institutions dominate the bond market, there is a burgeoning literature highlighting the importance of funding liquidity in the pricing kernel in explaining the pricing behavior of financial assets, including derivatives and OTC assets (He and Krishnamurthy (2012, 2013); Brunnermeier and Sannikov (2014); Siriwardane (2015)).[10] As a measure of funding

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[8] This approach to use risk-adjusted returns as dependent variables avoids the errors-in-variables bias in estimated coefficients created by errors in estimating factor loadings, since errors in the factor loadings are impounded in the dependent variable.

[9] Including VaR (5%) in the Fama-MacBeth regressions leads to a substantial reduction in the number of observations but does not qualitatively change the results, so we present the results without VaR.

[10] Insurance companies, mutual funds and ETFs in total hold 44% of the outstanding corporate bonds as of 2018. See https://www.statista.com/statistics/1083823/ownership-us-corporate-bonds.

liquidity, we will use the intermediary capital ratio (ICR) of He, Kelly, and Manela (2017).[11] ICR is the aggregated market value of equity of primary dealers divided by the sum of their aggregated market value of equity and book value of debt. Higher the ICR, larger is the capacity of financial intermediaries to bear risks, and better is the funding liquidity for aggregate intermediation.

To study the conditional IVOL-return relation, we run panel regressions of next month returns on IVOL and SVOL interacted with (1-ICR), which proxies for funding illiquidity. Dependent variables are excess return as well as the risk-adjusted returns using the Fama and French (FF, 1993) five-factor model and Bai, Bali, and Wen (BBW, 2019) four-factor model. We use the same set of controls as in Panel B of Table 2. To avoid the impact of outliers, we winsorize all the independent variables each month at the 0.5% and 99.5% levels. We provide results with and without fixed effects. We include time fixed effects and either firm or bond fixed effects. Table 3 presents the results. Standard errors are clustered by bond and time, and t-statistics are reported in parenthesis.

The coefficient estimates on the interaction term IVOL*(1-ICR) are significantly positive through all the specifications (using excess or risk-adjusted returns, and with or without the fixed effects) pointing to a positive IVOL-return relation in the corporate bond market when (1-ICR) is high, i.e., when the ICR is low or when funding liquidity is low. In economic terms, a one standard deviation increase in IVOL*(1-ICR) is related to an increase in the next month risk-adjusted return with BBW factors of 23.88% in column (12). While this may seem high, note that the coefficient on IVOL is -18.099 which translates to a return impact of -23.35% for a one standard deviation increase in IVOL. During periods of low funding liquidity, financial intermediaries (primary

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[11] He, Kelly, and Manela (2017) argue that their measure of funding liquidity is better than the broker-dealer leverage (BDL) of Adrian, Erkko, and Muir (2014) as the ICR is consistent with the empirical finding of the countercyclicality of leverage of financial intermediaries while the procyclicality of BDL is not. Moreover, ICR captures pricing in a larger group of assets, including options, CDS, and FX markets where the BDL fails.

dealers) in aggregate are more cautious when allocating capital to bonds with high IVOL, leading to low prices of the high IVOL bonds. It is the reversal in prices following the low funding liquidity period that gives rise to the positive IVOL-return relation. We will provide more direct evidence for the return reversal later when we use exogenous shocks to funding liquidity for identification.

The coefficient estimate on IVOL is significantly negative, indicating that the IVOL-return relation is negative after controlling for the interaction of IVOL with funding liquidity. Thus, upon controlling for the conditional impact of funding liquidity, high IVOL bonds have lower future returns, suggesting that it is the impact of funding liquidity that drives the positive IVOL-return relation in Chung, Wang, and Wu (2019). The coefficient estimates of SVOL and the interaction term SVOL*(1-ICR) are generally insignificant, suggesting that systematic volatility in the corporate bond market is not priced either unconditionally (see also Panel B of Table 2) or when conditioned on funding liquidity.

3.3. Robustness tests

We check for robustness with alternative definitions of IVOL and funding illiquidity. We replicate the tests in Table 3 with an alternative measure of IVOL estimated from daily returns over the past 36-month rolling window. While a longer time series allows for more precise estimates, it also contains information from a longer history that may be outdated and, thus, less relevant to the current IVOL-return relation. The IVOL estimated over the past 36-month daily returns has an average of 1.48% and a standard deviation of 1.87%, both larger than the IVOL measure obtained using the past 6-month daily returns. Panel A in the internet appendix Table A1 shows that the coefficients on IVOL*(1-ICR) are positive and significant at the 5% level across all specifications, thus, confirming the positive impact of funding illiquidity on the cross-sectional relationship between IVOL and bond returns.

Next, we check for robustness using a different proxy for funding illiquidity, specifically the CBOE volatility index VIX.[12] VIX is obtained from the prices of S&P 500 index options and is a real-time market index representing the market's expectations of volatility over the next 30 days. A higher VIX implies that volatility is expected to be high and it becomes riskier for intermediaries to provide liquidity, especially for high IVOL bonds. Panel B of Table A1 documents results that are qualitatively the same as in Table 3. The positive coefficient on the interaction term IVOL*VIX suggests that following high (low) VIX, bonds with high IVOL have higher (lower) expected excess and risk-adjusted returns.

Overall, the positive IVOL-return relation is robust conditional on funding illiquidity.

4. The IVOL-Return Relation Around the Volcker Rule

In this section, we rely on the exogenous implementation of the Volcker Rule on April 1, 2014 to provide further support to the positive bond IVOL-return relation when conditioned on funding liquidity. The Volcker Rule is a federal regulation that was enacted to prevent future banking excesses such as those that led to the financial crisis of 2008. The goal was to prevent banking entities with access to the discount window at the Federal Reserve or to FDIC insurance from engaging in risky proprietary trading including investing in hedge funds or private equity. Affected dealers can still trade securities to facilitate client-driven transactions, but they cannot transact in a way intended to make profits based on the price appreciation of securities. The regulation requires the establishment of an internal compliance program and the reporting of seven metrics: (i) risk and position limits and usage, (ii) risk factor sensitivities, (iii) value at risk (VaR) and stress

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[12] Jiang, Li, Sun, and Wang (2021) use the VIX as the proxy for financial market stress. Goldstein et al. (2017) and Jiang et al. (2020) stress the importance of VIX in the corporate bond market.

VaR, (iv) comprehensive profit and loss, (v) inventory turnover, (vi) inventory aging, and (vii) customer facing trade ratio. Dealers are disincentivized from taking large order imbalances that cannot be easily unwound, as these order imbalances could have potential effects of distorting the reported metrics.

Duffie (2012) has argued that bank specific regulations enacted in the wake of the financial crisis, such as the Volcker Rule, could reduce the ability or willingness of bank-affiliated dealers to provide liquidity. In our context, the over-the-counter nature of the corporate bond market makes it heavily reliant on dealer intermediation to provide liquidity. Bao, O'Hara, and Zhou (2018) show that the Volcker Rule has had a deleterious effect on corporate bond liquidity as dealers subject to the Rule become less willing to provide liquidity during periods of stress. Further, any additional liquidity provided by the non-Volcker-affected dealers is insufficient to offset the drop by Volcker-affected dealers who are the main liquidity providers.

4.1. Before versus after the Volcker Rule

We now use the Volcker Rule to provide support to the conditional bond IVOL-return relation. A large impact of ICR on the cross-sectional bond IVOL-return relation after the implementation of the Volcker Rule can lend strong support to the role of the aggregate funding liquidity in explaining the bond IVOL-return relation. We interact the two-way interaction term IVOL*(1-ICR) with a time dummy (POST) which equals 1 for the three year period after and 0 for the three year period before the implementation of the Volcker Rule.[13] Table 4 presents the results from regressing the

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[13] Li (2021) argues that the provision of liquidity by mutual funds in recent years alleviates the impact of the Volcker Rule and the reliance on dealers to intermediate the trades has decreased over time. Since the provision of liquidity is likely to be more limited in early years, we narrow the test sample to a period of three years before and three years after the implementation of the Volcker Rule.

next one-month excess and risk-adjusted returns on bond IVOL, bond SVOL, (1-ICR), POST and their interactions.

The triple interaction terms IVOL*(1-ICR)*POST and SVOL*(1-ICR)*POST are both significantly positive suggesting that after the implementation of the Volcker Rule, when the aggregate intermediary funding liquidity is low, the provision of liquidity for bonds with high total volatility is constrained. This leads to the higher returns after periods of low funding liquidity. The marginal impact of the aggregate intermediary funding liquidity on the bond IVOL-return relation is non-existent before the implementation of the Volcker Rule as evidenced by the insignificant coefficients on the double interaction term IVOL*(1-ICR). The negative coefficients on IVOL*POST and on SVOL*POST suggest that even in the post-Volcker period, if the funding liquidity is not constrained, investors do not require a premium for the high volatility bonds. Thus, the aggregate intermediation funding capacity is an essential component of the IVOL-return relation.[14]

4.2. The cross-sectional variation in the demand for funding liquidity

To establish causality, we now conduct a difference-in-differences test that exploits the cross-sectional demand for liquidity following downgrades from investment grade (IG) to non-investment grade (NIG). Institutions are often restricted, by regulation, private investment mandates, asset management policies, or regulatory capital requirements, from investing in NIG bonds. For instance, insurance companies are often constrained by regulations prohibiting large investments in NIG bonds and are forced to sell upon an IG to NIG downgrade. Hence, an IG to NIG downgrade results in selling pressure and a demand for liquidity. Ellul, Jotikasthira, and

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[14] The internet appendix Table A2 presents results from the same tests but with VIX as the alternative proxy for funding illiquidity. The coefficient estimates on IVOL*VIX*POST are positive, albeit insignificantly so.

Lundblad (2011) document that the severity of price declines around bond downgrades is indeed significantly larger when fire sales are more likely to happen during periods of broad industry distress and limited presence of buyers. Dealers are unlikely to step up to take the opposite side of fire sales as a large inventory of bonds with high IVOL increases total portfolio risk, which could bring additional regulatory scrutiny, especially post-Volcker. Other investors also do not buy and the forced selling generates significant downward price pressure.[15]

Applied to our setting, we expect that post-Volcker, when the aggregate intermediary funding liquidity provision is more circumscribed, the high IVOL bonds that experience downgrades from IG to NIG and are sold by institutions, such as insurance companies, would experience large price decreases in the downgrade month. These price declines would be reversed as funding liquidity improves.

Data on historical rating changes by major rating agencies are obtained from the Mergent Fixed Income Securities Database (FISD). Several rating agencies, including Standard & Poor's, Moody's, Fitch, and Duff & Phelps, provide credit ratings for each bond. Rating agencies differ with respect to the timing of the rating. We follow Ellul, Jotikasthira, and Lundblad (2011) to define the rating change event as the date of first downgrade from IG to NIG by a rating agency. In the three years before and three years after the implementation of the Volcker Rule, there are 468 bonds issued by 150 firms that experience an IG to NIG downgrade. We define a downgrade dummy variable (DG) for a given month which equals 1 if the bond experiences an IG to NIG downgrade in that month and 0 if there is no IG to NIG downgrade in that month.

Panel A (B) of Table 5 presents results from the panel regressions of the next one-month (two-month cumulative) returns on bond IVOL, bond SVOL, interacted with the downgrade

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[15] Wang, Zhang, and Zhang (2020) show that mutual funds significantly reduced the average net purchases of fire-sale bonds during quarters with downgrades following regulatory changes after the 2008–2009 financial crisis.

dummy (DG) and the post-Volcker Rule dummy (POST). The rationale for using the next two-month cumulative returns as regressands comes from Avramov et al. (2013) who show that the impact of a downgrade lasts for more than a month. The coefficient estimates on IVOL*DG*POST are positive across the board in both panels and significantly so, mainly in Panel B with a two-month cumulative return as a dependent variable. When firm and time fixed effects are used in the panel regressions along with the controls, a one standard deviation increase in IVOL*DG*POST results in 10.8 (10.6) basis points higher risk-adjusted return over the next two months, if the risk-adjustment is done with the FF (BBW) factors. Thus, the IG to NIG downgrade triggers forced sales that leads to a decline in prices for the high IVOL bonds and the subsequent reversals. This difference-in-differences result for the downgraded high IVOL bonds in the post-Volcker period provides causal evidence for the conditional impact of funding liquidity on the cross-sectional IVOL-return relation.

Since downgrades are not random events, one concern about the price pressure caused by the downgrade is that high IVOL bonds could be more likely to experience downgrades. If so, then it’s possible that the selling pressure is capturing some downside risks related to IVOL. We check this by investigating the effect of bond IVOL on the propensity of being downgraded from IG to NIG. We run Probit and OLS regressions with the downgrade dummy DG in the next month as the dependent variable. The OLS regressions include bond and time fixed effects. The independent variables are IVOL, SVOL and the bond characteristics including illiquidity, maturity, age, coupon and issue size. The sample period is from July 2002 to December 2019. The results are presented in the internet appendix Table A3.

The univariate Probit and OLS regressions show that high IVOL bonds are significantly more likely to be downgraded from IG to NIG. However, after controlling for bond SVOL, the predictability of IVOL for the next month downgrade becomes insignificant suggesting that the downgrades are not driven by IVOL but rather by systematic volatility. We can, thus, use downgrades as an exogeneous bond-level shock to funding liquidity, especially after the implementation of the Volcker Rule.

Overall, the results in this section show that both, the cross-sectional demand for and the time-series supply shocks to funding liquidity, impact the IVOL-return relation.

5. Causality Tests: the IVOL Effects at Times of Stress

While we have checked that the high IVOL bonds as compared to other bonds are not more likely to experience IG to NIG downgrades, the endogeneity concern cannot be fully allayed due to the possibility of an omitted variable. To provide a causal link between the intermediary funding liquidity and the IVOL-return relation, we investigate IVOL effects around two extreme shocks, specifically the global financial crisis in September 2008 and the COVID-19 crisis in March 2020. In both cases, due to a significant decline in asset prices, there was initially a negative shock to the aggregate intermediary capital followed by the expansionary Federal Reserve interventions that restored funding liquidity and quickly stabilized the market.

