# Idiosyncratic Bond Volatility and Funding Liquidity†

Jie Cao, Tarun Chordia, and Linyu Zhou

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**Abstract**

A positive cross-sectional relation between returns and lagged idiosyncratic volatility (IVOL) obtains in the corporate bond market because dealers are less willing to accept high IVOL bonds into inventory during low funding liquidity periods and the subsequent relaxation of this constraint causes an increase in prices. An exogenous shock to funding liquidity due to the Volcker rule (which limited the provision of liquidity by corporate bond dealers) drives the identification. Both, the time-series shock to the supply of funding liquidity and the cross-sectional variations in the demand for funding liquidity following the Volcker rule, impact the bond IVOL-return relation.

*Keywords:* Corporate bonds, idiosyncratic volatility, bond dealers, funding liquidity, Volcker Rule

*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 negative cross-sectional relation between lagged idiosyncratic volatility (IVOL) and returns (IVOL-return relation henceforth).

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 large, especially in terms of the number of issues. Since stocks and bonds are contingent claims on the same firm value (Merton (1974)), bond returns, like those of stocks, should also be impacted by the same information, including information about

[1] French, Schwert, and Stambaugh (1987), Campbell and Hentschel (1992), Ghysels, Santa-Clara, and Valkanov (2005), and Lundblad (2007) document a positive relation while Glosten, Jagannathan, and Runkle (1993) report a negative relation between the conditional expected returns and the market volatility. 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.

IVOL. However, bond and stock markets seem to be segmented,[3] possibly because bonds and stocks have different investment clienteles. Hence, bonds may react differently to IVOL than stocks, 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.[4] We follow Chung, Wang, and Wu (2019) to define bond IVOL as the residual volatility in six-month rolling regressions of daily bond excess returns on Fama and French (FF, 1993) five factors plus the change in market volatility as proxied by $\Delta$VIX and confirm the positive relation between IVOL and expected returns. The cross-sectional bond IVOL-return relation is indeed positive and robust to factor adjusted returns using the FF factors or the BBW factors. However, it is not clear what drives this positive IVOL-return relation.[5]

Unlike the stock market, which is highly liquid and dominated by retail investors, the over-the-counter (OTC) corporate bond market is a highly illiquid and institutional market with large trade sizes. Given the importance of funding liquidity in the pricing of OTC markets (He and Krishnamurthy (2012, 2013)), we investigate the IVOL-return relation conditional on the funding liquidity of primary dealers (FILLIQ), who play a crucial role in providing liquidity in the corporate bond market. Specifically, FILLIQ=(1-ICR)$\times$100, where ICR is the intermediary capital ratio in He, Kelly, and Manela (2017). Low ICR or high FILLIQ indicates low equity capital in the capital structure of intermediaries (the primary dealers), high marginal value of capital, and, hence, high funding illiquidity. The interaction term IVOL$\times$FILLIQ is positively related to the next

[3] See Collin-Dufresne, Goldstein, and Martin (2001), Schaefer and Strebulaev (2008), and Kapadia and Pu (2012).
[4] In the Internet Appendix B, we reconcile the results of Chung, Wang, and Wu (2019) and Bai, Bali, and Wen (2021).
[5] Chung, Wang, and Wu (2019) suggest that "*The effect of idiosyncratic bond volatility represents a separate source of risk for corporate bonds whose channels deserve further investigation.*"

month bond return, suggesting that the IVOL-return relation is stronger in the presence of high funding illiquidity.

The reason for this positive impact of lagged IVOL on returns following periods of high funding illiquidity is as follows. As compared to the low IVOL bonds, dealers are less willing to take high IVOL bonds into inventory during low funding liquidity periods, i.e., when they are more capital constrained, than during high funding liquidity periods. In subsequent periods when the funding liquidity improves and as the cost of holding inventory decreases, dealers become less constrained when buying and selling bonds. A funding liquidity related decline in trading costs (Brunnermeier and Pedersen (2009)) causes the high IVOL bonds to increase relatively more in prices.

We consider several alternative explanations for our findings. We rule out the possibility that the intermediary funding liquidity is a proxy for macroeconomic conditions, which are the actual drivers of the IVOL-return relation. Neither the level of bond liquidity nor its covariance with the bond market liquidity factor can explain the bond IVOL-return relation. We also verify that it is the level of funding liquidity measured by the intermediary capital ratio, rather than funding liquidity risk as proxied by the intermediary capital risk factor, that drives the IVOL-return relation. Furthermore, we show that other potential explanations, including investor under-diversification, investor risk aversion, and the long-term return reversals, do not drive the result.

Our identification depends on an exogenous shock to funding liquidity due to the implementation of the Volcker Rule, which impaired the corporate bond market dealers' ability and willingness to absorb inventory. The Volcker Rule 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 the supply of funding liquidity (see, for example, 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 implementation of the Volcker Rule, and this is precisely what we find. In addition, we explore cross-sectional variations by examining the IVOL-return relation around investment grade (IG) to non-investment grade (NIG) downgrades which may trigger widespread selling pressure and demand for liquidity from institutions that face regulatory constraints in terms of their ability to invest in NIG bonds (e.g., Ambrose, Cai, and Helwege (2008); Ellul, Jotikasthira, and Lundblad (2011)). The IVOL-return effect is stronger for the downgraded bonds after the implementation of the Volcker Rule.

We also study the return dynamics of high IVOL bonds during low and high funding liquidity periods around two additional shocks – (i) the Global Financial Crisis (GFC) of 2008, and (ii) the Covid crisis of 2020. In both cases, there was an initial negative shock to the dealer capital (Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018); O'Hara and Zhou (2021)) followed by the Federal Reserve (Fed) expansionary intervention that restored funding liquidity. When funding liquidity is constrained during both crises, high IVOL bonds earn lower returns. Subsequently, when the Federal Reserve loosens monetary policy, the funding liquidity condition of primary dealers improves and returns for the high IVOL bonds rebound. We are cautious about making inferences from these two shocks since the severe macroeconomic dislocation around both crises makes it harder to claim that the impact on funding liquidity is not confounded by other factors.

Overall, we provide robust evidence that, unlike in the case of stocks, lagged corporate bond IVOL is positively related to bond returns, especially following periods of low funding liquidity. Our findings emphasize the important role of liquidity provision from primary dealers in the pricing of corporate bonds. The constrained capital of the primary dealers limits their ability to absorb the sell order flow during periods of low funding liquidity, and this subsequently leads to the positive IVOL-return relation in the corporate bond market.

This paper contributes to two streams of the literatures, (i) the impact of IVOL on returns and (ii) intermediary asset pricing. The impact of IVOL on returns has been studied mainly in the context of stocks, where a positive IVOL-return relation would be consistent with investor under-diversification (Merton (1987)) while a negative IVOL-return relation could be driven by the skewness preferences of investors (e.g., Bali, Cakici, and Whitelaw (2011)) or the limits to arbitrage (e.g., Stambaugh, Yu, and Yuan (2015)). In the corporate bond market, we show that funding illiquidity negatively impacts the dealers' willingness to take high IVOL bonds into inventory and this is the source of the positive cross-sectional bond IVOL-return relation.

While a large literature on intermediary asset pricing focuses on the risk of impairment of intermediary capital, this paper suggests a role for the level of intermediary capital in the pricing of corporate bonds. He and Krishnamurthy (2012, 2013), Brunnermeier and Sannikov (2014), Siriwardane (2015), and Goldberg and Nozawa (2021) have highlighted the importance of funding liquidity in explaining the pricing of financial assets.[6] Primary dealers play a central market making role in the OTC corporate bond market and the financial friction arises when the funding liquidity environment is impaired. Then, capital constrained dealers become reluctant to take on inventory and this drives the positive bond IVOL-return relation.

## 2. Data

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.[7] Enhanced TRACE includes more transactions than the standard TRACE database in disseminating both sides of the inter-dealer trade. Besides,

[6] Market liquidity also impacts bond returns. Both the liquidity level (Bao, Pan, and Wang (2011)) and the exposure to liquidity risk factor (Lin, Wang, and Wu (2011)) are priced in the cross-section of corporate bonds.

[7] 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 enhanced TRACE data.

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 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.

Following Bai, Bali, and Wen (2019), we apply 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 floating rate or odd frequency of coupon payments; and (vi) have less than one year to maturity. Then 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. 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. 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 $t$.[8] Bond $i$'s excess return at month or day $t$ is $R_{i,t} = r_{i,t} - r_{f,t}$, where $r_{f,t}$ is the risk-free rate proxied by the one-month Treasury bill rate.