Given the short span of the crises, we switch to weekly panel regressions in this section to examine the price dynamics for bonds with different IVOL levels around the peak of the crisis and the following Federal Reserve (Fed) interventions. Dependent variables include weekly raw and abnormal returns computed as the raw return subtracted by the size-weighted average return of the pool of bonds sharing similar credit ratings and time to maturity in the same week (Cai, Han, Li, and Li (2019); Jiang, Li, Sun, and Wang (2021)). We expect bonds with high IVOL to experience extreme price declines during the crises followed by subsequent reversals due to improving funding liquidity after the Fed interventions.

5.1. The global financial crisis

There was the broad deterioration of liquidity in the corporate bond market around the global financial crisis in September 2008 around the Lehman bankruptcy (Dick-Nielsen, Feldhutter, and Lando (2012)). This meltdown of subprime mortgages raised concerns about the solvency and liquidity of financial institutions. Bessembinder et al. (2018) find that the dealer capital commitments declined during the financial crisis, especially for bank-affiliated dealers. Hence, the crisis period can be viewed as an abrupt exogenous shock to the intermediary funding liquidity in the corporate bond market.

The Fed began to ease monetary policy by lowering the interest rates to less than 0.25% and did not raise rates until December 2015. On October 8, 2008, the Federal Open Market Committee lowered its target for the federal funds rate by 50 basis points, from 2% from 1.5%. The Committee took this action, in light of evidence pointing to a weakening of economic activity and a reduction in inflationary pressures. The Fed's goal was to increase the amount of money available in the economy and spur economic growth. We expect to see return reversals in high IVOL bonds that were impacted by funding illiquidity during the crisis, prior to the interest rate reduction.

In Table 6, we investigate the IVOL-return relation around the 2008 financial crisis. In Panel A, we regress the contemporaneous weekly raw and abnormal returns (computed as the difference between raw returns and the size weighted average returns of bonds with the same rating and maturity buckets, following Cai, Han, Li, and Li (2019) and Jiang, Li, Sun, and Wang (2021)) on the most recent available bond IVOL and SVOL interacted with a dummy variable GFC which is one (zero) during the four weeks after (before) September 8, 2008. The crisis period starts on September 8, 2008, one week prior to the Lehman Brothers' bankruptcy on September 15, 2008, and the sample period spans from four weeks before to four weeks after the start of the crisis, i.e., August 11, 2008 to October 3, 2008. In Panel B, we regress the contemporaneous weekly raw and abnormal returns on IVOL (and SVOL) interacted with a dummy variable Rate_down which is one (zero) during the four weeks after (before) October 8, 2008. The sample period in this panel covers the four weeks before and four weeks after the decrease in the Fed funds rate, i.e., September 8, 2008 to October 31, 2008. IVOL and SVOL are computed as of the month-end prior to each week in Panels A and B. The control variables in both panels include the most recent available bond rating, bond illiquidity, lagged one-week bond return, maturity, age, coupon, and bond size. Standard errors are clustered at the bond level.

Panel A of Table 6 reports significantly negative coefficients on the interaction term IVOL*GFC with the contemporaneous weekly raw returns as the dependent variable, suggesting that bonds with high IVOL indeed tend to be particular vulnerable and suffer larger decreases in valuation during the four-week period after the start of the financial crisis. A one standard deviation increase in IVOL is associated with a drop in weekly raw return from its pre-crisis period by about 1.96% (1.29%×(-1.523)). When we use weekly abnormal return as the dependent variable, the coefficients on IVOL*GFC, while negative through column (6) to (8), remain significant only with the firm and time fixed effects. The economic significance is still large. A one standard deviation increase in IVOL would lead to a decrease of 0.93% (1.29%×(-0.722)) in the weekly abnormal return. The impact of SVOL is insignificant in all cases, consistent with the earlier finding that it is bonds with high idiosyncratic volatility rather than systematic volatility that are impacted by funding illiquidity.

The significantly positive coefficients on the interaction term of IVOL*Rate_down, in Panel B, point to the positive return reversals for the high IVOL bonds in periods after Fed's easing of monetary policy. In columns (4) and (8), after the decline in interest rates, a one standard deviation increase in IVOL is associated with an increase in weekly raw and abnormal return by about 2.25% (1.29%×(1.741)) and 1.79% (1.29%×(1.388)), respectively. The coefficients on SVOL*Rate_down, on the other hand, are negative suggesting that the decrease in interest rates causes the systematic volatility to be negatively related to returns.

Given that we focus on weekly regressions and that there may be a delay in the impact of the crisis and subsequent lower interest rates to fully show up, we provide results with raw and abnormal returns in next one-week (rather than during the contemporaneous week) as dependent variables in the internet appendix Table A4, with the same setting as in Table 6. The results remain robust.

Overall, there is robust evidence of the causal impact of funding liquidity on the IVOL-return relation. There is a decline in returns of the high IVOL bonds when funding liquidity deteriorates and a reversal in returns when liquidity improves.

5.2. COVID-19

Another large exogenous shock to liquidity especially in the corporate bond market is the COVID-19 crisis in March 2020. COVID-19 started with mounting concerns about the pandemic and quickly spiraled into a full-blown crisis within a couple of weeks with a surge in investors' exiting securities, especially the illiquid and risky ones. Jiang, Li, Sun, and Wang (2021) document the extraordinary price movements in the corporate bond market due to large sell order imbalances. O'Hara and Zhou (2021) provide evidence of increasing bond illiquidity in both investment and non-investment grade bonds. Transaction costs for block trades in IG bonds were only 24 bps in February 2020 but increased to more than 150 bps on March 23, 2020. Moreover, they show that dealers, particularly the non-primary dealers, shift from buying bonds to selling bonds, exacerbating market illiquidity and resulting in a cumulative negative $8 billion inventory position for the dealer community.

The Federal Reserve intervened with the announcement of the unprecedented secondary market corporate credit facility (SMCCF) on March 23, 2020, which aimed to improve liquidity by directly buying a substantial amount of corporate bonds in the secondary markets and rebalancing the order flow. This announcement effectively stabilized the corporate bond market within a couple of weeks (Boyarchenko, Kovner, and Shachar (2020); Kargar, Lester, Lindsay, Liu, Weill, and Zúñiga (2021); O'Hara and Zhou (2021)).[16] We expect bonds with high IVOL to see the most price declines during the early stages of the crisis and reverse later after the announcement of SMCCF.

The tests follow the setting in Table 6. The dummy variable COVID equals one for the four weeks after February 24, 2020 until March 20, 2020. The sample period spans from January 27, 2020 to March 20, 2020 for Panel A of Table 7, which includes the pre-COVID period of January 27 through February 24, 2020. Following Jiang, Li, Sun, and Wang (2021), in Panel B of Table 7, the SMCCF dummy equals one (zero) in the four weeks after (before) SMCCF announcement, and the sample period is from February 24, 2020 to April 17, 2020.

Panel A documents significant negative coefficients on the interaction term of IVOL*COVID, indicating large negative returns for bonds with high IVOL after the eruption of the COVID-19

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[16] Specifically, the Fed committed to buying eligible bonds that were required to have been investment-grade issues by US companies with a remaining maturity of five years or less.

crisis, before the SMCCF announcement. With time and bond fixed effects, a 1% increase in IVOL is accompanied with 1.37% and 1.33% decreases in weekly raw and abnormal return, respectively.

On the other hand, after the SMCCF announcement, dealers are more willing to offer liquidity in the bond market, and we expect to observe return reversals in bonds with high IVOL, which is confirmed in Panel B of Table 7. Coefficients on the interaction term IVOL*SMCCF are significantly positive, overall. Results with next one-week raw and abnormal returns as the dependent variables are provided in appendix Table A5 and are essentially unchanged.

In sum, bonds with high IVOL have significantly negative returns in several weeks during the global financial and the COVID-19 crises when the aggregate intermediary funding liquidity deteriorated. Later, due to the Fed interventions and the SMCCF announcement which significantly improved funding liquidity, the high IVOL bonds earned positive returns. Figure 1 shows the initial decline in returns of high IVOL bonds when funding liquidity is constrained (around week 0) and the subsequent reversal when the funding liquidity constraint is relaxed (around week 4) due to the easing of monetary policy by the Fed. These two exogenous shocks to the intermediary funding liquidity help us establish the causal effect of funding liquidity on cross-sectional IVOL-return relation in the corporate bond market.

6. Comparison to Bai, Bali, and Wen (2021)

In this section we reconcile our results with those of Bai, Bali, and Wen (2021) (henceforth BBW) who find no IVOL-return relation upon controlling for SVOL. The idea is that with institutions being the main participants in the corporate bond market they should be able to create well-diversified portfolios with little exposure to bond-specific risks. BBW use the past three year monthly returns to obtain IVOL with respect to their factors (Bai, Bali, and Wen (2019)).

There are differences in our computation of IVOL and those of BBW. Each month we compute IVOL using past six months of daily returns adjusted with respect to the daily Fama and French (1993) factors plus ΔVIX while BBW use past three years of monthly returns and adjust with respect to their monthly factors including the excess bond market return MKT_bond, the downside risk factor DRF, the credit risk factor CRF, and the liquidity risk factor LRF.[17] Thus, the components of the IVOL computation methodology differ with respect to the choice of (i) factor models, (ii) past six months versus past 36 months of returns, and (iii) daily versus monthly returns. In what follows, we change our computation methodology one component at a time to nail down the reasons for the differences in results in this paper and those in BBW.

The internet appendix Table A1 shows that the main results of the paper are robust to using past 36 months of daily returns as opposed to six months of daily returns when constructing bond IVOL. We then build the daily bond factors of BBW and in Panels A and B of Table 8 show that the results are robust to using the past 6-month and 36-month daily BBW factors, instead of the daily Fama and French (1993) factors plus ΔVIX. Finally, we use both sets of the monthly factors in Panels C and D of Table 8 to confirm the result in BBW of no IVOL-return relation. One reason could be the decrease in the sample size as we need bond data in at least 24 out of 36 months to be able to compute the IVOL using monthly data. Panel E of Table 8 shows that even if we restrict the sample to non-missing IVOL using monthly data (as in Panel C of Table 8) while computing IVOL using daily returns (as in Panel B of Table 8), we still find evidence of the significantly

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[17] A bond-month observation is included in the sample if there are at least 24 monthly return observations in the past 36-month rolling window. We thank the authors for providing these factors: https://drive.google.com/file/d/1U8lxEryuu3xF484x5Hh7Uaftpqd--ZCx/view.

positive IVOL-return relation following low funding liquidity. Thus, the frequency over which IVOL is computed (daily or monthly) plays a critical role in the IVOL-return relation.[18]

Support for using the daily returns to compute IVOL comes from Merton (1980) who has shown that second moments have lower estimation error when the data is sampled at high frequency. Further, the IVOL computed from daily returns is more volatile that that computed from monthly returns, as the return fluctuations are smoothed out at lower frequencies. The internet appendix Table A6 shows that the mean (median) IVOL computed using the past six months of daily BBW factors have a mean (median) of 4.45% (3.24%) with a standard deviation of 4.03%. When using the past 36 months of the daily BBW factors the mean (median) IVOL is 5.32% (4.04%) with a standard deviation of 4.56%. With monthly BBW factors the mean (median) IVOL is 2.40% (1.57%) with a standard deviation of 2.65%. Similar results obtain when using the Fama and French (1993) five factors plus ΔVIX to compute IVOL. Figure 2 shows the differences in IVOL over time when computed using different methods.

Overall, it is the frequency over which IVOL is measured that drives the differences in the results of this paper and those in BBW.

7. Conclusion

Unlike the extensive literature examining the cross-sectional relation between the idiosyncratic volatility (IVOL) and expected stock returns, there is very little work on the cross-sectional IVOL-return relation in the corporate bond market. Moreover, the findings are being debated in that Chung, Wang, and Wu (2019) find a positive bond IVOL-return relation while Bai, Bali, and Wen

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[18] Bali and Cakici (2008) find strong evidence that the data frequency used to calculate the idiosyncratic risk plays a critical role in determining the presence and significance of cross-sectional relation between IVOL and expected stock returns.

(2021) find none. In this paper, we not only reconcile the findings in the literature, but we also provide additional results about the conditional IVOL-return relation.

We document a positive IVOL-return relation that is causally impacted by funding liquidity. A decline in funding liquidity leads to price pressure that causes a decline in contemporaneous bond returns that is larger for the high IVOL bonds. The subsequent reversal results in the positive relation between bond IVOL and expected bond returns, which is the IVOL-return relation, we study. To establish the causality between funding liquidity and the IVOL-return relation, we rely on three exogenous shocks, (i) a decline in ratings from investment grade to non-investment grade following the implementation of the Volcker Rule, which constrained the ability of banks from providing liquidity, (ii) the Global Financial Crisis of 2008, and (iii) the COVID-19 crisis of 2020.

Overall, there is a positive IVOL-return relation in the corporate bond market, which is stronger following shocks that constrain funding liquidity.

Appendix

Variable Definitions

Bond Return Measures	
Excess return	Excess return is the difference between monthly raw return and risk-free rate proxied by one-month Treasury bill rate.
Risk-adjusted return using FF factors	Risk-adjusted return using FF factors is calculated following Brennan, Chordia, and Subrahmanyam (1998) as residuals from subtracting realizations of contemporaneous and one lag Fama and French (1993) factors, including MKT, SMB, HML, DEF and TERM, multiplied by corresponding full-period "post-ranking portfolio betas" estimated following Fama and French (1992), from monthly excess returns. To get the post-ranking portfolio betas, each month, we independently sort all bonds into 10×10 groups by bond size and maturity and get next one-month equal-weighted average excess returns for each group. With the time-series of monthly returns, we then run regressions of portfolio excess returns on contemporaneous and one lag factors in each group with the full sample data. Finally, portfolio betas are assigned to each bond in the same group. Hence, across time, factor loadings are the same for a certain portfolio but could vary for a certain bond.
Risk-adjusted return using BBW factors	Risk-adjusted return using BBW factors is calculated following Brennan, Chordia, and Subrahmanyam (1998) as residuals from subtracting realizations of contemporaneous and one lag Bai, Bali, and Wen (2019) factors, including MKT_bond, DRF, CRF, and LRF, multiplied by corresponding full-period "post-ranking portfolio betas" estimated following Fama and French (1992), from monthly excess returns. The factors are formed based on independently sorted bivariate portfolios of bond-level credit rating, value-at-risk, and illiquidity.
Weekly abnormal return	The weekly abnormal return is computed as the weekly raw return subtracted by the size-weighted average return of the pool of bonds that share similar credit ratings and time to maturity in the same week. Specifically, the credit rating buckets are AAA&AA, A, BBB, BB, B, C&D, and the maturity buckets are 1–5 years, 5–10 years, over ten years, respectively (Cai, Han, Li, and Li (2019); Jiang, Li, Sun, and Wang (2021)).
Bond Idiosyncratic and Systematic Volatilities	
IVOL	Individual bond's idiosyncratic volatility, following Chung, Wang, and Wu (2019), is defined as the standard deviation of return residuals estimated from time-series regressions of daily excess returns on Fama and French (1993) five factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX at daily frequency over past six months.
SVOL	Individual bond's systematic volatility is defined as the standard deviation of predicted returns estimated from time-series regressions of daily excess returns on Fama and French (1993) five factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX at daily frequency over past six months.
Control Variables	
Rating	Bond rating is the average of ratings provided by S&P and Moody's when both are available, or the rating provided by one of the two rating agencies when only one rating is available. Numerical score of one refers to AAA rating by S&P and Aaa rating by Moody's. Numerical score of 21 refers to C for both S&P and Moody's. Investment-grade bonds have ratings from 1 to 10. Non-investment-grade (high yield) bonds have ratings above 10. A larger number indicates higher credit risk or lower credit quality.