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

Following Chung, Wang, and Wu (2019), we define the idiosyncratic volatility (IVOL) for bond $i$ in month $t$ as the standard deviation of return residuals, $\epsilon_{i,t}$, from a time-series regression of daily excess returns $R_{i,t}$ on the Fama and French (1993) five factors (MKT, SMB, HML, TERM, and DEF) plus ΔVIX over the past six months,[9]

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

The systematic volatility (SVOL) for bond $i$ is the standard deviation of the fitted returns estimated using Equation (2). 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.[10]

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

[8] Computing accrued interest requires the coupon, 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.
[9] 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 retrieved from FRED. Other daily factors are retrieved from Ken French's website.
[10] The average (median) number of daily bond returns in the past 6-month window used to estimate IVOL is 51 (41). Results remain unchanged if we limit the number of non-missing daily returns to be higher than 48, 60, 80, and etc.

& Poor's (S&P).[11] 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 ten while non-investment-grade (high-yield) bonds have ratings above ten. 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 in Bao, Pan, and Wang (2011). RET1 is the bond return in the last month. Bond momentum (MOM) is cumulative monthly return over the past six months, 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 the number of outstanding bonds.

### *2.3. Descriptive statistics*

After merging enhanced TRACE and Mergent FISD datasets, our 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 statistics, for monthly returns, bond IVOL, SVOL, and other 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 8.56 (equivalent to BBB for S&P or Baa for Moody's), time-to-maturity is 9.27 years, time-since-issuance is 4.30 years, and par value of outstanding bonds 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%.

[Insert Table 1 about here]

Panel B of Table 1 reports the time-series averages of the cross-sectional correlations among bond IVOL, SVOL, and other bond characteristics. The correlation between bond

[11] A 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.

IVOL and SVOL is 0.82. Also, compared to IVOL, SVOL has lower correlations with bond characteristics like rating, coupon and size, consistent with its role as a measure of systematic risk. IVOL is moderately correlated with rating, ILLIQ, and coupon with correlations of 0.38, 0.57, and 0.30 respectively, indicating that bonds with the higher credit risk, lower liquidity, and higher coupon rate have, on average, higher idiosyncratic volatilities. Bond size is negatively correlated with bond IVOL with a correlation of -0.43, indicating a smaller IVOL for larger bond issues.

## 3. The Impact of Funding Illiquidity on the Bond IVOL-return Relation

In this section, we first confirm the significantly positive cross-sectional relation between lagged IVOL and bond returns documented in Chung, Wang, and Wu (2019). We then extend their findings by investigating the bond IVOL-return relation conditional on funding illiquidity, under the rationale that corporate bond trading is dominated by institutions in the corporate bond market and hence the capacity of financial intermediaries such as the primary dealers to provide liquidity possibly plays an important role in the pricing of corporate bonds.

### *3.1. The replication of bond IVOL-return relation*

In this subsection, we analyze 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.[12] 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 IVOL quintile and the difference between the highest and lowest IVOL quintiles. The average returns are in percent per month and Newey-West (1987) *t*-

[12] Throughout the paper, value-weighting uses the number of outstanding bonds as weights.

statistics with three lags are reported in parenthesis.

[Insert Table 2 about here]

With equal weighting, the average bond excess return in quintile IVOL,1 is 0.23% per month, and it increases monotonically to 1.20% per month in quintile IVOL,5. 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. Results for the EW and VW IVOL portfolios are quite similar. The last six columns report average bond characteristics, including the bond credit rating, age, maturity, ILLIQ, size, and 5% Value-at-Risk (VaR).[13] Age, maturity, and ILLIQ increase monotonically while size decreases with IVOL, consistent with 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 examine the IVOL-return relation after controlling for the other bond characteristics. In Panel B of Table 2, we first sort bonds into five quintiles based on a bond characteristic (illiquidity, rating, bond size, age, maturity, and coupon). Then, within each quintile, we sort bonds based on IVOL into five portfolios. All portfolios are rebalanced monthly and are value-weighted. Then the five portfolios sorted on IVOL are averaged across the characteristic quintiles. The excess returns of long-short IVOL portfolios are still significantly positive and have similar magnitudes to those in Panel A, thereby suggesting that it is IVOL instead of other bond characteristics that IVOL might be proxying for, that drives the IVOL-return relation.

We also run Fama-MacBeth regressions to examine the cross-sectional relation between IVOL and excess returns with bond characteristics as controls. Panel C of Table 2 reports the time-series averages of the slope coefficients (multiplied by 100) and the

[13] We follow Bai, Bali, and Wen (2019) to define 5% VaR as the second lowest monthly return over the past 36 months as a measure of a bond's downside risk.

average adjusted-$R^2$. 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, using the Fama and French (1993) five factors (MKT, SMB, HML, DEF, and TERM) as well as the Bai, Bali, and Wen (BBW, 2019) four factors (MKT_bond, DRF, CRF, and LRF).[14] The methodology is described in the Appendix.[15]

In addition to the bond characteristics including bond rating, illiquidity, maturity, age, coupon, and size, we also control for lagged one-month bond returns (RET1) (Bali, Subrahmanyam, and Wen (2021)) and bond momentum (MOM) over past 6-month skipping the most recent month (Jostova, Nikolova, Philipov, and Stahel (2013)). 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 (1993) five factors and the BBW (2019) four factors, respectively.

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

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[14] Monthly TERM and DEF factors are computed similarly to the daily TERM and DEF factors. We thank the authors for providing the monthly BBW factors, https://drive.google.com/file/d/1U8lxEryuu3xF484x5Hh7Uaftpqd--ZCx/view. The DRF and CRF factors are available from July 2004.

[15] The 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. Note that by using risk adjusted returns, the errors in the factor loadings are impounded in the dependent variable.

*3.2. Intermediary funding illiquidity*

Given that institutions dominate the bond market,[16] there is a burgeoning literature highlighting the importance of funding liquidity in the intermediary pricing models in explaining the pricing behavior of financial assets, including derivatives and OTC assets (He and Krishnamurthy (2012, 2013); Brunnermeier and Sannikov (2014); and Siriwardane (2015)). Goldberg and Nozawa (2021) show that liquidity supply shocks impact aggregate dealer inventory capacity and have significant explanatory power for both cross-sectional and time-series variation in expected returns for corporate bonds, beyond the standard risk factors. Their findings point to liquidity supply by financially constrained intermediaries as a main driver of asset prices in the corporate bond market.

Based on the importance of funding liquidity and the cross-sectional heterogeneity in liquidity provision by intermediaries in the corporate bond market, in this subsection, we investigate whether the financial frictions caused by shocks to primary dealer capital has any implications for the cross-section of bond returns. The idea is to exploit the impact of funding liquidity shocks on the cross-section of the bond IVOL-return relation. As a measure of funding liquidity, we use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017). They show that the intermediary (primary dealer) sector's net worth (or, equivalently, its equity capital ratio) is a sensible proxy of its marginal value of wealth. When the intermediary capital ratio is low, i.e., the aggregate funding liquidity available for intermediation is low, the marginal value of intermediary capital is high and risk bearing capacity is constrained.[17]

[16] Institutional investors dominate the US corporate bond market. Retail investors hold less than 10% of the outstanding corporate bonds (Federal Reserve Statistical Release: Z.1 Financial Accounts of the U.S., September 21, 2017).

[17] ICR is the aggregated market value of equity of the primary dealers divided by the sum of their aggregated market value of equity and book value of debt. 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. He, Kelly, and Manela (2017) argue that their measure of funding liquidity, the intermediary capital ratio (ICR), is better than the broker-dealer leverage (BDL) of Adrian, Erkko, and Muir (2014) as the ICR is consistent with the

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. In the sample from July 2002 to December 2019, the raw ICR measure ranges from 2.23% to 9.15%, with the average and standard deviation of 6.37% and 1.61%, respectively. Throughout the paper, we define the proxy for funding illiquidity (FILLIQ) as (1-ICR) multiplied by 100, which ranges from 90.85 to 97.77.

### *3.2.1. The impact of funding illiquidity on the IVOL-return relation*

When funding liquidity is low, we expect the primary dealers to be less willing to provide liquidity for riskier bonds with high IVOL. This is what we test. Specifically, we run panel regressions of next month returns on IVOL and SVOL, interacted with FILLIQ. Dependent variables are excess returns as well as the risk-adjusted returns using the FF five-factor model and BBW four-factor model.[18] We use the same set of controls as in Panel C of Table 2.

One concern is that dealers care about other bond characteristics or that IVOL may be a proxy for some other variable that drives the IVOL-return relation and we may be capturing a spurious relation between the funding illiquidity and the IVOL-return relation. Therefore, we include not only the bond characteristics but also their interactions with FILLIQ as additional controls. 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, including time fixed effects and either firm or bond fixed effects in Table 3. Standard errors are clustered by bond and time, and the *t*-statistics are

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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. We thank the authors for providing the data: https://voices.uchicago.edu/zhiguohe/data-and-empirical-patterns/intermediary-capital-ratio-and-risk-factor/.

[18] Kelly, Palhares, and Pruitt (2023) propose a five-factor model based on the instrumented principal component analysis (IPCA). Results remain unchanged with IPCA factor adjusted returns. We thank the authors for providing the factors: https://sethpruitt.net/2022/03/29/reconciling-trace-bond-returns.

reported in parenthesis. The coefficients on these control variables are shown in Panel A of the Internet Appendix Table A1.

[Insert Table 3 about here]

The coefficient estimates on the interaction term IVOL×FILLIQ in Table 3 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 FILLIQ is high, i.e., when the funding liquidity is low. In economic terms, a one-standard-deviation increase in IVOL is related to an increase of about 0.52% in the next month risk-adjusted return with the FF factors with bond and month fixed effects.[19] In terms of explanatory power, we find that excluding IVOL×FILLIQ from the panel regressions causes the adjusted-$R^2$ to decline by about 0.3% to 0.5% across the specifications, while excluding the interaction terms of other bond characteristic and FILLIQ makes no difference to the adjusted-$R^2$. The coefficient estimates of SVOL and the interaction term SVOL×FILLIQ are generally insignificant, consistent with the results in Panel C of Table 2. This implies that, even though IVOL and SVOL have a high cross-sectional correlation, their impact on returns is quite distinctive.

Previous studies (see e.g., Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008); Bao, Pan, and Wang (2011); Friewald, Jankowitsch, and Subrahmanyam (2012); and Bongaerts, De Jong, and Driessen (2017)) have documented an illiquidity premium in the corporate bond market, i.e., more illiquid bonds earn higher returns. However, the insignificant coefficients on bond illiquidity and its interaction with FILLIQ in Panel A of the Internet Appendix Table A1 suggest that the impact of FILLIQ on the bond IVOL-return relationship cannot be explained by bond illiquidity. Moreover, the impact of bond

[19] Given that the sample average of FILLIQ is 93.63, The economic magnitude is calculated as follows: $-20.102 \times 1.29\% + 0.219 \times 1.29\% \times 93.63 = 0.52\%$.

illiquidity is not sensitive to the choice of the liquidity measure. For instance, Panel B of the Internet Appendix Table A1 documents that the baseline results remain essentially unchanged if we use the monthly average of daily Imputed Round-trip Costs (IRC) liquidity measure of Dick-Nielsen, Feldhütter, and Lando (2012) as an alternative measure of bond illiquidity.

Institutions are often restricted, by regulation, private investment mandates, asset management policies, or regulatory capital requirements, from investing in NIG (non-investment-grade) bonds, which leads to the segmentation between IG (investment-grade) and NIG bonds.[20] It is possible that funding liquidity has different pricing implications for IG versus NIG bonds. We further interact IVOL, FILLIQ, with the NIG dummy, which equals one for bonds with ratings lower than BBB$^-$, and zero otherwise. As shown in the Internet Appendix Table A2, after interacting with the NIG dummy, the coefficients on the interaction term of IVOL and FILLIQ are positive yet insignificant. Together with the significantly positive coefficients on IVOL×FILLIQ×NIG, it implies that following low funding liquidity, the positive IVOL effect concentrates in the NIG bonds.

### *3.2.2. Dealer and institutional corporate bond holdings*

The results, thus far, are surprising in that it is the idiosyncratic volatility that is priced. Institutional investors should hold diversified portfolios such that IVOL is not priced. Also, bond returns are not impacted by systematic volatility during periods of high funding illiquidity. This difference in the impact on bonds with different IVOL rather than different SVOL could be due to dealers not willing to accept high IVOL bonds into inventory when their capital is constrained.

Goldstein and Hotchkiss (2020) document that dealers endogenously adjust their

[20] For instance, insurance companies, who take up a large market share (nearly 30%) of US corporate bonds, are restricted by the National Association of Insurance Commissioners (NAIC) to hold a limited proportion of NIG bonds in their portfolios. The capital requirements for the holdings of NIG bonds are also much higher than for IG bonds.

behavior to mitigate inventory risk from trading in risky bonds. When dealers face both significant inventory risk upon purchasing a bond from a customer and potentially high search costs in locating a counterparty for an offsetting trade, they have a substantially higher propensity to offset trades within the same day rather than committing capital for longer periods, especially for riskier bonds. Thus, compared to low IVOL bonds, the primary dealers are likely to be more reluctant to allocate capital to the risky, high IVOL bonds during periods of low funding liquidity (when their capital is more constrained) than during high liquidity periods. In other words, dealers are less willing to take high IVOL bonds into inventory and it is the subsequent willingness on part of dealers to supply liquidity following the low funding liquidity periods that gives rise to the positive IVOL-return relation.[21]

To test this hypothesis, we examine the aggregate dealer inventory changes for high and low IVOL bonds across high and low funding liquidity periods. We define the monthly aggregate dealer inventory change, i.e., dealer net buy, as the difference in the par value between aggregate dealers buys from customers and aggregate dealers sells to customers in a month, scaled by the number of outstanding bonds. In each month, we sort 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. We define a month with the intermediary capital ratio above (below) median to be a high (low) funding liquidity month. The monthly average dealer inventory changes are computed in the full sample and in the two extreme IVOL groups during the high and low funding liquidity periods. Results are shown in Panel A.1 of Table 4.

In the full sample results, we see that dealers buy more of the IVOL,5 bonds as compared to the IVOL,1 bonds. For IVOL,5 bonds, the average monthly dealer net buy is 0.022% (0.305%) in low (high) funding liquidity periods. The difference in dealer net

[21] We provide the direct identification for the dynamic mechanism of contemporaneous price declines and subsequent increases for the high IVOL bonds with exogenous shocks to the funding liquidity in Section 4.2.

buys between low and high funding liquidity periods for IVOL,5 bonds is -0.283% ($t$-statistic = -2.67). The economic magnitude is non-trivial given that the average cross-sectional median of dealer net buy is 0.019%. Also, during high funding liquidity periods, dealers buy more of the IVOL,5 bonds as compared to the IVOL,1 bonds with the difference being 0.307 ($t$-statistic = 2.71). The average differences-in-differences of dealer net buys between high and low IVOL bonds and between low and high funding liquidity periods is -0.296% ($t$-statistic = -2.59). Thus, compared to IVOL,1 bonds, dealers are much less willing to take the IVOL,5 bonds into inventory during the low funding liquidity periods as compared to high funding liquidity periods.

[Insert Table 4 about here]

Next, we study the demand for liquidity by examining the ownership changes of US institutional investors, which primarily consist of insurance companies and bond mutual funds.[22] In Panels B, C, and D of Table 4, we calculate the average ownership changes for each bond in each quarter, i.e., the change in the holding amount of a bond, scaled by the number of outstanding bonds, for institutions, insurance companies, and mutual funds, respectively. We average the ownership changes in the full sample and in the two extreme bond IVOL quintiles during high and low funding liquidity periods. In the full sample we see that institutions as well as insurance companies and mutual funds, increase their holdings of the IVOL,1 bonds and decrease their holdings of the IVOL,5 bonds. With institutions decreasing their holdings, it is not surprising to find that dealers end up purchasing the IVOL, 5 bonds (see Panels A.1 at the monthly frequency and A.2 at the quarterly frequency).

Also, institutions decrease their holdings of high IVOL bonds during high and low

[22] Corporate bond holdings by US institutions are extracted from Thomson Reuters Lipper eMAXX, which is survivorship-bias free and contains quarter-end security-level corporate bond holdings of about 20,000 institutional investors, including insurance companies, mutual funds, and pension funds. Foreign investors are excluded.

funding liquidity periods. In fact, the decline in institutional holdings is larger during high funding liquidity periods possibly because the dealers are willing to accept more inventory during these periods. Note that the difference-in-differences are statistically insignificant, possibly because of the smaller sample size due to data availability at only the quarterly frequency. This is confirmed by the results in Panel A.2 of Table 4 when the dealers buys and sells are sampled at the quarterly frequency the difference-in-differences tests are insignificant.[23]

*3.3. Potential explanations*

In this subsection, we consider alternative potential explanations for our findings. We discuss each of the different explanations in the subsections below.