ILLIQ	Bond illiquidity (ILLIQ), following Bao, Pan, and Wang (2011), is the auto-covariance of bond daily log price change in each month multiplied by -1.
MOM	Bond momentum (MOM), following Jostova, Nikolova, Philipov, and Stahel (2013), is the cumulative monthly return in past six months, skipping the most recent month.
Maturity	Bond maturity is the years to maturity.
Age	Bond age is the years since issuance.
Coupon	Coupon is individual bond's coupon rate.
Size	Bond size is the logarithm of offering amount of individual bond.
VaR (5%)	5% Value-at-Risk (VaR) for individual bond, following Bai, Bali, and Wen (2019), is defined as the second lowest monthly return over the past 36 months.
RET1	Individual bond's raw return in the past one month.
Intermediary Funding Illiquidity Proxies	
ICR	The Intermediary Capital Ratio (ICR) is provided in He, Kelly, and Manela (2017). To construct this factor, they aggregate the balance sheets of the primary dealers' sector and calculate the capital ratio for the aggregated sector. Specifically, each quarter t, the (aggregate) value-weighted average of primary dealers' capital ratios is computed as $\eta_t = \sum_j Market\ Equity_{jt} \Big/ \sum_j (Market\ Equity_{jt} + Book\ Debt_{jt})$ where firm j is a New York Fed primary dealer designee during quarter t. Book value of debt is equal to total assets less common equity, with the most recent data available for each firm at the end of a calendar quarter. Market value of equity is share price times shares outstanding on the last trading day of the quarter. In the paper, we use ICR at the monthly frequency where the market equity is updated monthly with information from CRSP, together with the most recent quarterly book debt of holding companies in Compustat.
VIX	The CBOE Volatility Index (VIX) is a real-time market index representing the market's expectations for volatility over the coming 30 days, which is derived from the prices of S&P 500 index options with near-term expiration dates.

References

Adrian, Tobias, Erkko Etula, and Tyler Muir, 2014, Financial intermediaries and the cross-section of asset returns, *Journal of Finance* 69, 2557–2596.

Ambrose, Brent W., Nianyun Kelly Cai, and Jean Helwege, 2008, Forced selling of fallen angels, *Journal of Fixed Income* 18, 72–85.

Ang, Andrew, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang, 2006, The cross-section of volatility and expected returns, *Journal of Finance* 61, 259–299.

Ang, Andrew, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang, 2009, High idiosyncratic volatility and low returns: International and further US evidence, *Journal of Financial Economics* 91, 1–23.

Avramov, Doron, Tarun Chordia, Gergana Jostova and Alexander Philipov, 2013, Anomalies and financial distress, *Journal of Financial Economics* 108, 139-159.

Bai, Jennie, Tarun G. Bali, and Quan Wen, 2019, Common risk factors in the cross–section of corporate bond returns, *Journal of Financial Economics* 131, 619–642.

Bai, Jennie, Tarun G. Bali, and Quan Wen, 2021, Is there a risk-return tradeoff in the corporate bond market? Time-series and cross-sectional evidence, *Journal of Financial Economics*, forthcoming.

Bali, Turan G., and Nusret Cakici, 2008, Idiosyncratic volatility and the cross-section of expected returns, *Journal of Financial and Quantitative Analysis* 43, 29–58.

Bali, Turan G., Nusret Cakici, and Robert F. Whitelaw, 2011, Maxing out: stocks as lotteries and the cross-section of expected returns, *Journal of Financial Economics* 99, 427–446.

Bao, Jack, Jun, Pan, and Jiang, Wang, 2011, The illiquidity of corporate bonds, *Journal of Finance* 66, 911–946.

Bao, Jack, Maureen O'Hara, and Xing Alex Zhou, 2018, The Volcker Rule and corporate bond market making in times of stress, *Journal of Financial Economics* 130, 95–113.

Bali, Tarun G., Avanidhar Subrahmanyam, and Quan Wen, 2021, Long-term reversals in the corporate bond market, *Journal of Financial Economics* 139, 656–677.

Bessembinder, Hendrik, Kathleen M. Kahle, William F. Maxwell, and Danielle Xu, 2009, Measuring abnormal bond performance, *Review of Financial Studies* 22, 4219–4258.

Bessembinder, Hendrik, William F. Maxwell, and Kumar Venkataraman, 2006, Market transparency, liquidity externalities, and institutional trading costs in corporate bonds, *Journal of Financial Economics* 82, 251–288.

Bessembinder, Hendrik, Stacey Jacobsen, William Maxwell, and Kumar Venkataraman, 2018, Capital commitment and illiquidity in corporate bonds, *Journal of Finance* 73, 1615–1661.

Boyarchenko, Nina, Anna Kovner, and Or Shachar, 2020, It's what you say and what you buy: A holistic evaluation of the corporate credit facilities, Working Paper.

Brennan, Michael J., Tarun Chordia, and Avanidhar Subrahmanyam, 1998, Alternative factor specifications, security characteristics, and the cross-section of expected stock returns, *Journal of Financial Economics* 49, 345–373.

Brunnermeier, Markus. K., and Yuliy Sannikov, 2014, A macroeconomic model with a financial sector, *American Economic Review* 104, 379–421.

Cai Fang, Song Han, Dan Li, Yi Li, 2019, Institutional herding and its price impact: Evidence from the corporate bond market, *Journal of Financial Economics* 131, 139–167.

Campbell, J., and L. Hentschel, 1992, No news is good news: An asymmetric model of changing volatility in stock returns, *Journal of Financial Economics* 31, 281-318.

Chan, K. C., G. A. Karolyi, Rene M. Stulz, 1992, Global financial markets and the risk premium on U.S. equity, *Journal of Financial Economics* 32, 137-167.

Chung, Kee. H., Junbo Wang, and Chunchi Wu, 2019, Volatility and the cross-section of corporate bond returns, *Journal of Financial Economics* 133, 397–417.

Dick-Nielsen, Jens, 2014, How to clean enhanced TRACE data, Working Paper.

Dick-Nielsen, Jens, Peter Feldhütter, and David Lando, 2012, Corporate bond liquidity before and after the onset of the subprime crisis, *Journal of Financial Economics* 103, 471–492.

Duffie, Darrell, 2012, Market making under the proposed Volcker Rule, *Rock Center for Corporate Governance at Stanford University*, Working Paper.

Ellul, Andrew, Chotibhak Jotikasthira, and Christian T. Lundblad, 2011, Regulatory pressure and fire sales in the corporate bond market, *Journal of Financial Economics* 101, 596–620.

Fama, Eugene F., and Kenneth R. French, 1992, The cross-section of expected stock returns, *Journal of Financial Economics* 47, 427–465.

Fama, Eugene F., and Kenneth R. French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3–56.

Fama, Eugene F., and James D. MacBeth, 1973, Risk, return, and equilibrium: Empirical tests, *Journal of Political Economy* 81, 607–636.

French, Kenneth, W. Schwert, and R. Stambaugh, 1987, Expected stock returns and volatility, *Journal of Financial Economics* 19, 3–29.

Fu, Fangjian, 2009, Idiosyncratic risk and the cross–section of expected stock returns, *Journal of Financial Economics* 91, 24–37.

Ghysels, Eric, Pedro Santa-Clara, and Rossen Valkanov, 2005, There is a risk-return tradeoff after all, *Journal of Financial Economics* 76, 509–548.

Glosten, L., R. Jagannathan, and D.E. Runkle, 1993, On the relation between the expected value and the volatility of nominal excess returns on stocks, *Journal of Finance* 48, 1779–1801.

Goldstein, Itay, Hao Jiang, and David T. Ng, 2017, Investor flows and fragility in corporate bond funds, *Journal of Financial Economics* 126, 592–613.

Guo, Hui, and Robert Savickas, 2010, Relation between time-series and cross-sectional effects of idiosyncratic variance on stock returns, *Journal of Banking and Finance* 34, 1637–1649.

He, Zhiguo, and Arvind Krishnamurthy, 2012, A model of capital and crises, *Review of Economic Studies* 79, 735–777.

He, Zhiguo, and Arvind Krishnamurthy, 2013, Intermediary asset pricing, *American Economic Review* 103, 732–770.

He, Zhiguo, Bryan Kelly, and Asaf Manela, 2017, Intermediary asset pricing: New evidence from many asset classes, *Journal of Financial Economics* 126, 1–35.

Huang, Wei, Qianqiu Liu, S. Ghon Rhee, and Liang Zhang, 2010, Return reversals, idiosyncratic risk, and expected returns, *Review of Financial Studies* 23, 147–168.

Jiang, Hao, Dan Li, and Ashley Wang, 2020, Dynamic liquidity management by corporate bond mutual funds, *Journal of Financial and Quantitative Analysis* 55, 2613–2640.

Jiang, Hao, Yi Li, Zheng Sun, and Ashley Wang, 2021, Does mutual fund illiquidity introduce fragility into asset prices? Evidence from the corporate bond market, *Journal of Financial Economics*.

Jiang, George J., Danielle Xu, and Tong Yao, 2009, The information content of idiosyncratic volatility, *Journal of Financial and Quantitative Analysis* 44, 1–28.

Jostova, Gergana, Stanislava Nikolova, Alexander Philipov, and Christof W. Stahel, 2013, Momentum in corporate bond returns, *Review of Financial Studies* 26, 1649–1693.

Kargar, Mahyar, Benjamin Lester, David Lindsay, Shuo Liu, Pierre-Olivier Weill, and Diego Zúñiga, 2021, Coroprate bond liquidity during the COVID-19 crisis, *National Bureau of Economic Research*, Working Paper.

Levy, Haim, 1978, Equilibrium in an imperfect market: a constraint on the number of securities in the portfolio, *American Economic Review* 68, 643–658.

Li, Jian, 2021, The importance of investor heterogeneity: An examination of the corporate bond market, Working Paper.

Lintner, John, 1965, The valuation of risky assets and the selection of risky investments in stock portfolios and capital budgets, *Review of Economics and Statistics* 47, 13–37.

Lundblad, C. T., 2007, The risk return tradeoff in the long-run: 1836-2003, *Journal of Financial Economics* 85, 123-150.

Merton, Robert C., 1973, An intertemporal capital asset pricing model, *Econometrica, Journal of the Econometric Society*, 867–887.

Merton, Robert C., 1980, On estimating the expected return on the market: An exploratory investigation, *Journal of Financial Economics* 8, 323-361.

Merton, Robert C., 1987, A simple model of capital market equilibrium with incomplete information.

Mossin, Jan, 1966, Equilibrium in a capital asset market, *Econometrica* 34, 768–783.

Nanda, Vikram, Wei Wu, and Xing Alex Zhou, 2019, Investment commonality across insurance companies: Fire sale risk and corporate yield spreads, *Journal of Financial and Quantitative Analysis* 54, 2543–2574.

Nelson, D.B., 1991, Conditional heteroskedasticity in asset returns: a new approach, *Econometrica* 59, 347-370.

Newey, Whitney, and Kenneth D. West, 1987, A simple, positive semi–definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55, 703–708.

O’Hara, Maureen, and Xing Alex Zhou, 2021, Anatomy of a liquidity crisis: Corporate bonds in the COVID-19 crisis, *Journal of Financial Economics*.

Sharpe, William F., 1964, Capital asset prices: A theory of market equilibrium under conditions of risk, *Journal of Finance* 19, 425–442.

Siriwardane, Emil Nuwan, 2015, Concentrated capital losses and the pricing of corporate credit risk, *Harvard Business School*, Working Paper.

Tinic, Seha M., and Richard R. West, 1986, Risk, return, and equilibrium: A revisit, *Journal of Political Economy* 94, 126–147.

Wang, Z. Jay, Hanjiang Zhang, and Xinde Zhang, 2020, Fire sales and impediments to liquidity provision in the corporate bond market, *Journal of Financial and Quantitative Analysis* 55, 2613–2640.

Yu, Jianfeng, and Yu Yuan, 2011, Investor sentiment and the mean–variance relation, *Journal of Financial Economics* 100, 367–381.

Table 1. Summary Statistics

This table provides descriptive statistics of the data used in our empirical analysis. Panel A reports the number of bond-month observations (N), the time-series average of cross-sectional mean, standard deviation, lower quartile (Q1), median, and upper quartile (Q3) for corporate bond monthly return, bond idiosyncratic volatility (IVOL) and systematic volatility (SVOL), and other bond characteristics. Raw return and excess return are bond monthly raw return and return in excess of the one-month Treasury bill rate, respectively. Following Chung, Wang, and Wu (2019), bond IVOL is the standard deviation of return residuals from time-series regressions of daily bond excess returns against Fama and French (1993) five factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX over past 6-month. Bond SVOL is the standard deviation of predicted returns from the same regressions used to calculate IVOL. Bond rating is the numerical rating score, where 1 refers to a AAA rating by S&P and Aaa by Moody's, 21 refers to a C rating for both S&P and Moody's. Ratings of 10 or below are considered investment grade, and ratings above 10 are considered non-investment (high yield) grade. A larger number indicates higher credit risk or lower credit quality. Bond illiquidity (ILLIQ) is the auto-covariance of bond daily log price changes in each month multiplied by -1 as in Bao, Pan, and Wang (2011). MOM is the bond cumulative monthly return in past six months, skipping the most recent month. Maturity is the years to maturity. Age denotes years since bond issuance. Coupon is the coupon rate. Size is the logarithm of offering amount of the bond. Panel B reports the time-series average of cross-sectional correlations among bond IVOL, SVOL, and characteristics. All bond characteristics are winsorized each month at the 0.5% level. The sample period is from July 2002 to December 2019.

Panel A: Time-Series Average of Cross-Sectional Distributions

Variable		N	Mean	Std	Q1	Median	Q3
Raw return	(%)	1,108,893	0.71	4.51	-0.57	0.49	1.69
Excess return	(%)	1,108,893	0.61	4.51	-0.67	0.38	1.58
IVOL	(%)	763,909	1.12	1.29	0.47	0.78	1.33
SVOL	(%)	763,909	0.50	0.56	0.20	0.34	0.60
Rating		1,057,804	9.06	4.58	6.02	8.14	10.74
ILLIQ		997,039	2.37	9.47	0.04	0.26	1.11
MOM	(%)	918,713	3.15	7.60	0.08	2.45	5.21
Maturity		1,108,893	9.27	8.08	3.61	6.40	10.88
Age		1,108,893	4.30	3.89	1.54	3.25	5.87
Coupon		1,108,893	5.77	1.71	4.65	5.66	6.75
Size		1,108,893	12.65	1.38	12.23	12.90	13.50

Panel B: Time-Series Average of Cross-Sectional Correlations

	SVOL	*Rating*	*ILLIQ*	*MOM*	*Maturity*	*Age*	*Coupon*	*Size*
IVOL	0.82	0.39	0.57	0.03	0.28	0.24	0.30	-0.43
SVOL		0.27	0.49	0.01	0.40	0.13	0.24	-0.35
Rating			0.17	0.13	-0.09	0.05	0.47	-0.02
ILLIQ				-0.02	0.14	0.14	0.12	-0.29
MOM					0.06	0.05	0.11	0.03
Maturity						0.02	0.13	-0.05
Age							0.37	-0.09
Coupon								0.02

Table 2. The IVOL-Return Relation in the Corporate Bond Market

This table replicates the relation between bond idiosyncratic volatility (IVOL) and the next month bond returns documented in Chung, Wang, and Wu (2019). In Panel A, equal-weighted (EW) and value-weighted (VW, with bond issue size as weights) portfolios are formed by sorting corporate bonds into quintiles based on bond IVOL. IVOL,1 is the quintile with the lowest IVOL, and IVOL,5 is the quintile with the highest IVOL. The last row IVOL,5-1 shows the difference in monthly average excess returns between the highest and lowest IVOL quintiles. The portfolios are held for one month and rebalanced monthly. We report the average IVOL and next one-month average excess returns in percentage terms for each quintile as well as the long-short portfolio. The last six columns report average bond characteristics for each quintile, including bond rating, age, maturity, illiquidity (ILLIQ), bond size and VaR, defined as in Bai, Bali, and Wen (2019) as the second lowest monthly return over the past 36 months. Panel B presents the time-series averages of monthly Fama-MacBeth regressions. The dependent variable for columns (1) and (2) is next one-month excess return. In columns (3) and (4), the dependent variable is one-month-ahead risk-adjusted return using Fama and French (FF, 1993) five factors (MKT, SMB, HML, DEF, and TERM) while in columns (5) and (6), it is the risk-adjusted return using Bai, Bali and Wen (BBW, 2019) four factors (MKT_bond, DRF, CRF, and LRF). The control variables include bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond MOM, maturity, age, coupon, and size. We additionally control for bond systematic volatility (SVOL) in column (2), (4), and (6). All independent variables are standardized and winsorized at the 0.5% level each month. Coefficients are multiplied by 100. Newey-West (1987) adjusted t-statistics are reported in the parenthesis. The sample period is from July 2002 to December 2019.

Panel A: Univariate Portfolio Sorts on Bond IVOL

Quintiles	N	Average IVOL (%)	Excess Return (%)		Bond Characteristics					
			EW	VW	Rating	Age	Maturity	ILLIQ	Size	VaR
IVOL,1	152,689	0.26	0.23***	0.23***	6.82	3.14	3.73	0.05	13.76	-0.03
			(3.50)	(3.50)						
IVOL,2	152,826	0.47	0.34***	0.34***	8.52	3.46	6.12	0.16	13.45	-0.04
			(3.62)	(3.61)						
IVOL,3	152,825	0.70	0.41***	0.42***	9.19	3.75	8.91	0.34	13.25	-0.06
			(3.36)	(3.36)						
IVOL,4	152,826	1.05	0.50***	0.51***	9.66	4.32	12.16	0.78	12.98	-0.07
			(3.16)	(3.19)						
IVOL,5	152,743	2.37	1.20***	1.20***	11.72	6.17	13.19	4.52	12.45	-0.12
			(3.12)	(3.15)						
IVOL,5-1			**0.97*****	**0.97*****						
			(2.84)	**(2.87)**						

Panel B: Bond-Level Fama-MacBeth Cross-Sectional Regressions

	Excess returns		Risk-adjusted returns using FF factors		Risk-adjusted returns using BBW factors	
	(1)	(2)	(3)	(4)	(5)	(6)
IVOL	**0.274****	**0.224****	**0.232****	**0.198***	**0.198***	**0.210****
	(2.52)	**(2.15)**	**(2.16)**	**(1.92)**	**(1.87)**	**(1.98)**
SVOL		0.062		0.038		-0.017
		(1.35)		-0.86		(-0.44)
Rating	0.199**	0.196**	0.212***	0.209***	0.129	0.13
	(2.37)	(2.37)	(2.65)	(2.65)	(1.63)	(1.65)
ILLIQ	0.004	0.001	0.013	0.012	0.001	0.003
	(0.09)	(0.02)	(0.31)	(0.29)	(0.04)	(0.07)
RET1	-0.458***	-0.459***	-0.451***	-0.453***	-0.442**	-0.443**
	(-2.67)	(-2.69)	(-2.91)	(-2.93)	(-2.48)	(-2.50)
MOM	-0.007	-0.004	-0.03	-0.027	-0.022	-0.02
	(-0.10)	(-0.05)	(-0.39)	(-0.37)	(-0.26)	(-0.24)
Maturity	0.124**	0.123**	0.006	0.011	0.011	0.019
	(2.15)	(2.17)	(0.17)	(0.28)	(0.28)	(0.50)
Age	0.012	0.013	0.017	0.017	0.013	0.012
	(0.51)	(0.57)	(0.76)	(0.76)	(0.55)	(0.53)
Coupon	-0.061	-0.06	-0.078*	-0.076*	-0.072	-0.072
	(-1.27)	(-1.25)	(-1.69)	(-1.66)	(-1.47)	(-1.47)
Size	0.082**	0.084**	0.198***	0.199***	0.253***	0.250***
	(2.01)	(2.01)	(3.00)	(2.97)	(3.03)	(2.97)
Average adj-R^2	0.21	0.22	0.18	0.18	0.18	0.18
# of observations	706,104	706,104	706,104	706,104	647,218	647,218

Table 3. The Effects of Funding Illiquidity on Bond IVOL-Return Relation

This table presents the effects of funding illiquidity on the cross-sectional relationship between IVOL and expected returns in the corporate bond market. We use the intermediary capital ratio (ICR) of He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), (1-ICR) which proxies for funding illiquidity, and their interactions. (1-ICR) is multiplied by 100. The dependent variable in columns (1) to (4) is next one-month excess return. In columns (5) to (8) and (9) to (12), dependent variables are risk-adjusted returns using Fama and French (FF, 1993) five-factor model, and the Bai, Bali, and Wen (BBW, 2019) four-factor model, respectively. There are no fixed effects in columns (1), (5), and (9). Columns (2), (6), and (10) include time fixed effects. Columns (3), (7), and (11) include both time and firm fixed effects while columns (4), (8), and (12) include time and bond fixed effects. In all columns, the control variables are bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond momentum, maturity, age, coupon, and bond size. We omit coefficients on control variables for brevity. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. T-statistics are reported in parenthesis below coefficients. The sample period is from July 2002 to December 2019.

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-19.502***	-19.351***	-20.120***	-21.058***	-15.918***	-18.008***	-18.488***	-19.708***	-14.156***	-17.609***	-17.442***	-18.099***
	(-3.38)	(-4.00)	(-3.59)	(-4.05)	(-3.23)	(-3.62)	(-3.24)	(-3.75)	(-2.93)	(-3.22)	(-2.91)	(-3.12)
SVOL	12.136	8.689	1.764	3.742	6.457	7.168	-0.743	2.395	18.564*	16.521*	14.371	18.912
	(0.78)	(0.80)	(0.13)	(0.29)	(0.52)	(0.76)	(-0.07)	(0.21)	(1.78)	(1.76)	(1.14)	(1.64)
IVOL×(1-ICR)	**0.213*****	**0.211*****	**0.219*****	**0.230*****	**0.174*****	**0.197*****	**0.201*****	**0.215*****	**0.155*****	**0.192*****	**0.191*****	**0.199*****
	(3.39)	**(4.01)**	**(3.56)**	**(4.05)**	**(3.24)**	**(3.64)**	**(3.23)**	**(3.76)**	**(2.96)**	**(3.25)**	**(2.92)**	**(3.17)**
SVOL×(1-ICR)	-0.126	-0.090	-0.014	-0.038	-0.066	-0.074	0.012	-0.024	-0.195*	-0.173*	-0.149	-0.198
	(-0.76)	(-0.76)	(-0.10)	(-0.28)	(-0.49)	(-0.72)	(0.10)	(-0.20)	(-1.78)	(-1.75)	(-1.13)	(-1.64)
(1-ICR)	-0.001				-0.002***				-0.002**			
	(-0.71)				(-2.97)				(-2.25)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.039	0.130	0.171	0.163	0.034	0.059	0.086	0.096	0.028	0.046	0.062	0.060
# of observations	706,104	706,104	618,434	705,174	706,104	706,104	618,434	705,174	647,218	647,218	565,864	646,271

Table 4. The IVOL-Return Relation Around the Volcker Rule

This table reports the effects of funding illiquidity on the cross-sectional relationship between IVOL and expected bond returns, around the Volcker Rule. We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), (1-ICR), and the time dummy (POST). The POST dummy equals to 1 (0) if the month is after (before) the Volcker Rule effective date (April 1, 2014). (1-ICR) is multiplied by 100. The dependent variable in columns (1) to (4) is next one-month excess return. In columns (5) to (8) and (9) to (12), dependent variables are risk-adjusted returns using Fama and French (FF, 1993) five-factor model, and the Bai, Bali, and Wen (BBW, 2019) four-factor model, respectively. There are no fixed effects in columns (1), (5), and (9). Columns (2), (6), and (10) include time fixed effects. Columns (3), (7), and (11) include both time and firm fixed effects while columns (4), (8), and (12) include time and bond fixed effects. In all columns, the control variables are bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond momentum, maturity, age, coupon, and bond size. We omit coefficients on control variables for brevity. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. T-statistics are reported in parenthesis below coefficients. The sample period is from April 2011 to March 2017, i.e., 3 years before and 3 years after the implementation of the Volcker Rule.

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-10.685	-1.256	7.682	5.762	-0.683	-0.088	9.564	8.389	17.465	11.441	21.833	19.897
	(-0.46)	(-0.06)	(0.37)	(0.27)	(-0.04)	(-0.00)	(0.53)	(0.45)	(0.94)	(0.61)	(1.11)	(0.97)
SVOL	-31.588	-37.500	-52.408	-47.660	-21.459	-21.333	-35.109	-32.208	-20.136	-11.644	-25.197	-22.777
	(-0.55)	(-0.79)	(-1.08)	(-1.00)	(-0.66)	(-0.68)	(-1.07)	(-0.98)	(-0.62)	(-0.36)	(-0.76)	(-0.65)
IVOL×(1-ICR)	0.117	0.018	-0.074	-0.050	0.011	0.005	-0.095	-0.077	-0.179	-0.116	-0.223	-0.198
	(0.48)	(0.08)	(-0.34)	(-0.22)	(0.06)	(0.03)	(-0.50)	(-0.39)	(-0.92)	(-0.59)	(-1.08)	(-0.92)
SVOL×(1-ICR)	0.335	0.396	0.552	0.503	0.228	0.226	0.370	0.343	0.212	0.124	0.265	0.243
	(0.55)	(0.80)	(1.08)	(1.00)	(0.67)	(0.68)	(1.07)	(0.99)	(0.63)	(0.36)	(0.76)	(0.66)
IVOL×(1-ICR)×POST	**1.643****	**1.654****	**1.477***	**1.586****	**1.473****	**1.538****	**1.325***	**1.443****	**1.604****	**1.633****	**1.417***	**1.537****
	(2.14)	**(2.29)**	**(1.88)**	**(2.25)**	**(2.11)**	**(2.20)**	**(1.76)**	**(2.10)**	**(2.17)**	**(2.25)**	**(1.81)**	**(2.12)**
SVOL×(1-ICR)×POST	2.747*	2.329*	2.626**	2.432*	2.457**	2.344**	2.672**	2.522**	2.512**	2.417**	2.748**	2.591**
	(1.97)	(1.74)	(2.05)	(1.89)	(2.11)	(2.03)	(2.42)	(2.27)	(2.12)	(2.07)	(2.44)	(2.29)
IVOL×POST	-154.172**	-155.363**	-139.074*	-149.433**	-138.380**	-144.482**	-124.743*	-136.015**	-150.982**	-153.625**	-133.523*	-144.941**
	(-2.13)	(-2.28)	(-1.88)	(-2.25)	(-2.10)	(-2.19)	(-1.76)	(-2.10)	(-2.18)	(-2.25)	(-1.81)	(-2.13)
SVOL×POST	-256.918*	-217.540*	-244.888**	-226.837*	-229.691**	-219.095**	-249.342**	-235.668**	-234.712**	-225.984**	-256.617**	-242.244**
	(-1.96)	(-1.73)	(-2.03)	(-1.87)	(-2.10)	(-2.02)	(-2.41)	(-2.27)	(-2.12)	(-2.07)	(-2.43)	(-2.28)
(1-ICR)×POST	-0.015***				-0.017**				-0.015**			
	(-3.15)				(-2.50)				(-2.30)			
(1-ICR)	0.000				-0.001				-0.001			
	(0.26)				(-0.85)				(-0.66)			
POST	1.366***				1.575**				1.385**			
	(3.14)				(2.50)				(2.29)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.096	0.195	0.219	0.206	0.070	0.084	0.099	0.099	0.065	0.084	0.098	0.098
# of observations	279,055	279,055	250,627	278,514	279,055	279,055	250,627	278,514	279,055	279,055	250,627	278,514

Table 5. The IVOL-Return Relation Around the Volcker Rule, Interacted with Downgrades

This table reports the effects of investment to high-yield downgrades on the cross-sectional relationship between IVOL and expected bond returns, around the Volcker Rule. We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), interacted with the downgrade dummy (DG) and the time dummy (POST). The DG dummy is 1 if the bond experiences a downgrade from investment to speculative grade at that month, and 0 otherwise. The POST dummy is 1 (0) if the month is after (before) the Volcker Rule effective date (April 1, 2014). In Panel A, the dependent variable in columns (1) to (4) is next one-month excess return. In columns (5) to (8) and (9) to (12), dependent variables are risk-adjusted returns using Fama and French (FF, 1993) five-factor model, and the Bai, Bali, and Wen (BBW, 2019) four-factor model, respectively. There are no fixed effects in columns (1), (5), and (9). Columns (2), (6), and (10) include time fixed effects. Columns (3), (7), and (11) include both time and firm fixed effects while columns (4), (8), and (12) include time and bond fixed effects. In all columns, the control variables are bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond momentum, maturity, age, coupon, and bond size. We omit coefficients on control variables for brevity. All independent variables are winsorized at the 0.5% level each month. Panel B is the same as Panel A except that the dependent variables are cumulated over the next two months, i.e., the two-month excess or risk adjusted returns. Standard errors are clustered by bond and time. T-statistics are reported in parenthesis below coefficients. The sample period is from April 2011 to March 2017, i.e., 3 years before and 3 years after the Volcker Rule.