*3.3.1. Macroeconomic conditions*

To investigate the possibility that the intermediary funding liquidity is a proxy for macroeconomic conditions, and it is the macro variables rather than funding liquidity that drives the IVOL-return relation, we interact the macroeconomic variables with IVOL. Specifically, in Table 5, we include interactions of IVOL with the Chen, Roll and Ross (1986) variables, monthly industrial production change (MP), inflation change (DINF), the TERM, and the DEF in the baseline regressions.[24]

[Insert Table 5 about here]

The coefficients on the interaction term $\text{IVOL} \times \text{FILLIQ}$ remain positive and

---

[23] We report the quarterly dealer inventory changes, defined as the difference in the par value between all dealers' buy from customers and all dealers' sell to customers in a quarter scaled by the number of outstanding bonds, in Panel A.2 of Table 4. The average differences-in-differences of quarterly dealer net buy is insignificant, but the sign is still negative. Given the differences in sample size and that we observe the dealers' inventory change dynamics more clearly at the monthly than quarterly frequency, it is possible that the average monthly (quarterly) differences-in-difference of dealer net buy is significant (insignificant).
[24] MP measures the growth rate in US industrial production. Inflation change is defined as the monthly change in the natural log of the US Consumer Price Index.

significant across all the specifications with magnitudes close to those in the baseline regressions, while the interactions of IVOL with the macroeconomic variables are generally insignificant. In contrast, coefficients on SVOL×MP are significantly negative, indicating that the macroeconomic conditions impact the systematic volatility and drive the cross-sectional SVOL-return but not the IVOL-return relation.

Another concern is that it could be the general market liquidity conditions instead of intermediary funding liquidity that impacts the cross-sectional pricing of bond IVOL. To proxy for the overall market-wide liquidity, we use the "noise" measure in Hu, Pan, and Wang (2013), which exploits the connection between liquidity and the amount of arbitrage capital available in the US Treasury market.[25] We take the average of the daily "noise" measure each month,[26] and further interact it with IVOL and SVOL. In Panel A of the Internet Appendix Table A3, the coefficients on IVOL×FILLIQ remain significantly positive across all the columns, while those on IVOL×Noise are insignificant. Therefore, the general market-wide liquidity does not subsume the impact of funding liquidity on bond IVOL-return relation.

In a liquidity-adjusted capital asset pricing model, Acharya and Pedersen (2005) show that the required return of an asset depends on the level of liquidity and covariances of its returns and liquidity with market returns and market liquidity. We further examine whether the bond IVOL-return relation could be driven by bond liquidity risk in the spirit of Acharya and Pedersen (2005). For bond portfolios sorted on size and time-to-maturity, we calculate the following three liquidity betas using the full sample monthly time-series, including i) the covariance between a bond's illiquidity and the market illiquidity; (ii) bond return covariance with market illiquidity; and (iii) bond illiquidity covariance with market returns. Then, we assign the portfolio betas to individual bonds. In Panel B of the

[25] The shortage of arbitrage capital allows the yields to deviate more from the yield curve, resulting in more noise in prices, and the average "pricing errors" measure the illiquidity of the aggregate market. The noise measure performs well in capturing various market-wide liquidity crises.

[26] The correlation between this monthly "noise" measure and our funding illiquidity proxy FILLIQ is 0.46.

Internet Appendix Table A3, we additionally control for three bond-level liquidity betas and their interactions with FILLIQ. The positive coefficients on IVOL×FILLIQ remain significant and have similar magnitudes to those in the baseline regressions, suggesting that the impact of funding liquidity on the bond IVOL-return relation is not driven by bond liquidity risk, either.

### *3.3.2. Funding liquidity risk*

Thus far, we have shown that the cross-sectional IVOL-return relation is significantly positive following low funding liquidity periods. We have focused exclusively on the level of funding liquidity, proxied by the intermediary capital ratio (ICR). But could the ICR be proxying for funding liquidity risk? He, Kelly, and Manela (2017) find that shocks to the equity capital ratio of financial intermediaries, i.e., the intermediary capital risk factor (ICRF) defined as the innovation in the AR(1) process of ICR divided by the lagged capital ratio, exhibits significant explanatory power for the cross-sectional variation in expected returns for different asset classes, including corporate bonds. Using ten portfolios sorted on yield spreads (Nozawa (2017)), they obtain an intermediary capital risk premium for corporate bonds of 7.56% per quarter with a $t$-statistic of 2.58 and $R^2$ of 84%.

We follow He, Kelly, and Manela (2017) to assess whether differential exposures to the intermediary capital risk factor could explain the variation in expected returns for bonds with high and low IVOL. Each month, we form value-weighted IVOL portfolios by sorting corporate bonds into deciles based on bond IVOL, and ask whether different factor models, including (i) MKT_bond, (ii) MKT_Stock, SMB, HML, TERM, and DEF, and (iii) MKT_bond, DRF, CRF, and LRF, could capture the time-series return variations in IVOL sorted portfolios, controlling for the portfolio averages of bond characteristics including bond systematic volatility (SVOL), rating, illiquidity (ILLIQ), lagged one-month return (RET1), MOM, maturity, age, coupon, and size. Specifically, we ask whether the alphas of bond IVOL portfolios from time-series regressions are jointly zero.

We also examine the alpha of the long-short IVOL portfolio (IVOL,10 – IVOL,1). To assess whether funding liquidity risk drives the IVOL-return relation, we investigate the incremental impact of ICRF by comparing long-short IVOL portfolio alphas in factor models with and without ICRF.

The *p*-values of the GRS tests in Panel A of the Internet Appendix Table A4 suggest that the null hypothesis that all of the alphas of bond IVOL portfolios are jointly zero is rejected for all cases (with and without ICRF), except for the third model. The long-short portfolio alphas in Panel A also suggest that ICRF has no incremental ability to explain IVOL portfolio returns.

We then run cross-sectional regressions of portfolio excess returns on the factor betas to estimate the risk premiums on ICRF, with the same sets of average bond characteristics within portfolios. Panel B of the Internet Appendix Table A4 reports the risk premiums for ICRF with the Newey-West (1987) adjusted *t*-statistics in parenthesis. The risk premiums for ICRF are indistinguishable from zero. Thus, funding liquidity risk does not drive the pricing of bond IVOL. Moreover, for funding liquidity risk to impact bond IVOL pricing, the price of risk for the high IVOL bonds would have to vary with the intermediary balance sheet constraints. Instead, it is the level of funding liquidity that drives the bond-IVOL relation.

### *3.3.3. Under-diversified investor portfolios*

Could the positive return for bonds with high IVOL be the compensation for under-diversified portfolios as suggested by Merton (1987)? To proxy for the extent of diversification, we obtain the quarter-end number of corporate bonds held by institutions and the Herfindahl–Hirschmann Index (HHI) of their portfolios.[27] The difference in the time-series average of cross-sectional mean for the number of bonds held between low and

[27] The institutions include US insurance companies, mutual funds, and pension funds. We obtain their quarterly holding information from eMAXX.

high funding liquidity periods is 0.75 ($t$-statistic = 0.52). This is negligible compared to the quarterly average number of bonds in institutional portfolios of 64. In addition, the average cross-sectional means of HHI of institutional portfolios are 0.167 and 0.163 during low and high funding liquidity periods, respectively. The lack of variation in institutional bond portfolio diversification across high versus low funding liquidity periods rejects the hypothesis that the positive IVOL-return relation represents compensation for holding less diversified portfolios.

Thus, the bond portfolios of institutional investors seem to be well diversified. It is the possible lack of diversification of dealer portfolios due to investor sells of high IVOL bonds during periods of low funding liquidity that possibly drives the results.

*3.3.4. Risk aversion*

Could time-varying investor risk aversion lead to the positive IVOL-return relation during periods of high funding illiquidity? Specifically, when the funding liquidity condition deteriorates, investors are more risk-averse to high IVOL bonds and hence require higher returns as compensation. We use the time series of the monthly aggregate investor risk aversion index (RR) in Bekaert, Engstrom, and Xu (2022) to examine this possibility.[28] We add the interaction terms IVOL×RR and SVOL×RR in our baseline regressions, to control for the conditional effects of investor risk aversion on bond returns.