Panel A: Next One-Month Returns as Dependent Variables

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	0.635***	0.534***	0.789***	1.275***	0.418**	0.439**	0.657***	1.231***	0.420**	0.457**	0.666***	1.223***
	(2.95)	(2.85)	(4.29)	(5.47)	(2.31)	(2.45)	(3.74)	(5.28)	(2.28)	(2.48)	(3.54)	(5.03)
SVOL	0.614	0.462	0.440	0.483	0.399	0.390	0.362	0.620*	0.160	0.288	0.260	0.498*
	(1.06)	(1.23)	(1.16)	(1.22)	(1.37)	(1.42)	(1.34)	(1.98)	(0.64)	(1.10)	(1.00)	(1.70)
IVOL×*DG*	1.336	0.937	1.849	1.114	0.681	0.763	1.190	1.150	0.346	0.532	0.635	0.958
	(1.17)	(0.96)	(1.59)	(1.46)	(0.68)	(0.80)	(1.09)	(1.56)	(0.33)	(0.52)	(0.73)	(1.06)
SVOL×*DG*	-5.357	-3.906	-4.125	-4.022	-3.818	-3.661	-3.058	-4.145*	-3.555	-3.866	-3.202	-4.461
	(-1.65)	(-1.28)	(-1.51)	(-1.60)	(-1.25)	(-1.22)	(-1.16)	(-1.68)	(-1.10)	(-1.20)	(-1.23)	(-1.57)
IVOL*×*DG*×*POST	**3.838***	**3.402***	**2.359**	**2.885**	**3.403***	**3.257**	**2.689**	**2.558**	**3.714***	**3.399***	**3.176**	**2.691**
	(1.69)	**(1.67)**	**(1.06)**	**(1.37)**	**(1.70)**	**(1.66)**	**(1.27)**	**(1.25)**	**(1.79)**	**(1.71)**	**(1.58)**	**(1.28)**
SVOL×*DG*×*POST*	6.837	5.249	5.772	5.539	5.515	5.076	4.922	5.815	5.355	5.245	4.965	6.050
	(0.90)	(0.70)	(0.75)	(0.75)	(0.74)	(0.68)	(0.64)	(0.79)	(0.71)	(0.70)	(0.65)	(0.80)
IVOL×*POST*	-0.016	-0.038	-0.194	-0.232	-0.006	-0.013	-0.147	-0.214	-0.036	-0.025	-0.154	-0.205
	(-0.04)	(-0.09)	(-0.57)	(-0.67)	(-0.02)	(-0.04)	(-0.48)	(-0.67)	(-0.11)	(-0.07)	(-0.51)	(-0.65)
SVOL×*POST*	0.950	1.002	1.282	1.304	1.123	1.107	1.364**	1.118	1.294*	1.163	1.416**	1.170
	(0.96)	(1.14)	(1.55)	(1.54)	(1.47)	(1.48)	(2.00)	(1.46)	(1.74)	(1.59)	(2.12)	(1.54)
DG×*POST*	-0.017	-0.017	-0.008	-0.015	-0.019	-0.016	-0.009	-0.015	-0.017	-0.017	-0.012	-0.016
	(-0.51)	(-0.67)	(-0.33)	(-0.71)	(-0.67)	(-0.59)	(-0.36)	(-0.65)	(-0.59)	(-0.63)	(-0.47)	(-0.68)
DG	0.005	0.005	-0.003	0.003	0.008	0.006	-0.001	0.004	0.009	0.008	0.003	0.006
	(0.68)	(0.78)	(-0.88)	(0.46)	(1.12)	(0.92)	(-0.15)	(0.56)	(1.09)	(1.09)	(0.58)	(0.79)
POST	-0.005				-0.004				-0.004			
	(-1.50)				(-1.23)				(-1.34)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.044	0.157	0.185	0.172	0.032	0.047	0.066	0.066	0.029	0.049	0.068	0.066
# of observations	279,055	279,055	250,627	278,514	279,055	279,055	250,627	278,514	279,055	279,055	250,627	278,514

Panel B: Next Two-Month Cumulative Returns as Dependent Variables

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	1.016***	0.925***	1.506***	2.534***	0.693**	0.735**	1.242***	2.431***	0.736**	0.777**	1.270***	2.422***
	(2.69)	(2.75)	(4.45)	(6.35)	(2.09)	(2.26)	(3.76)	(6.03)	(2.21)	(2.35)	(3.71)	(5.86)
SVOL	1.660**	1.181**	1.136**	1.200**	0.952**	1.004***	0.945**	1.424***	0.445	0.784**	0.709*	1.124***
	(2.42)	(2.35)	(2.17)	(2.26)	(2.49)	(2.72)	(2.44)	(3.31)	(1.29)	(2.17)	(1.83)	(2.78)
IVOL×*DG*	1.003	0.699	1.312	0.981	0.453	0.488	0.938	1.192	0.301	0.521	0.834	1.261
	(0.82)	(0.59)	(1.09)	(1.01)	(0.36)	(0.41)	(0.81)	(1.40)	(0.22)	(0.40)	(0.67)	(1.19)
SVOL×*DG*	-6.216*	-4.740	-4.041	-4.494*	-4.601	-4.455	-3.608	-5.026*	-4.182	-4.472	-3.835	-5.107*
	(-1.74)	(-1.32)	(-1.60)	(-1.73)	(-1.25)	(-1.22)	(-1.37)	(-1.99)	(-1.08)	(-1.20)	(-1.32)	(-1.81)
IVOL*×*DG*×*POST	**8.021****	**6.921****	**5.971***	**6.046***	**6.316****	**6.158****	**5.376***	**4.899**	**6.043****	**5.912****	**5.306***	**4.719**
	(2.23)	**(2.18)**	**(1.77)**	**(1.70)**	**(2.09)**	**(2.09)**	**(1.74)**	**(1.49)**	**(2.01)**	**(2.05)**	**(1.77)**	**(1.45)**
SVOL×*DG*×*POST*	9.107	7.475	6.652	7.795	8.107	7.511	6.786	8.815	7.856	7.500	6.911	8.730
	(0.92)	(0.80)	(0.69)	(0.83)	(0.89)	(0.83)	(0.73)	(0.96)	(0.86)	(0.84)	(0.75)	(0.96)
IVOL×*POST*	0.499	0.358	-0.078	-0.011	0.423	0.420	0.036	0.044	0.341	0.388	0.021	0.046
	(0.73)	(0.52)	(-0.14)	(-0.02)	(0.69)	(0.67)	(0.07)	(0.08)	(0.59)	(0.67)	(0.04)	(0.09)
SVOL×*POST*	1.353	1.674	2.266*	2.056	1.854	1.788	2.331**	1.608	2.195*	1.909	2.459**	1.787
	(0.86)	(1.13)	(1.68)	(1.49)	(1.42)	(1.39)	(2.00)	(1.27)	(1.73)	(1.50)	(2.11)	(1.42)
DG×*POST*	-0.036	-0.033	-0.021	-0.032	-0.031	-0.028	-0.018	-0.028	-0.027	-0.025	-0.016	-0.025
	(-0.76)	(-0.96)	(-0.61)	(-1.17)	(-0.77)	(-0.77)	(-0.50)	(-0.94)	(-0.65)	(-0.65)	(-0.42)	(-0.80)
DG	0.010	0.009	-0.001	0.003	0.012	0.010	0.002	0.004	0.010	0.010	0.003	0.004
	(1.00)	(0.95)	(-0.12)	(0.41)	(1.22)	(1.11)	(0.34)	(0.51)	(1.04)	(1.06)	(0.47)	(0.46)
POST	-0.011**				-0.009*				-0.010*			
	(-2.16)				(-1.69)				(-1.75)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^{2}	0.082	0.186	0.227	0.236	0.063	0.075	0.107	0.136	0.057	0.074	0.107	0.132
# of observations	269,430	269,430	242,695	268,891	269,430	269,430	242,695	268,891	269,430	269,430	242,695	268,891

Table 6. The IVOL-Return Relation During the Financial Crisis

This table reports results from the regressions of contemporaneous weekly raw and abnormal corporate bond returns on bond IVOL and SVOL, interacted with the time dummy. In Panel A, the sample period spans from August 11, 2008 to October 3, 2008. The GFC dummy is 1 (0) for the four weeks after (before) September 8, 2008. In Panel B, the sample period spans from September 8, 2008 to October 31, 2008. The Rate_down dummy is 1 (0) for the four weeks after (before) October 8, 2008. The dependent variables in column (1) to (4), and column (5) to (8) are the contemporaneous weekly raw and abnormal returns, respectively. The weekly abnormal return of a bond is calculated as the difference between the raw return and the size-weighted average weekly returns of bonds in the same rating and maturity buckets as that of the bond. There are no fixed effects in columns (1) and (5). Columns (2) and (6) include time fixed effects. Columns (3) and (7) include both time and firm fixed effects while columns (4) and (8) include time and bond fixed effects. Independent variables are the most recent available ones before each week. The control variables include bond rating, bond illiquidity, lagged one-week bond return, maturity, age, coupon, and bond size. We omit coefficients on control variables for brevity. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond. T-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the Financial Crisis

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IVOL	0.581***	0.576***	0.522***	2.344*	0.416**	0.434**	0.313*	1.891
	(2.85)	(2.77)	(2.90)	(1.91)	(2.08)	(2.12)	(1.77)	(1.55)
SVOL	-0.007	-0.019	-0.056	4.529	-0.118	-0.117	-0.113	4.739
	(-0.02)	(-0.06)	(-0.19)	(1.50)	(-0.37)	(-0.36)	(-0.40)	(1.57)
IVOL×GFC	**-1.723****	**-1.761****	**-1.174*****	**-1.523****	**-1.085**	**-1.250**	**-0.722*****	**-0.909**
	(-2.20)	**(-2.13)**	**(-4.23)**	**(-2.53)**	**(-1.39)**	**(-1.52)**	**(-2.63)**	**(-1.53)**
SVOL×GFC	4.797	4.874	0.938	2.275	4.230	4.689	0.714	1.975
	(1.63)	(1.58)	(1.59)	(1.04)	(1.43)	(1.52)	(1.21)	(0.90)
GFC	-0.029***				-0.017**			
	(-3.66)				(-2.09)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.081	0.092	0.180	0.124	0.061	0.067	0.112	0.098
# of observations	11,931	11,931	10,124	11,645	11,925	11,925	10,120	11,638

Panel B: Before and After the Decrease in Interest Rates

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IVOL	-0.788	-0.790	-0.211	0.927	-0.331	-0.441	0.037	1.277
	(-1.25)	(-1.20)	(-0.61)	(0.74)	(-0.53)	(-0.67)	(0.10)	(1.01)
SVOL	4.069	4.075	1.571***	6.468*	3.451	3.825	1.253**	6.185*
	(1.57)	(1.51)	(3.01)	(1.77)	(1.33)	(1.42)	(2.38)	(1.68)
IVOL×Rate_down	**2.638*****	**2.684*****	**0.774****	**1.741****	**2.161*****	**2.284*****	**0.487**	**1.388***
	(3.76)	**(3.68)**	**(2.12)**	**(2.24)**	**(3.11)**	**(3.15)**	**(1.37)**	**(1.80)**
SVOL×Rate_down	-4.988**	-4.957**	-1.376**	-3.851	-4.348*	-4.704**	-1.037*	-3.636
	(-2.23)	(-2.11)	(-2.34)	(-1.46)	(-1.94)	(-2.01)	(-1.79)	(-1.38)
Rate_down	0.001				-0.005			
	(0.11)				(-0.84)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.040	0.077	0.153	0.088	0.035	0.037	0.053	0.050
# of observations	11,960	11,960	10,002	11,694	11,948	11,948	9,993	11,687

Table 7. The IVOL-Return Relation During the COVID-19

This table reports results from the regressions of contemporaneous weekly raw and abnormal corporate bond returns on bond IVOL and SVOL, interacted with the time dummy. In Panel A, the sample period spans from January 27, 2020 to March 20, 2020. The COVID dummy is 1 (0) for the four weeks after (before) February 24, 2020. In Panel B, the sample period spans from February 24, 2020 to April 17, 2020. The SMCCF dummy is 1 (0) for the four weeks after (before) March 23, 2020 The dependent variables in column (1) to (4), and column (5) to (8) are the contemporaneous weekly raw and abnormal returns, respectively. The weekly abnormal return of a bond is calculated as the difference between the raw return and the size-weighted average weekly returns of bonds in the same rating and maturity buckets as that of the bond. There are no fixed effects in columns (1) and (5). Columns (2) and (6) include time fixed effects. Columns (3) and (7) include both time and firm fixed effects while columns (4) and (8) include time and bond fixed effects. Independent variables are the most recent available ones before each week. The control variables include bond rating, bond illiquidity, lagged one-week bond return, maturity, age, coupon, and bond size. We omit coefficients on control variables for brevity. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond. T-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the COVID-19

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
IVOL	-0.053	-0.007	0.374*	1.525	-0.146	-0.153	0.538**	0.924
	(-0.42)	(-0.05)	(1.87)	(1.43)	(-1.08)	(-1.14)	(2.55)	(0.90)
SVOL	1.626***	1.748***	2.967***	7.191***	-0.375	-0.372	0.874**	3.517*
	(5.54)	(5.40)	(6.48)	(3.74)	(-1.19)	(-1.19)	(2.09)	(1.87)
IVOL×COVID	**-0.150**	**-0.912*****	**-1.402*****	**-1.373*****	**-0.873*****	**-0.818*****	**-1.463*****	**-1.133*****
	(-0.61)	**(-3.42)**	**(-4.67)**	**(-4.10)**	**(-3.17)**	**(-2.96)**	**(-4.60)**	**(-3.38)**
SVOL×COVID	-4.204***	-4.528***	-4.400***	-5.034***	-0.459	-0.428	-0.040	-0.701**
	(-13.28)	(-13.67)	(-13.30)	(-15.65)	(-1.41)	(-1.34)	(-0.12)	(-2.19)
COVID	-0.014***				0.005***			
	(-18.52)				(6.00)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.290	0.483	0.505	0.469	0.027	0.028	0.080	0.040
# of observations	35,062	35,062	30,009	34,708	35,049	35,049	29,997	34,696

Panel B: Before and After the SMCCF Announcement

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
IVOL	-0.714**	-1.045***	-1.651***	-1.154	-0.878***	-0.923***	-0.977**	0.229
	(-2.15)	(-3.25)	(-3.73)	(-1.63)	(-2.84)	(-2.95)	(-2.40)	(0.35)
SVOL	-7.815***	-6.217***	-5.330***	-6.233***	-1.569***	-1.537***	0.218	0.481
	(-12.46)	(-10.31)	(-8.08)	(-6.85)	(-2.95)	(-2.82)	(0.40)	(0.62)
IVOL×SMCCF	**1.704*****	**2.055*****	**2.593*****	**2.597*****	**1.110*****	**1.152*****	**1.382*****	**0.834**
	(4.28)	**(5.37)**	**(5.07)**	**(4.19)**	**(3.01)**	**(3.10)**	**(2.91)**	**(1.42)**
SVOL×SMCCF	7.297***	6.923***	6.325***	7.692***	1.817***	1.830***	0.410	0.625
	(11.90)	(11.94)	(10.36)	(10.27)	(3.51)	(3.51)	(0.82)	(1.02)
SMCCF	0.036***				-0.009***			
	(27.68)				(-7.47)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.259	0.455	0.472	0.453	0.020	0.022	0.059	0.027
# of observations	34,323	34,323	29,300	33,891	34,296	34,296	29,274	33,859

Table 8. Reconciling the IVOL-Return Relation with Bai, Bali, and Wen (2021)

In this table, we use different measures of IVOL and repeat the tests in Table 3 to reconcile our results with those in Bai, Bali and Wen (2021). We use the intermediary capital ratio (ICR) of He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), (1-ICR) which proxies for funding illiquidity, and their interactions. (1-ICR) is multiplied by 100. In Panels A to D, IVOL measures are respectively the standard deviation of residuals from time-series regressions of: i) daily bond excess returns on daily Bai, Bali, and Wen (BBW, 2019) factors (MKT_bond, DRF, CRF, LRF) over past six months; ii) daily bond excess returns on daily BBW factors over past 36 months; iii) monthly bond excess returns on the monthly Fama and French (FF, 1993) factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX over past 36-month; iv) monthly bond excess returns on monthly BBW factors over past 36 months. Panel E reports results from a sample with non-missing IVOL using past monthly returns while computing IVOL using daily returns as in Panel B. The dependent variable in columns (1) to (4) is the next one-month excess return. In columns (5) to (8) and (9) to (12), dependent variables are the risk-adjusted returns using Fama and French (FF, 1993) five-factor model, and the Bai, Bali, and Wen (BBW, 2019) four-factor model, respectively. There are no fixed effects in columns (1), (5), and (9). Columns (2), (6), and (10) include time fixed effects. Columns (3), (7), and (11) include both time and firm fixed effects while columns (4), (8), and (12) include time and bond fixed effects. In all columns, the control variables are bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond MOM, maturity, age, coupon, and bond size. We omit coefficients on control variables for brevity. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. T-statistics are reported in parenthesis below coefficients. The sample period is from July 2002 to December 2019.

Panel A: IVOL from Regressing Daily Returns on Daily BBW Factors, Past 6-Month

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-15.624***	-15.081***	-16.825***	-15.943***	-11.718***	-13.840***	-15.355***	-14.669***	-10.127***	-13.756***	-15.505***	-14.297***
	(-2.74)	(-3.51)	(-2.95)	(-3.38)	(-2.78)	(-3.44)	(-2.91)	(-3.43)	(-2.89)	(-3.67)	(-3.52)	(-3.49)
SVOL	1.615	-2.496	-3.170	-1.357	-3.429	-3.029	-4.418	-1.858	8.938	6.861	8.671	9.345
	(0.11)	(-0.20)	(-0.22)	(-0.10)	(-0.27)	(-0.27)	(-0.35)	(-0.15)	(0.67)	(0.54)	(0.58)	(0.63)
IVOL×(1-ICR)	**0.171*****	**0.164*****	**0.183*****	**0.176*****	**0.128*****	**0.151*****	**0.167*****	**0.161*****	**0.111*****	**0.150*****	**0.168*****	**0.157*****
	(2.77)	**(3.52)**	**(2.95)**	**(3.42)**	**(2.80)**	**(3.46)**	**(2.91)**	**(3.48)**	**(2.94)**	**(3.70)**	**(3.51)**	**(3.57)**
SVOL×(1-ICR)	-0.013	0.033	0.041	0.020	0.043	0.038	0.055	0.025	-0.089	-0.066	-0.084	-0.093
	(-0.08)	(0.24)	(0.26)	(0.13)	(0.31)	(0.32)	(0.41)	(0.18)	(-0.64)	(-0.49)	(-0.54)	(-0.59)
(1-ICR)	-0.000				-0.002***				-0.002**			
	(-0.33)				(-2.83)				(-2.32)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.044	0.162	0.183	0.172	0.039	0.073	0.092	0.085	0.027	0.046	0.062	0.059
# of observations	659,397	659,397	576,658	658,523	659,397	659,397	576,658	658,523	647,217	647,217	565,863	646,270

Panel B: IVOL from Regressing Daily Returns on Daily BBW Factors, Past 36-Month

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-14.845**	-11.900**	-15.130**	-15.650**	-10.262*	-10.492**	-13.066**	-13.422**	-6.428	-8.897*	-11.298**	-11.656**
	(-2.21)	(-2.18)	(-2.28)	(-2.54)	(-1.91)	(-2.07)	(-2.13)	(-2.40)	(-1.45)	(-1.92)	(-2.27)	(-2.37)
SVOL	-10.405	-10.195	-17.176*	-10.479	-12.052	-9.006	-17.158*	-10.005	-5.970	-5.114	-11.781	-4.645
	(-1.04)	(-1.32)	(-1.71)	(-0.96)	(-1.43)	(-1.22)	(-1.90)	(-0.97)	(-0.69)	(-0.61)	(-1.12)	(-0.33)
IVOL×(1-ICR)	**0.161****	**0.129****	**0.164****	**0.171****	**0.112***	**0.114****	**0.142****	**0.147****	**0.071**	**0.097***	**0.123****	**0.128****
	(2.23)	**(2.21)**	**(2.28)**	**(2.58)**	**(1.93)**	**(2.09)**	**(2.14)**	**(2.44)**	**(1.48)**	**(1.95)**	**(2.28)**	**(2.42)**
SVOL×(1-ICR)	0.116	0.113	0.188*	0.115	0.132	0.099	0.187*	0.109	0.066	0.057	0.129	0.052
	(1.08)	(1.36)	(1.76)	(1.00)	(1.46)	(1.26)	(1.94)	(0.99)	(0.72)	(0.65)	(1.16)	(0.35)
(1-ICR)	-0.000				-0.002***				-0.001**			
	(-0.49)				(-3.14)				(-2.56)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.040	0.159	0.185	0.168	0.036	0.073	0.099	0.085	0.028	0.045	0.067	0.057
# of observations	767,806	767,806	668,655	766,515	767,806	767,806	668,655	766,515	754,495	754,495	656,891	753,144

Panel C: IVOL from Regressing Monthly Returns on Monthly FF Factors and ΔVIX, Past 36-Month

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	6.146	3.911	1.560	4.944	5.279	3.547	1.153	4.585	4.066	3.787	1.743	4.962
	(1.27)	(1.03)	(0.27)	(0.69)	(1.26)	(1.02)	(0.22)	(0.69)	(1.22)	(1.24)	(0.38)	(0.84)
SVOL	-15.473*	-12.599*	-13.910	-17.756*	-14.577**	-12.413**	-13.937*	-17.988**	-9.663*	-9.794*	-10.388	-14.134*
	(-1.80)	(-1.83)	(-1.58)	(-1.84)	(-2.14)	(-2.07)	(-1.84)	(-2.10)	(-1.75)	(-1.80)	(-1.52)	(-1.79)
IVOL×(1-ICR)	**-0.066**	**-0.042**	**-0.017**	**-0.054**	**-0.056**	**-0.038**	**-0.012**	**-0.050**	**-0.043**	**-0.040**	**-0.018**	**-0.053**
	(-1.27)	**(-1.03)**	**(-0.26)**	**(-0.69)**	**(-1.26)**	**(-1.02)**	**(-0.22)**	**(-0.70)**	**(-1.22)**	**(-1.24)**	**(-0.37)**	**(-0.84)**
SVOL×(1-ICR)	0.166*	0.135*	0.151	0.191*	0.156**	0.133**	0.151*	0.193**	0.103*	0.105*	0.113	0.152*
	(1.81)	(1.84)	(1.60)	(1.85)	(2.14)	(2.07)	(1.86)	(2.11)	(1.75)	(1.80)	(1.53)	(1.80)
(1-ICR)	-0.000				-0.002**				-0.002			
	(-0.30)				(-2.02)				(-1.63)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.048	0.172	0.208	0.179	0.048	0.096	0.136	0.106	0.039	0.062	0.098	0.072
# of observations	422,472	422,472	369,330	421,888	422,472	422,472	369,330	421,888	419,058	419,058	366,401	418,456

Panel D: IVOL from Regressing Monthly Returns on Monthly BBW Factors, Past 36-Month

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-3.415	-3.191	-6.219	-6.927	-2.623	-3.059	-5.840	-6.693	-2.728	-2.785	-5.021	-5.548
	(-0.72)	(-0.76)	(-1.25)	(-1.00)	(-0.61)	(-0.77)	(-1.30)	(-1.06)	(-0.71)	(-0.74)	(-1.20)	(-0.97)
SVOL	-6.829	-6.047	-6.527	-6.465	-7.465	-6.404	-7.362	-7.337	-3.605	-3.655	-3.745	-4.009
	(-1.10)	(-1.06)	(-0.98)	(-1.16)	(-1.42)	(-1.26)	(-1.24)	(-1.45)	(-0.83)	(-0.80)	(-0.71)	(-0.88)
IVOL×(1-ICR)	**0.037**	**0.035**	**0.067**	**0.074**	**0.029**	**0.033**	**0.063**	**0.072**	**0.030**	**0.031**	**0.055**	**0.060**
	(0.73)	**(0.78)**	**(1.27)**	**(1.01)**	**(0.63)**	**(0.80)**	**(1.32)**	**(1.07)**	**(0.73)**	**(0.76)**	**(1.23)**	**(0.99)**
SVOL×(1-ICR)	0.073	0.064	0.071	0.068	0.079	0.068	0.080	0.077	0.038	0.038	0.041	0.042
	(1.10)	(1.06)	(1.00)	(1.17)	(1.41)	(1.25)	(1.25)	(1.45)	(0.81)	(0.79)	(0.73)	(0.87)
(1-ICR)	0.000				-0.002*				-0.002			
	(0.28)				(-1.83)				(-1.63)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.046	0.171	0.208	0.177	0.046	0.095	0.135	0.103	0.039	0.062	0.098	0.070
# of observations	416,480	416,480	363,980	415,898	416,480	416,480	363,980	415,898	413,066	413,066	361,051	412,466

Panel E: IVOL from Regressing Daily Returns on Daily BBW Factors, Past 36-Month, Narrow Sample

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-9.691	-9.299*	-18.525***	-15.471**	-5.469	-7.273	-15.291**	-11.389*	-2.942	-6.126	-13.859**	-9.931*
	(-1.45)	(-1.70)	(-2.72)	(-2.36)	(-0.98)	(-1.40)	(-2.36)	(-1.81)	(-0.61)	(-1.28)	(-2.46)	(-1.67)
SVOL	-40.418	-31.509	-38.128	-47.575	-40.829*	-31.245	-39.284	-49.624	-29.419	-24.537	-28.134	-38.397
	(-1.41)	(-1.49)	(-1.41)	(-1.39)	(-1.70)	(-1.59)	(-1.65)	(-1.56)	(-1.50)	(-1.39)	(-1.34)	(-1.35)
IVOL×(1-ICR)	**0.107**	**0.103***	**0.202*****	**0.171****	**0.062**	**0.081**	**0.167****	**0.127***	**0.034**	**0.069**	**0.152****	**0.112***
	(1.49)	**(1.74)**	**(2.73)**	**(2.44)**	**(1.03)**	**(1.44)**	**(2.38)**	**(1.88)**	**(0.66)**	**(1.33)**	**(2.48)**	**(1.76)**
SVOL×(1-ICR)	0.432	0.337	0.410	0.505	0.436*	0.334	0.422*	0.525	0.314	0.262	0.303	0.407
	(1.42)	(1.49)	(1.43)	(1.41)	(1.70)	(1.59)	(1.66)	(1.57)	(1.50)	(1.39)	(1.36)	(1.37)
(1-ICR)	-0.001				-0.002***				-0.002**			
	(-0.72)				(-2.82)				(-2.41)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.046	0.168	0.200	0.177	0.044	0.091	0.124	0.102	0.038	0.060	0.091	0.072
# of observations	422,471	422,471	369,329	421,887	422,471	422,471	369,329	421,887	419,057	419,057	366,400	418,455

Table A1. The Effects of Funding Illiquidity on Bond IVOL-Return Relation, with Alternative Identifications

In this table, we replicate tests in Table 3. In Panel A, we use IVOL calculated as the standard deviation of return residuals from time-series regressions of daily excess returns against Fama-French (1993) five factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX in past 36-month. The proxy for illiquidity (1-ICR) is multiplied by 100. In Panel B, we use VIX as the alternative proxy for intermediary funding illiquidity. High VIX stands for high funding illiquidity. The dependent variable for column (1) to (4) is next one-month excess return. For column (5) to (8) and (9) to (12), dependent variables are risk-adjusted returns using Fama and French (FF, 1993) five-factor model, and using Bai, Bali, and Wen (BBW, 2019) four-factor model, respectively. There are no fixed effects in column (1), (5), and (9). Column (2), (6), and (10) include time fixed effects. Column (3), (7), and (11) include both time and firm fixed effects while column (4), (8), and (12) include time and bond fixed effects. In all columns, the control variables are bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond MOM, maturity, age, coupon, and bond size. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. T-statistics are reported in parenthesis below coefficients. The sample period is from July 2002 to December 2019.