The Internet Appendix Table A5 shows that, after controlling for the impact of risk aversion, the coefficients on IVOL×FILLIQ remain significantly positive. On the other hand, the coefficients on IVOL×RR are insignificant for all the specifications. Thus, it is

[28] Bekaert, Engstrom, and Xu (2022) develop a measure of the time-varying price of risk. i.e., risk aversion, with a dynamic no-arbitrage asset pricing model for equities and corporate bonds. The aggregate risk aversion coefficient reflects the relative risk aversion of the marginal investor in a generalized habit-like model with preference shocks. Specifically, it is a function of six financial instruments, namely the term spread, credit spread, a detrended earnings yield, realized and risk-neutral equity return variance, and realized corporate bond return variance. We thank the authors for providing the US risk aversion index: https://www.nancyxu.net/risk-aversion-index.

the funding liquidity rather than investor risk aversion that drives the cross-sectional IVOL-return relation in the corporate bond market.

*3.3.5. Long-term return reversals*

While we have controlled for the lagged one-month bond return to control for the possibility of a short-term reversal, we now control for long-term return reversal (LTR).[29] Following Bali, Subrahmanyam, and Wen (2021), LTR is defined as the past 36-month cumulative returns from month $t-48$ to month $t-13$ while skipping the 12-month momentum and one-month short-term reversal month. Results with LTR and its interaction with FILLIQ as the additional controls are presented in Panel A of the Internet Appendix Table A6. The coefficients on IVOL$\times$FILLIQ remain significantly positive across all specifications and the magnitudes are very close to the baseline results in Table 3, suggesting that LTR does not affect the role of funding illiquidity in driving the cross-sectional bond IVOL-return relation.

*3.3.6. Alternative measures of IVOL and funding liquidity*

We also consider 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 slightly larger than the IVOL measure obtained using the past 6-month daily returns. The positive coefficients on IVOL$\times$FILLIQ in Panel B of the Internet Appendix Table A6 confirm the positive impact of funding illiquidity on the cross-sectional IVOL-return relation. The magnitudes are lower than those in Table 3, probably because for the IVOL

[29] Controlling for LTR leads to a decline in sample size and hence we do not include LTR in the main tests.

measure from past 36-month contains information from a longer history that may be less related to current prices.

Next, we check the robustness using a different proxy for funding illiquidity, the CBOE volatility index VIX.[30] VIX is obtained from the prices of S&P 500 index options and is a real-time, model free, risk neutral measure of implied volatility representing the market's expectations of volatility over the next 30 days. A higher VIX implies that future volatility is expected to be high making it riskier for intermediaries to hold inventory and, thus, to provide liquidity, especially for high IVOL bonds.[31] In our sample, the VIX measure ranges from 10.13 to 62.64, with the mean and standard deviation of 18.85 and 8.42, respectively. Panel C of the Internet Appendix Table A6 presents 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 conditional IVOL-return relation is driven by the funding liquidity level, rather than by macroeconomic conditions, funding liquidity risk, investor under-diversification, time-varying investor risk aversion, or long-term return reversals. It is also robust to alternative specifications of IVOL and funding illiquidity measures.

## 4. Identification

In this section, we exploit an exogenous shock to funding liquidity, to support the idea that funding liquidity causally drives the positive IVOL-return relation. The Volcker Rule, implemented on April 1, 2014, is a federal regulation that was enacted to prevent banking

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[30] Jiang, Li, Sun, and Wang (2022) use VIX as the proxy for financial market stress. Goldstein, Jiang, and Ng (2017) also stress the importance of VIX in the corporate bond market.

[31] One concern is that investors' demand for high IVOL bonds falls more than for low IVOL bonds during high VIX periods. Thus, it is possible that the change in investor demand, rather than dealer funding liquidity, drives the positive cross-sectional IVOL-return relation. To rule out potential confounding effects, we use the Volcker Rule in Section 4.1 as an exogenous shock to dealer capital allocated to corporate bonds. The Rule reduced the ability of bank-affiliated dealers to provide liquidity, especially to the risky (high IVOL) bonds, but not affect investor demand for bonds with high versus low IVOL.

excesses such as those that led to the financial crisis of 2008. The goal was to prevent financial institutions 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 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. The impact is likely to be larger for the high IVOL bonds for which the dealers are more reluctant to supply liquidity.

### *4.1. The IVOL-return relation after the Volcker Rule*

We first conduct an event study around the implementation of the Volcker Rule. A large impact of ICR on the cross-sectional bond IVOL-return relation after the implementation can lend support to the role of funding liquidity in explaining the bond IVOL-return relation. We interact the two-way interaction term IVOL×FILLIQ with a time dummy, POST, which is equal to one (zero) for the three-year period after (before) the implementation of the Volcker Rule.[32] Table 6 presents the results from regressing the next one-month excess and risk-adjusted returns on bond IVOL, bond SVOL, FILLIQ, POST dummy, and their interactions.

[Insert Table 6 about here]

The coefficients on the triple interaction term IVOL × FILLIQ × POST are significantly positive, suggesting that after the implementation of the Volcker Rule, when the funding liquidity is low, the provision of liquidity for bonds with high IVOL bonds 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×FILLIQ. Thus, the aggregate intermediation capacity is an essential driver of the cross-sectional IVOL-return relation.

The triple interaction term SVOL×FILLIQ×POST is also significantly positive indicating that the liquidity provision for bonds with high SVOL is also constrained and that, after the implementation of the Volcker Rule, dealers care about bond systematic volatility as well. 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, there is no premium for the high volatility bonds.

In addition, we use the Global Financial Crisis and the COVID-19 crisis to provide support to the idea that funding liquidity impacts the bond IVOL-return relation. We

[32] Li and Yu (2023) argue 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.

focus on the return dynamics for high IVOL bonds during the low funding liquidity period at the time advent of the crisis and then during the high funding liquidity period when the Federal Reserve significantly loosened monetary policy. The results in the Internet Appendix C document that the initial return declines more for high IVOL bonds during periods with constrained funding liquidity and then increases more for these bonds when funding liquidity improves. While these results are suggestive, we are cautious about making strong inferences because during both the crises the severe economic shocks makes is harder to cleanly separate the funding liquidity shock from the macroeconomic dislocations.

*4.2. Downgrades from investment to non-investment grade*

Ellul, Jotikasthira, and Lundblad (2011) document that the severity of price declines around bond downgrades is significantly larger when fire sales are more likely to happen during periods of broad industry distress and limited liquidity provision. We exploit the effect of cross-sectional demand for liquidity following downgrades from investment grade to non-investment grade.[33] We expect that post-Volcker, when the aggregate intermediary funding liquidity provision from primary dealers is more circumscribed, the high IVOL bonds that experience downgrades from IG to NIG would experience larger price declines in the downgrade month due to selling pressure and limited liquidity provision. These price declines would be reversed as funding liquidity improves.

The Internet Appendix Figure A1 plots the average monthly raw and risk-adjusted returns in the one-year period around (i.e., six-month before to six-month after) the IG

[33] Data on historical rating changes by major rating agencies are obtained from Mergent 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) and Avramov, Chordia, Jostova, and Philipov (2013) 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.

to NIG downgrades for bonds in the highest and lowest IVOL quintiles. Month 0 is the downgrade month. Month $-t$ ($t$) is $t$-month before (after) the downgrade month. When the funding liquidity is more constrained after the Volcker Rule, the magnitudes of price declines and subsequent reversals in the high IVOL bonds are indeed significantly larger than those before the Rule.

To formally test the hypothesis, we conduct a difference-in-differences test to take various fixed effects and controls into consideration. We define a downgrade dummy variable (DG) equal to one if the bond experiences an IG to NIG downgrade in that month, and zero otherwise. Panel A (B) of Table 7 presents results from the panel regressions of the next one-month (two-month cumulative) returns on bond IVOL, bond SVOL, DG, and POST.[34] 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 the dependent variable. After the implementation of the Volcker Rule with dealers being constrained and with the IG to NIG downgrade triggering investors sales, there is a decline in prices of the high IVOL and subsequent return reversals.[35]

[Insert Table 7 about here]

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

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[34] The rationale for using the next two-month cumulative returns as regressands comes from Avramov, Chordia, Jostova, and Philipov (2013) who show that the impact of a downgrade lasts for more than a month.

[35] Since downgrades are not random events, one concern is that high IVOL bonds could be more likely to experience future downgrades. If so, then it is possible that the selling pressure is capturing downside risks related to IVOL instead of cross-sectional variations in the demand for funding liquidity. We check the propensity of high IVOL bonds being downgraded from IG to NIG by regressing the DG dummy in the next month on IVOL, SVOL, and bond characteristics including illiquidity, maturity, age, coupon, and size, in both Probit and OLS settings. There are no significant coefficients on IVOL, suggesting that the future downgrade probability is not significantly correlated with bond IVOL. We, thus, consider IG to NIG downgrades as orthogonal shocks (unrelated to IVOL) to the cross-sectional demand for funding liquidity.