Panel A: IVOL from Regressing Daily Returns on Daily FF Factors and ΔVIX, Past 36-Month

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-9.737**	-9.347***	-9.635**	-7.370**	-8.662***	-9.110***	-9.324**	-6.928**	-7.651**	-9.225**	-11.149**	-9.127**
	(-2.53)	(-2.69)	(-2.16)	(-2.03)	(-2.60)	(-2.73)	(-2.21)	(-2.03)	(-1.99)	(-2.21)	(-2.43)	(-2.04)
SVOL	-13.193	-8.387	-21.220*	-23.686*	-9.413	-5.508	-18.842*	-20.946	-2.968	-3.204	-7.522	-8.760
	(-1.04)	(-0.98)	(-1.94)	(-1.70)	(-0.92)	(-0.69)	(-1.93)	(-1.63)	(-0.32)	(-0.37)	(-0.70)	(-0.59)
IVOL×(1-ICR)	**0.106****	**0.102*****	**0.105****	**0.081****	**0.094*****	**0.099*****	**0.102****	**0.076****	**0.084****	**0.101****	**0.121****	**0.100****
	(2.53)	**(2.68)**	**(2.15)**	**(2.05)**	**(2.60)**	**(2.73)**	**(2.20)**	**(2.05)**	**(2.00)**	**(2.22)**	**(2.43)**	**(2.06)**
SVOL×(1-ICR)	0.148	0.095	0.233**	0.259*	0.105	0.063	0.206**	0.228*	0.034	0.036	0.084	0.096
	(1.09)	(1.04)	(1.99)	(1.74)	(0.96)	(0.74)	(1.97)	(1.67)	(0.34)	(0.39)	(0.73)	(0.62)
(1-ICR)	-0.000				-0.001***				-0.001***			
	(-0.42)				(-3.23)				(-2.71)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.034	0.132	0.172	0.158	0.031	0.061	0.090	0.091	0.027	0.044	0.066	0.059
# of observations	821,817	821,817	716,839	820,508	821,817	821,817	716,839	820,508	754,705	754,705	657,072	753,340

Panel B: VIX as the Alternative Proxy for Funding Illiquidity

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IVOL	-0.796***	-0.744***	-0.800***	-0.721***	-0.746***	-0.717***	-0.766***	-0.705***	-0.290	-0.351	-0.375	-0.147
	(-2.94)	(-3.65)	(-3.13)	(-3.26)	(-3.17)	(-3.47)	(-2.95)	(-3.20)	(-1.14)	(-1.23)	(-1.09)	(-0.43)
SVOL	1.325	1.229	0.831	1.100	1.210	1.149	0.740	1.076	1.320**	1.354**	1.167	1.434**
	(1.21)	(1.49)	(0.80)	(1.14)	(1.28)	(1.55)	(0.82)	(1.24)	(2.11)	(2.34)	(1.51)	(1.99)
IVOL×VIX	**0.041*****	**0.037*****	**0.038*****	**0.037*****	**0.037*****	**0.036*****	**0.036*****	**0.036*****	**0.030****	**0.034****	**0.035****	**0.030****
	(3.30)	**(4.00)**	**(2.92)**	**(3.69)**	**(3.51)**	**(3.83)**	**(2.75)**	**(3.57)**	**(2.41)**	**(2.45)**	**(1.99)**	**(2.06)**
SVOL×VIX	-0.035	-0.028	-0.010	-0.026	-0.029	-0.026	-0.008	-0.025	-0.043**	-0.042***	-0.032	-0.042**
	(-0.86)	(-0.89)	(-0.27)	(-0.76)	(-0.81)	(-0.95)	(-0.23)	(-0.84)	(-2.28)	(-2.62)	(-1.43)	(-2.13)
VIX	0.000				-0.000**				-0.000*			
	(1.48)				(-2.36)				(-1.78)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.040	0.127	0.167	0.158	0.033	0.056	0.082	0.091	0.029	0.046	0.062	0.059
# of observations	706,104	706,104	618,434	705,174	706,104	706,104	618,434	705,174	647,218	647,218	565,864	646,271

Table A2. The IVOL Effects Around the Volcker Rule, with VIX

In this Table, we replicate tests in Table 4. We use VIX as the alternative proxy for intermediary funding illiquidity. High VIX stands for high funding illiquidity. The dependent variable for column (1) to (4) is next one-month excess return. For column (5) to (8) and (9) to (12), dependent variables are risk-adjusted returns using Fama and French (FF, 1993) five-factor model, and using Bai, Bali, and Wen (BBW, 2019) four-factor model, respectively. There are no fixed effects in column (1), (5), and (9). Column (2), (6), and (10) include time fixed effects. Column (3), (7), and (11) include both time and firm fixed effects while column (4), (8), and (12) include time and bond fixed effects. In all columns, the control variables are bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond MOM, maturity, age, coupon, and bond size. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. T-statistics are reported in parenthesis below coefficients. The sample period is from April 2011 to March 2017, i.e., 3 years before and 3 years after the Volcker Rule.

	Excess returns				Risk-adjusted returns using FF factors				Risk-adjusted returns using BBW factors			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
IVOL	0.653	0.920	1.421**	1.907***	0.758*	0.781*	1.282***	1.823***	1.076**	1.074**	1.589***	2.059***
	(1.10)	(1.64)	(2.36)	(2.92)	(1.70)	(1.70)	(2.68)	(3.33)	(2.12)	(2.14)	(2.95)	(3.52)
SVOL	0.482	-0.327	-0.896	-0.637	0.045	0.061	-0.488	-0.079	-0.392	-0.151	-0.744	-0.360
	(0.33)	(-0.27)	(-0.74)	(-0.55)	(0.06)	(0.08)	(-0.65)	(-0.11)	(-0.46)	(-0.18)	(-0.93)	(-0.43)
IVOL×VIX	-0.002	-0.019	-0.032	-0.034	-0.017	-0.017	-0.033	-0.032	-0.035	-0.032	-0.049**	-0.046*
	(-0.06)	(-0.67)	(-1.07)	(-1.13)	(-0.83)	(-0.80)	(-1.48)	(-1.41)	(-1.61)	(-1.46)	(-2.04)	(-1.92)
SVOL×VIX	0.004	0.039	0.066	0.056	0.020	0.017	0.043	0.036	0.034	0.024	0.052	0.045
	(0.05)	(0.63)	(1.05)	(0.89)	(0.48)	(0.42)	(1.08)	(0.89)	(0.77)	(0.55)	(1.24)	(0.99)
IVOL×VIX×POST	**0.041**	**0.041**	**0.031**	**0.006**	**0.035**	**0.047**	**0.033**	**0.012**	**0.109**	**0.114**	**0.106**	**0.083**
	(0.23)	**(0.25)**	**(0.19)**	**(0.04)**	**(0.22)**	**(0.30)**	**(0.22)**	**(0.08)**	**(0.72)**	**(0.76)**	**(0.71)**	**(0.56)**
SVOL×VIX×POST	0.462**	0.393*	0.362*	0.392*	0.317*	0.311*	0.279	0.310	0.256	0.239	0.205	0.233
	(2.13)	(1.91)	(1.71)	(1.87)	(1.76)	(1.71)	(1.47)	(1.65)	(1.44)	(1.32)	(1.10)	(1.25)
IVOL×POST	-0.602	-0.719	-0.751	-0.387	-0.586	-0.782	-0.734	-0.464	-1.827	-1.895	-1.932	-1.591
	(-0.23)	(-0.29)	(-0.30)	(-0.16)	(-0.25)	(-0.33)	(-0.32)	(-0.20)	(-0.78)	(-0.82)	(-0.85)	(-0.70)
SVOL×POST	-6.473*	-5.152	-4.251	-4.773	-3.881	-3.820	-2.950	-3.729	-2.865	-2.634	-1.721	-2.456
	(-1.87)	(-1.58)	(-1.27)	(-1.43)	(-1.40)	(-1.37)	(-1.01)	(-1.27)	(-1.04)	(-0.95)	(-0.60)	(-0.84)
VIX×POST	-0.001				-0.001				-0.001			
	(-0.69)				(-0.92)				(-0.37)			
VIX	0.000				0.000				-0.000			
	(0.77)				(0.03)				(-0.01)			
POST	0.009				0.017				0.005			
	(0.49)				(0.80)				(0.23)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.057	0.163	0.188	0.175	0.035	0.050	0.066	0.067	0.037	0.054	0.070	0.068
# of observations	279,055	279,055	250,627	278,514	279,055	279,055	250,627	278,514	279,055	279,055	250,627	278,514

Table A3. The Effects of Bond IVOL on Future Downgrades

This table presents the Probit and OLS regressions of next one-month bond downgrade dummy on bond IVOL, with different sets of controls. The dependent variable is the one-month-ahead downgrade dummy variable (DG) which equals to 1 if the bond experiences a downgrade from investment to high-yield grade at that month, and 0 otherwise. In column (2) and (5), we control for bond systematic volatility (SVOL). In column (3) and (6), we additionally include bond illiquidity (ILLIQ), maturity, age, coupon, and bond size as controls. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. T-statistics are reported in parenthesis below coefficients. In OLS regressions, we control for bond and time fixed effects. We report "Pseudo-R^2" for Probit regressions and "Adj-R^2" for OLS regressions. The sample period is from July 2002 to December 2019.

	Probit			OLS		
	(1)	(2)	(3)	(4)	(5)	(6)
IVOL	**2.803*****	**0.682**	**0.688**	**0.034*****	**0.012**	**0.011**
	(14.60)	**(1.20)**	**(1.20)**	**(2.68)**	**(0.41)**	**(0.39)**
SVOL		6.145***	5.900***		0.065	0.069
		(4.17)	(3.80)		(0.79)	(0.82)
ILLIQ			-0.000**			-0.000
			(-2.25)			(-0.25)
Maturity			0.000			-0.001
			(0.19)			(-1.61)
Age			-0.005**			0.001
			(-2.43)			(0.76)
Coupon			0.034***			
			(8.90)			
Size			-0.010			
			(-1.32)			
Pseudo-R^2	0.008	0.009	0.012			
Adj-R^2				0.004	0.004	0.004
# of observations	743,181	743,181	739,292	742,269	742,269	738,349

Table A4. The IVOL Effects During the Financial Crisis, on Next Week Returns

This table replicate tests in Table 6. We regress one-week-ahead raw and abnormal returns on bond IVOL, bond SVOL, interacted with the time dummy. In Panel A, the sample period spans from August 11, 2008 to October 3, 2008. The GFC dummy equals to 1 (0) for the four weeks after (before) September 8, 2008. In Panel B, the sample period spans from September 8, 2008 to October 31, 2008. The Rate_down dummy equals to 1 (0) for the four weeks after (before) October 8, 2008. The dependent variable in column (1) to (4), and column (5) to (8) are raw return and abnormal return in the next week, respectively. Weekly abnormal return is calculated as subtracting size-weighted average weekly returns of bonds in the same rating and maturity buckets from the raw return. There are no fixed effects in column (1) and (5). Column (2) and (6) include time fixed effects. Column (3) and (7) include both time and firm fixed effects while column (4) and (8) include time and bond fixed effects. Independent variables are the most recent available ones before each week. The control variables include bond rating, bond illiquidity, lagged one-week bond return, maturity, age, coupon, and bond size. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond. T-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the Financial Crisis

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IVOL	0.307	0.292	0.724**	-1.468	0.117	0.110	0.557*	-1.306
	(1.51)	(1.44)	(2.15)	(-0.96)	(0.58)	(0.54)	(1.67)	(-0.86)
SVOL	0.015	0.004	-0.057	-1.975	-0.124	-0.135	-0.093	-1.347
	(0.05)	(0.01)	(-0.11)	(-0.79)	(-0.41)	(-0.44)	(-0.19)	(-0.54)
IVOL×GFC	**-1.162*****	**-1.158*****	**-1.347*****	**-1.376*****	**-0.554***	**-0.574***	**-0.892****	**-0.756***
	(-3.80)	**(-3.79)**	**(-3.37)**	**(-3.41)**	**(-1.89)**	**(-1.95)**	**(-2.30)**	**(-1.87)**
SVOL×GFC	1.338	1.348	1.800	2.252	1.130	1.126	1.707	1.884
	(1.08)	(1.09)	(1.15)	(1.15)	(0.93)	(0.92)	(1.10)	(0.96)
GFC	-0.018***				-0.007			
	(-3.63)				(-1.39)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.050	0.062	0.098	0.047	0.034	0.036	0.074	0.020
# of observations	11,887	11,887	10,127	11,615	11,887	11,887	10,127	11,615