## 5. 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. In this paper, we document a positive IVOL-return relation that is causally driven by funding liquidity. When the funding liquidity is constrained, dealers are more cautious about taking bonds into inventory and less willing to provide liquidity to high IVOL bonds. The easing of funding liquidity leads to the positive relation between IVOL and subsequent bond returns. In addition, we confirm that funding liquidity is not proxying for macroeconomic conditions, and it is the funding liquidity level, instead of the funding liquidity risk, bond liquidity or liquidity risk, investor under-diversification, risk aversion, or long-term return reversals, that drives the positive IVOL-return relation.

For identification, we rely on the Volcker Rule which constrained the ability of banks to provide liquidity. Thus, the Volcker rule represents and exogenous shock to primary dealers' funding liquidity. The IVOL-return relation is significantly positive after the Volcker Rule was implemented.

## Appendix:

## Variable Definitions

*Bond Return Measures*

| | |
|---|---|
| Excess return | Excess return is the difference between 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 $10\times10$ 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 | We follow Jiang, Li, Sun, and Wang (2022) to define the weekly abnormal return as the weekly raw return subtracted by the value-weighted average return of the pool of bonds that share similar credit ratings and time to maturity at the beginning of each 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. |

*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, and DEF) plus $\Delta$VIX 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, and DEF) plus $\Delta$VIX 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. For month $t$, MOM is the cumulative returns from month $t$-7 to month $t-2$. |
| LTR | Bond long-term return reversal (LTR), as in Bali, Subrahmanyam, and Wen (2021), is past 36-month cumulative returns from month $t$-48 to month $t$-13, skipping the 12-month momentum and the one-month short-term reversal. |
| 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 number of outstanding bonds. |
| 5% VaR | 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

$$\eta_t = \sum\nolimits_j \mathit{Market\ Equity}_{jt} \Big/ \sum\nolimits_j (\mathit{Market\ Equity}_{jt} + \mathit{Book\ Debt}_{jt})$$

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.

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**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, and DEF) plus $\Delta$VIX over past 6-month. Bond SVOL is the standard deviation of the fitted 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 and 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 number of outstanding bonds. Panel B reports the time-series average of cross-sectional correlations among bond IVOL, SVOL, and other 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 Averages of the 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 | | 1,043,176 | 8.56 | 3.81 | 5.95 | 8.01 | 10.34 |
| 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 Averages of the Cross-Sectional Correlations

| | SVOL | Rating | ILLIQ | MOM | Maturity | Age | Coupon | Size |
|---|---|---|---|---|---|---|---|---|
| IVOL | 0.82 | 0.38 | 0.57 | 0.03 | 0.28 | 0.24 | 0.30 | -0.43 |
| SVOL | | 0.25 | 0.49 | 0.01 | 0.40 | 0.13 | 0.24 | -0.35 |
| Rating | | | 0.14 | 0.12 | -0.12 | 0.07 | 0.55 | 0.01 |
| 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 the number of outstanding bonds as weight) portfolios are formed by sorting corporate bonds into quintiles based on bond IVOL. IVOL,1 is the quintile portfolio with the lowest average 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. In Panel B, we report average excess returns in percentage terms of the IVOL portfolios, controlling for different bond characteristics. Specifically, we first sort bonds into five quintiles based on a bond characteristic (rating, age, maturity, illiquidity, bond size, and coupon). Then, within each quintile, we sort bonds based on IVOL into five portfolios. All portfolios are rebalanced monthly and are value-weighted. The returns of the five portfolios sorted on IVOL are then averaged across the characteristic quintiles. Panel C presents the time-series averages of monthly Fama-MacBeth regressions. The dependent variable in 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, ILLIQ, lagged one-month bond return (RET1), bond MOM, maturity, age, coupon, and size. We additionally control for bond systematic volatility (SVOL) in Columns (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 Characteristic | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | EW | VW | Rating | Age | Maturity | ILLIQ | Size | VaR |
| *IVOL,1* | 152,689 | 0.26 | $0.23^{***}$ | $0.24^{***}$ | 6.62 | 3.14 | 3.73 | 0.05 | 13.76 | -0.03 |
| | | | (3.50) | (3.49) | | | | | | |
| *IVOL,2* | 152,826 | 0.47 | $0.34^{***}$ | $0.37^{***}$ | 8.22 | 3.46 | 6.12 | 0.16 | 13.45 | -0.04 |
| | | | (3.62) | (3.46) | | | | | | |
| *IVOL,3* | 152,825 | 0.70 | $0.41^{***}$ | $0.49^{***}$ | 8.86 | 3.75 | 8.91 | 0.34 | 13.25 | -0.06 |
| | | | (3.36) | (3.44) | | | | | | |
| *IVOL,4* | 152,826 | 1.05 | $0.50^{***}$ | $0.63^{***}$ | 9.33 | 4.32 | 12.16 | 0.78 | 12.98 | -0.07 |
| | | | (3.16) | (3.46) | | | | | | |
| *IVOL,5* | 152,743 | 2.37 | $1.20^{***}$ | $1.26^{***}$ | 11.35 | 6.17 | 13.19 | 4.52 | 12.45 | -0.12 |
| | | | (3.12) | (3.43) | | | | | | |
| ***IVOL,5-1*** | | | $\mathbf{0.97^{***}}$ | $\mathbf{1.02^{***}}$ | | | | | | |
| | | | **(2.84)** | **(3.13)** | | | | | | |

Panel B: Bivariate Portfolio Sorts on Bond Characteristic and IVOL

| Control for bond characteristic | Rating | Age | Maturity | ILLLIQ | Size | Coupon |
|---|---|---|---|---|---|---|
| *IVOL,1* | $0.29^{***}$ | $0.23^{***}$ | $0.34^{***}$ | $0.33^{***}$ | $0.23^{***}$ | $0.29^{***}$ |
| | (3.65) | (3.61) | (3.41) | (3.47) | (3.46) | (3.89) |
| *IVOL,2* | $0.37^{***}$ | $0.37^{***}$ | $0.39^{***}$ | $0.40^{***}$ | $0.32^{***}$ | $0.41^{***}$ |
| | (3.02) | (3.56) | (3.41) | (3.30) | (3.32) | (3.59) |
| *IVOL,3* | $0.56^{***}$ | $0.47^{***}$ | $0.44^{***}$ | $0.53^{***}$ | $0.44^{***}$ | $0.46^{***}$ |
| | (3.37) | (3.38) | (3.51) | (3.48) | (3.06) | (3.32) |
| *IVOL,4* | $0.61^{***}$ | $0.65^{***}$ | $0.57^{***}$ | $0.67^{***}$ | $0.69^{***}$ | $0.62^{***}$ |
| | (2.89) | (3.52) | (3.42) | (3.28) | (2.87) | (3.39) |
| *IVOL,5* | $0.98^{***}$ | $1.23^{***}$ | $1.20^{***}$ | $1.19^{***}$ | $1.23^{***}$ | $1.11^{***}$ |
| | (3.38) | (3.33) | (3.27) | (3.51) | (3.03) | (3.17) |
| ***IVOL,5-1*** | $\mathbf{0.69^{***}}$ | $\mathbf{1.00^{***}}$ | $\mathbf{0.86^{***}}$ | $\mathbf{0.86^{***}}$ | $\mathbf{1.00^{***}}$ | $\mathbf{0.82^{***}}$ |
| | (**2.95**) | **(3.03)** | **(2.67)** | **(3.13)** | **(2.78)** | **(2.73)** |

Panel C: 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 | 0.130 |
| | (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 | -0.030 | -0.027 | -0.022 | -0.020 |
| | (-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 | -0.060 | -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 months | 210 | 210 | 210 | 210 | 186 | 186 |

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

This table presents results from a panel regression of one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), funding illiquidity (FILLIQ), and their interactions as well as controls. We use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. ICR is the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies. FILLIQ is defined as (1-ICR) 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 (MOM), maturity, age, coupon, size, and their interactions with FILLIQ. The coefficients on control variables are shown in Panel A of the Internet Appendix Table A1. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. The *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* | -21.366*** | -20.664*** | -18.226*** | -21.731*** | -17.153*** | -19.062*** | -16.361*** | -20.102*** | -13.082** | -16.569*** | -14.902** | -17.350*** |
| | (-3.18) | (-3.67) | (-2.98) | (-3.59) | (-3.14) | (-3.45) | (-2.77) | (-3.42) | (-2.48) | (-2.78) | (-2.36) | (-2.67) |
| *SVOL* | 13.500 | 9.601 | 1.865 | 9.092 | 8.192 | 7.297 | -1.338 | 7.119 | 18.863* | 14.826 | 10.850 | 19.029* |
| | (1.02) | (1.00) | (0.15) | (0.82) | (0.77) | (0.86) | (-0.13) | (0.75) | (1.90) | (1.62) | (0.93) | (1.70) |
| ***IVOL×FILLIQ*** | **0.232*** ** | **0.224*** ** | **0.198*** ** | **0.236*** ** | **0.186*** ** | **0.207*** ** | **0.178*** ** | **0.219*** ** | **0.143** ** | **0.181*** ** | **0.163** ** | **0.190*** ** |
| | **(3.17)** | **(3.66)** | **(2.97)** | **(3.58)** | **(3.13)** | **(3.44)** | **(2.76)** | **(3.41)** | **(2.51)** | **(2.81)** | **(2.38)** | **(2.70)** |
| *SVOL×FILLIQ* | -0.140 | -0.098 | -0.016 | -0.093 | -0.083 | -0.074 | 0.018 | -0.072 | -0.198* | -0.155 | -0.111 | -0.198* |
| | (-0.99) | (-0.95) | (-0.12) | (-0.79) | (-0.73) | (-0.81) | (0.16) | (-0.71) | (-1.90) | (-1.61) | (-0.90) | (-1.69) |
| *FILLIQ* | -0.008* | | | | -0.008* | | | | -0.012** | | | |
| | (-1.72) | | | | (-1.70) | | | | (-2.17) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.050 | 0.160 | 0.178 | 0.175 | 0.045 | 0.076 | 0.093 | 0.094 | 0.038 | 0.058 | 0.076 | 0.072 |
| # of obs. | 698,730 | 698,730 | 615,107 | 697,812 | 698,730 | 698,730 | 615,107 | 697,812 | 640,373 | 640,373 | 562,654 | 639,439 |

**Table 4. Dealer Inventory Changes in High and Low Funding Liquidity Periods**

This table reports average aggregate dealer inventory changes and institutional ownership changes in percentage terms for high and low IVOL bonds. In each month (quarter), we sort bonds into quintiles based on bond IVOL (average bond IVOL in a quarter). IVOL,1 is the quintile with the lowest IVOL, and IVOL,5 is the quintile with the highest IVOL. In Panel A.1 (A.2), for each bond, we define the aggregate dealer inventory change, i.e., dealer net buy, as the difference in the par value between dealers' buys from customers and dealers' sells to customers in a month (quarter), scaled by the number of outstanding bonds. In Panels B, C, and D, we calculate the average ownership changes of a bond in each quarter, i.e., the change in the holding amount of a bond, scaled by the number of outstanding bonds, for US institutions, insurance companies, and mutual funds, respectively. We average the measures across the two extreme IVOL quintiles, in the full sample, and in periods with high and low funding liquidity, separately. A month/quarter with the intermediary capital ratio above (below) the sample median is a high (low) funding liquidity month/quarter. We also report the average differences between low and high funding liquidity periods, between the highest and lowest IVOL quintiles, the average differences-in-differences, and $t$-statistics. The sample period is from July 2002 to December 2019.

| Sample | All | Low funding liquidity | High funding liquidity | (Low-High) funding liquidity | $t$-statistic |
|---|---|---|---|---|---|
| | | Panel A.1: (Monthly) Dealer Net Buy (%) | | | |
| *IVOL,1* | 0.005 | 0.011 | -0.002 | 0.013 | (0.28) |
| *IVOL,5* | 0.163 | 0.022 | 0.305 | -0.283 | (-2.67) |
| *IVOL,5-1* | 0.158 | 0.011 | 0.307 | -0.296 | |
| $t$-statistic | (2.72) | (0.48) | (2.71) | (-2.59) | |
| | | Panel A.2: (Quarterly) Dealer Net Buy (%) | | | |
| *IVOL,1* | 0.092 | 0.099 | 0.084 | 0.016 | (0.12) |
| *IVOL,5* | 0.200 | 0.029 | 0.370 | -0.341 | (-1.20) |
| *IVOL,5-1* | 0.108 | -0.071 | 0.286 | -0.357 | |
| $t$-statistic | (0.68) | (-1.06) | (0.93) | (-1.18) | |
| | | Panel B: (Quarterly) US Institutional Ownership Changes (%) | | | |
| *IVOL,1* | 0.251 | 0.261 | 0.241 | 0.020 | (0.12) |
| *IVOL,5* | -0.363 | -0.244 | -0.481 | 0.237 | (1.15) |
| *IVOL,5-1* | -0.614 | -0.505 | -0.722 | 0.217 | |
| $t$-statistic | (-4.72) | (-4.46) | (-3.08) | (1.11) | |
| | | Panel C: (Quarterly) Insurance Ownership Changes (%) | | | |
| *IVOL,1* | 0.151 | 0.127 | 0.175 | -0.048 | (-0.43) |
| *IVOL,5* | -0.196 | -0.145 | -0.248 | 0.103 | (0.85) |
| *IVOL,5-1* | -0.347 | -0.272 | -0.423 | 0.151 | |
| $t$-statistic | (-4.20) | (-3.48) | (-2.89) | (1.16) | |
| | | Panel D: (Quarterly) Mutual Fund Ownership Changes (%) | | | |
| *IVOL,1* | 0.103 | 0.105 | 0.100 | 0.005 | (0.06) |
| *IVOL,5* | -0.078 | -0.074 | -0.082 | 0.008 | (0.09) |
| *IVOL,5-1* | -0.181 | -0.179 | -0.182 | 0.003 | |
| $t$-statistic | (-2.80) | (-3.16) | (-1.56) | (0.05) | |