Panel B: Before and After the Decrease in Interest Rates

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IVOL	-0.637***	-0.631**	-0.148	-0.256	-0.178	-0.182	0.136	0.298
	(-2.59)	(-2.56)	(-0.41)	(-0.24)	(-0.73)	(-0.74)	(0.37)	(0.28)
SVOL	1.461	1.473	1.272	4.357***	1.022	1.015	0.926	3.036*
	(1.09)	(1.10)	(0.90)	(2.60)	(0.77)	(0.76)	(0.65)	(1.77)
IVOL×Rate_down	**2.293*****	**2.327*****	**0.392**	**1.965*****	**1.806*****	**1.817*****	**0.126**	**1.293***
	(4.35)	**(4.42)**	**(0.86)**	**(2.88)**	**(3.47)**	**(3.48)**	**(0.28)**	**(1.89)**
SVOL×Rate_down	-2.607**	-2.582*	-0.786	-4.604**	-2.132	-2.116	-0.435	-3.427
	(-1.97)	(-1.94)	(-0.57)	(-2.10)	(-1.61)	(-1.60)	(-0.31)	(-1.55)
Rate_down	-0.010**				-0.014***			
	(-2.23)				(-3.26)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.023	0.060	0.110	0.051	0.018	0.019	0.064	0.011
# of observations	11,939	11,939	10,033	11,680	11,939	11,939	10,033	11,680

Table A5. The IVOL Effects During the COVID-19, on Next Week Returns

This table replicate tests in Table 7. We regress next 1-week raw and weekly abnormal corporate bond returns on bond IVOL, interacted with the time dummy. In Panel A, the sample period spans from January 27, 2020 to March 20, 2020. The COVID dummy equals to 1 (0) for the four weeks after (before) February 24, 2020. In Panel B, the sample period spans from February 24, 2020 to April 17, 2020. The SMCCF dummy equals to 1 (0) for the four weeks after (before) March 23, 2020. The dependent variable in column (1) to (4), and column (5) to (8) are raw return and abnormal return in the next week, respectively. Weekly abnormal return is calculated as subtracting size-weighted average weekly returns of bonds in the same rating and maturity buckets from the raw return. There are no fixed effects in column (1) and (5). Column (2) and (6) include time fixed effects. Column (3) and (7) include both time and firm fixed effects while column (4) and (8) include time and bond fixed effects. Independent variables are the most recent available ones before each week. The control variables include bond rating, bond illiquidity, lagged one-week bond return, maturity, age, coupon, and bond size. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond. T-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the COVID-19

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
IVOL	-0.042	-0.114	0.349*	1.991*	-0.296**	-0.304**	0.372*	-0.368
	(-0.30)	(-0.76)	(1.66)	(1.83)	(-2.03)	(-2.10)	(1.72)	(-0.34)
SVOL	1.172***	1.747***	3.124***	8.694***	-0.209	-0.214	1.225**	5.827**
	(4.01)	(5.34)	(6.00)	(3.78)	(-0.65)	(-0.68)	(2.54)	(2.56)
IVOL×COVID	**0.299**	**-0.856*****	**-1.323*****	**-1.424*****	**-0.924*****	**-0.869*****	**-1.494*****	**-1.251*****
	(1.22)	**(-3.22)**	**(-4.41)**	**(-4.17)**	**(-3.40)**	**(-3.18)**	**(-4.76)**	**(-3.72)**
SVOL×COVID	-4.837***	-4.490***	-4.317***	-4.932***	-0.247	-0.219	0.157	-0.594*
	(-14.69)	(-12.93)	(-12.03)	(-14.58)	(-0.73)	(-0.65)	(0.44)	(-1.81)
COVID	-0.014***				0.005***			
	(-18.25)				(5.59)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.293	0.482	0.504	0.472	0.026	0.027	0.080	0.046
# of observations	34,862	34,862	29,849	34,486	34,862	34,862	29,849	34,486

Panel B: Before and After the SMCCF Announcement

	Weekly raw returns				Weekly abnormal returns			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
IVOL	-0.332	-1.173***	-1.457***	-0.837	-1.091***	-1.161***	-1.126***	0.018
	(-1.01)	(-3.69)	(-3.47)	(-1.15)	(-3.55)	(-3.71)	(-2.87)	(0.03)
SVOL	-7.600***	-5.565***	-4.353***	-5.850***	-1.196**	-0.960*	0.830	0.173
	(-12.18)	(-8.95)	(-6.06)	(-6.14)	(-2.22)	(-1.69)	(1.38)	(0.22)
IVOL×SMCCF	**1.617*****	**2.311*****	**2.721*****	**2.577*****	**1.354*****	**1.424*****	**1.762*****	**1.236****
	(3.85)	**(5.69)**	**(5.21)**	**(4.26)**	**(3.43)**	**(3.58)**	**(3.48)**	**(2.07)**
SVOL×SMCCF	7.869***	6.853***	6.037***	7.530***	1.280**	1.344**	-0.106	0.423
	(12.35)	(11.38)	(8.89)	(9.37)	(2.31)	(2.45)	(-0.19)	(0.64)
SMCCF	0.032***				-0.007***			
	(25.41)				(-6.08)			
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Bond FE	N	N	N	Y	N	N	N	Y
Time FE	N	Y	Y	Y	N	Y	Y	Y
Adj-R^2	0.265	0.457	0.476	0.455	0.019	0.021	0.060	0.026
# of observations	34,129	34,129	29,159	33,732	34,129	34,129	29,159	33,732

Table A6. Summary Statistics for Different IVOL measures

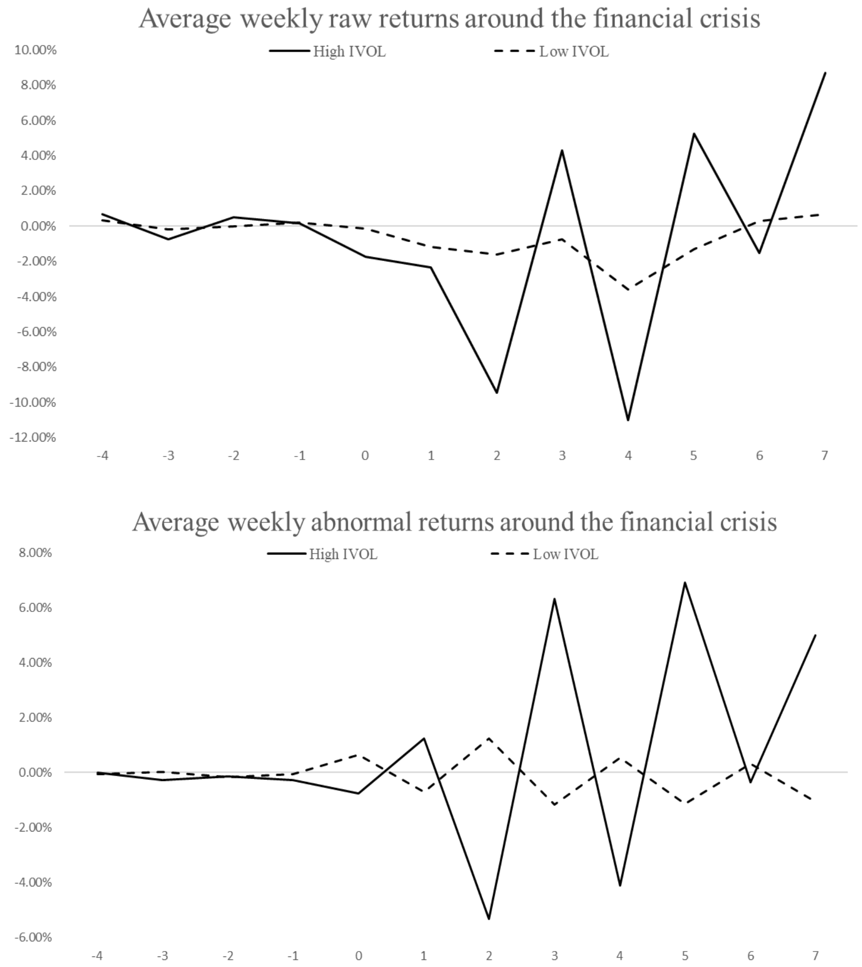
This table provides descriptive statistics of bond IVOL calculated with different methods. We report the number of bond-month observations (N), the time-series average of cross-sectional mean, standard deviation, the 5th percentile, lower quartile (Q1), median, upper quartile (Q3), and the 95th percentile for each IVOL measure in percentage. From the top to the bottom, IVOL measures marked as Daily_FF_P6, Daily_BBW_P6, Daily_FF_P36, Daily_BBW_P36, Monthly_FF_P36, and Monthly_BBW_P36 are separately the standard deviation of residuals from time-series regressions of: i) daily bond excess returns on daily Fama and French (FF, 1993) factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX over past 6-month; ii) daily bond excess returns on daily Bai, Bali, and Wen (BBW, 2019) factors (MKT_bond, DRF, CRF, LRF) over past 6-month; iii) daily bond excess returns on daily FF factors plus ΔVIX over past 36-month; iv) daily bond excess returns on daily BBW factors over past 36-month; v) monthly bond excess returns on monthly FF factors plus ΔVIX over past 36-month; and vi) monthly bond excess returns on monthly BBW factors over past 36-month. To make IVOL measures from daily and monthly returns comparable, we multiply IVOL obtained from daily returns by $\sqrt{22}$. The sample period is from July 2002 to December 2019.

IVOL measures	N	Mean	Std	5th	Q1	Median	Q3	95th
Daily_FF_P6	763,909	5.27	6.05	1.11	2.22	3.66	6.22	14.04
Daily_BBW_P6	712,993	4.45	4.03	0.99	1.97	3.24	5.58	11.80
Daily_FF_P36	973,046	6.93	8.77	1.41	2.87	4.79	7.87	18.23
Daily_BBW_P36	909,607	5.32	4.56	1.20	2.44	4.04	6.79	13.27
Monthly_FF_P36	450,096	2.46	2.83	0.54	0.96	1.58	2.68	7.83
Monthly_BBW_P36	443,766	2.40	2.65	0.52	0.94	1.57	2.71	7.38

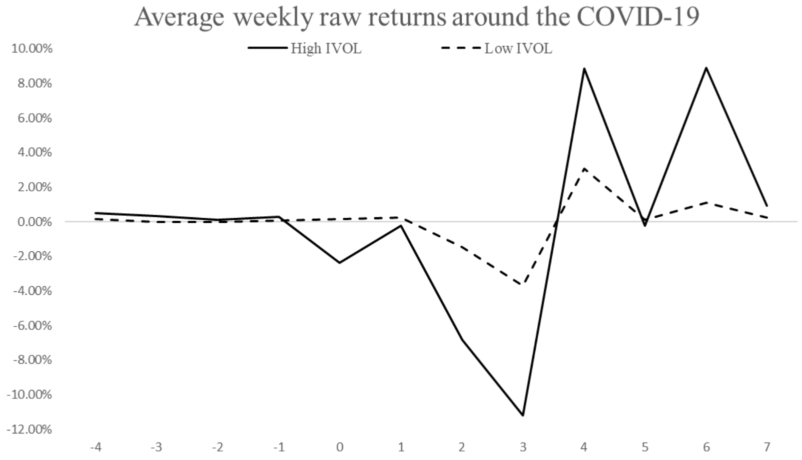
Figure 1. The IVOL Effects During Periods of Stress

This figure shows the average weekly raw and abnormal returns for bonds with high versus low IVOL, during the period of global financial crisis in Panel A and COVID-19 crisis in Panel B, respectively. In Panel A, week 0 is the week of the spark of financial crisis in 2008, and week 4 is the week of Fed's announcement of decreasing interest rates. In Panel B, week 0 is the week of the spark of COVID-19 in 2020, and week 4 is the week of Fed's announcement of SMCCF. Each week, we sort all bonds into five equal quintiles on bond IVOL as of the month-end prior to the week, and then calculate contemporaneous average portfolio raw and abnormal returns for the top (high IVOL) and bottom (low IVOL) quintiles.

Panel A: Weekly Raw and Abnormal Returns, Around the Financial Crisis



Panel B: Weekly Raw and Abnormal Returns, Around the COVID-19



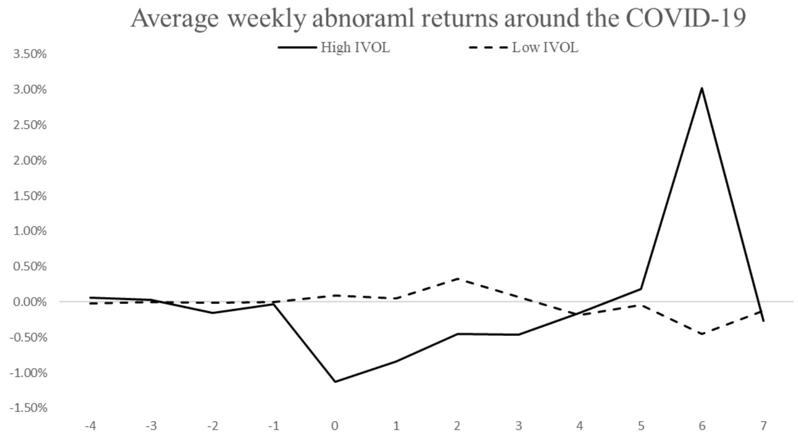


Figure 2. Time Series of Cross-Sectional Averages of Different IVOL Measures

This figure shows time-series of cross-sectional average of different IVOL measures in the sample period from December 2004 to December 2019 during which all the six measures are non-missing. IVOL measures marked as Daily_FF_P6, Daily_BBW_P6, Daily_FF_P36, Daily_BBW_P36, Monthly_FF_P36, and Monthly_BBW_P36 are separately the standard deviation of residuals from time-series regressions of: i) daily bond excess returns on daily Fama and French (FF, 1993) factors (MKT, SMB, HML, TERM, DEF) plus ΔVIX over past 6-month; ii) daily bond excess returns on daily Bai, Bali, and Wen (BBW, 2019) factors (MKT_bond, DRF, CRF, LRF) over past 6-month; iii) daily bond excess returns on daily FF factors plus ΔVIX over past 36-month; iv) daily bond excess returns on daily BBW factors over past 36-month; v) monthly bond excess returns on monthly FF factors plus ΔVIX over past 36-month; and vi) monthly bond excess returns on monthly BBW factors over past 36-month. To make IVOL measures from daily and monthly returns comparable, we multiply the IVOL obtained from daily returns by $\sqrt{22}$.