**Table 5. The Impact of Funding Illiquidity and Macroeconomic Conditions on Bond IVOL-Return Relation**

This table presents results from a panel regression of one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), funding illiquidity (FILLIQ), macro variables, and their interactions as well as controls. We use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. FILLIQ is defined as (1-ICR) multiplied by 100. The macro conditions include the four macroeconomic variables in Chen, Roll, and Ross (1986): monthly industrial production change (MP), inflation change (DINF), TERM, and DEF. 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, size, and their interactions with FILLIQ. 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. The $t$-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) |
| $IVOL$ | -26.236$^{***}$ | -23.469$^{***}$ | -23.665$^{***}$ | -25.760$^{***}$ | -21.349$^{***}$ | -21.708$^{***}$ | -21.348$^{***}$ | -23.926$^{***}$ | -14.709$^{***}$ | -17.724$^{***}$ | -18.577$^{***}$ | -19.836$^{***}$ |
| | (-4.06) | (-4.31) | (-4.13) | (-4.73) | (-3.76) | (-4.13) | (-3.89) | (-4.56) | (-2.87) | (-3.29) | (-3.09) | (-3.19) |
| $SVOL$ | 24.442$^{**}$ | 22.792$^{**}$ | 21.478$^{**}$ | 25.281$^{**}$ | 26.767$^{**}$ | 22.475$^{**}$ | 19.877$^{**}$ | 25.289$^{**}$ | 36.521$^{***}$ | 34.390$^{***}$ | 35.974$^{***}$ | 40.817$^{***}$ |
| | (2.11) | (2.17) | (1.99) | (2.32) | (2.55) | (2.31) | (2.03) | (2.50) | (3.36) | (3.17) | (3.44) | (3.33) |
| $\boldsymbol{IVOL\times FILLIQ}$ | **0.284$^{***}$** | **0.254$^{***}$** | **0.256$^{***}$** | **0.279$^{***}$** | **0.231$^{***}$** | **0.235$^{***}$** | **0.231$^{***}$** | **0.259$^{***}$** | **0.158$^{***}$** | **0.190$^{***}$** | **0.199$^{***}$** | **0.214$^{***}$** |
| | **(4.04)** | **(4.30)** | **(4.11)** | **(4.72)** | **(3.75)** | **(4.11)** | **(3.87)** | **(4.54)** | **(2.90)** | **(3.33)** | **(3.14)** | **(3.25)** |
| $SVOL\times FILLIQ$ | -0.259$^{**}$ | -0.241$^{**}$ | -0.228$^{**}$ | -0.269$^{**}$ | -0.285$^{**}$ | -0.238$^{**}$ | -0.211$^{**}$ | -0.269$^{**}$ | -0.385$^{***}$ | -0.362$^{***}$ | -0.378$^{***}$ | -0.430$^{***}$ |
| | (-2.10) | (-2.16) | (-1.99) | (-2.32) | (-2.54) | (-2.30) | (-2.03) | (-2.50) | (-3.38) | (-3.18) | (-3.45) | (-3.35) |
| $IVOL\times MP$ | 32.323$^{*}$ | 25.312 | 33.310$^{**}$ | 29.366$^{*}$ | 25.930$^{*}$ | 20.235 | 26.613$^{*}$ | 24.009 | 7.925 | 3.485 | 3.009 | 6.466 |
| | (1.92) | (1.64) | (2.25) | (1.76) | (1.89) | (1.39) | (1.83) | (1.50) | (0.44) | (0.17) | (0.13) | (0.29) |
| $SVOL\times MP$ | -79.030$^{**}$ | -75.044$^{**}$ | -96.697$^{***}$ | -84.825$^{***}$ | -96.465$^{***}$ | -77.418$^{***}$ | -95.696$^{***}$ | -86.703$^{***}$ | -65.187$^{***}$ | -64.390$^{***}$ | -76.589$^{***}$ | -71.692$^{***}$ |
| | (-2.38) | (-2.47) | (-3.33) | (-2.69) | (-3.72) | (-3.20) | (-4.33) | (-3.27) | (-3.61) | (-3.72) | (-4.80) | (-2.96) |
| $IVOL\times DINF$ | -8.711 | -2.431 | -0.329 | -0.538 | -2.069 | -9.185 | -8.459 | -7.438 | -32.336 | -46.479 | -56.852 | -45.615 |
| | (-0.39) | (-0.12) | (-0.01) | (-0.03) | (-0.11) | (-0.48) | (-0.39) | (-0.38) | (-1.08) | (-1.42) | (-1.57) | (-1.35) |
| $SVOL\times DINF$ | -117.841$^{*}$ | -89.512 | -147.432$^{**}$ | -96.514$^{*}$ | -88.342 | -55.178 | -104.485$^{*}$ | -61.531 | -63.692 | -53.017 | -85.711$^{*}$ | -53.865 |
| | (-1.83) | (-1.55) | (-2.25) | (-1.73) | (-1.57) | (-1.11) | (-1.88) | (-1.29) | (-1.61) | (-1.38) | (-1.88) | (-1.37) |
| $IVOL\times TERM$ | -1.420 | 0.821 | 1.691 | 1.138 | -1.029 | -0.065 | 0.549 | 0.191 | 18.397$^{***}$ | 22.044$^{***}$ | 24.050$^{**}$ | 22.179$^{***}$ |
| | (-0.24) | (0.16) | (0.32) | (0.22) | (-0.23) | (-0.01) | (0.12) | (0.04) | (2.97) | (3.04) | (2.59) | (2.83) |
| $SVOL\times TERM$ | 38.223$^{**}$ | 27.306$^{*}$ | 33.955$^{*}$ | 26.395$^{*}$ | 29.647$^{**}$ | 24.106$^{**}$ | 30.032$^{**}$ | 23.234$^{**}$ | 3.161 | 0.899 | 5.685 | 0.765 |
| | (2.35) | (1.90) | (1.86) | (1.86) | (2.26) | (2.09) | (1.98) | (2.01) | (0.56) | (0.16) | (0.79) | (0.11) |
| $IVOL\times DEF$ | -1.835 | -0.357 | 0.465 | -0.172 | -4.431 | -0.790 | -0.163 | -0.731 | 14.148$^{**}$ | 14.035$^{*}$ | 14.231$^{*}$ | 14.206$^{*}$ |
| | (-0.16) | (-0.03) | (0.04) | (-0.02) | (-0.43) | (-0.08) | (-0.01) | (-0.07) | (2.11) | (1.85) | (1.82) | (1.82) |
| $SVOL\times DEF$ | 21.887$^{*}$ | 18.168$^{**}$ | 18.725$^{*}$ | 15.613$^{*}$ | 20.576$^{**}$ | 14.532$^{*}$ | 14.907 | 12.123 | 6.397 | 3.041 | 3.786 | 0.498 |
| | (1.92) | (2.00) | (1.72) | (1.74) | (2.06) | (1.66) | (1.44) | (1.41) | (1.07) | (0.52) | (0.52) | (0.08) |
| $FILLIQ$ | -0.011$^{**}$ | | | | -0.008 | | | | -0.012$^{**}$ | | | |
| | (-2.37) | | | | (-1.65) | | | | (-2.02) | | | |
| $MP$ | 0.421 | | | | 0.169 | | | | 0.299 | | | |
| | (1.42) | | | | (1.43) | | | | (1.42) | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *DINF* | 0.651* | | | | 0.515** | | | | 0.620** | | | |
| | (1.90) | | | | (2.47) | | | | (2.20) | | | |
| *TERM* | 0.164* | | | | -0.148*** | | | | -0.144* | | | |
| | (1.71) | | | | (-3.19) | | | | (-1.78) | | | |
| *DEF* | 0.073 | | | | -0.070 | | | | -0.260** | | | |
| | (0.59) | | | | (-0.73) | | | | (-2.59) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.085 | 0.171 | 0.196 | 0.187 | 0.062 | 0.086 | 0.108 | 0.104 | 0.061 | 0.078 | 0.104 | 0.091 |
| # of obs. | 698,730 | 698,730 | 615,107 | 697,812 | 698,730 | 698,730 | 615,107 | 697,812 | 640,373 | 640,373 | 562,654 | 639,439 |

**Table 6. The Bond IVOL-Return Relation Around the Volcker Rule**

This table presents results from a panel regression in the sample period around the implementation of the Volcker Rule. One-month-ahead corporate bond returns are regressed on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), funding illiquidity (FILLIQ), a time dummy (POST), and their interactions as well as controls. We use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. FILLIQ is defined as (1-ICR) multiplied by 100. and the. The POST dummy is equal to one (zero) if the month is after (before) the Volcker Rule effective date (April 1, 2014). 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, size, and their interactions with POST and FILLIQ. 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. The $t$-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* | -24.215 | -8.030 | -2.630 | 8.971 | -10.863 | -6.390 | -0.200 | 11.358 | 1.036 | -1.546 | 5.328 | 20.771 |
| | (-1.01) | (-0.51) | (-0.16) | (0.63) | (-0.86) | (-0.47) | (-0.01) | (0.85) | (0.09) | (-0.12) | (0.40) | (1.40) |
| *SVOL* | -5.209 | -18.066 | -28.624 | -25.442 | -18.801 | -20.454 | -30.864 | -21.076 | -11.239 | -12.669 | -23.302 | -12.822 |
| | (-0.11) | (-0.63) | (-1.13) | (-0.89) | (-0.95) | (-0.85) | (-1.46) | (-0.89) | (-0.64) | (-0.57) | (-1.19) | (-0.56) |
| *IVOL×FILLIQ* | 0.259 | 0.087 | 0.033 | -0.085 | 0.116 | 0.069 | 0.005 | -0.111 | -0.009 | 0.018 | -0.053 | -0.210 |
| | (1.03) | (0.53) | (0.19) | (-0.57) | (0.87) | (0.48) | (0.04) | (-0.79) | (-0.07) | (0.13) | (-0.37) | (-1.35) |
| *SVOL×FILLIQ* | 0.056 | 0.190 | 0.301 | 0.268 | 0.197 | 0.215 | 0.324 | 0.223 | 0.117 | 0.133 | 0.244 | 0.136 |
| | (0.11) | (0.63) | (1.13) | (0.89) | (0.94) | (0.85) | (1.45) | (0.89) | (0.63) | (0.56) | (1.18) | (0.56) |
| ***IVOL×FILLIQ×POST*** | **2.115**$^{***}$ | **2.006**$^{***}$ | **1.755**$^{***}$ | **1.995**$^{***}$ | **1.816**$^{***}$ | **1.983**$^{***}$ | **1.717**$^{***}$ | **1.952**$^{***}$ | **1.916**$^{***}$ | **1.998**$^{***}$ | **1.746**$^{***}$ | **2.039**$^{***}$ |
| | **(3.25)** | **(3.61)** | **(3.21)** | **(3.66)** | **(3.34)** | **(3.70)** | **(3.27)** | **(3.68)** | **(3.46)** | **(3.70)** | **(3.28)** | **(3.77)** |
| *SVOL×FILLIQ×POST* | 2.906$^{**}$ | 2.640$^{**}$ | 2.783$^{**}$ | 2.770$^{**}$ | 2.557$^{**}$ | 2.573$^{**}$ | 2.738$^{**}$ | 2.761$^{**}$ | 2.786$^{**}$ | 2.746$^{**}$ | 2.913$^{***}$ | 2.916$^{***}$ |
| | (2.50) | (2.39) | (2.51) | (2.52) | (2.45) | (2.43) | (2.55) | (2.62) | (2.61) | (2.55) | (2.68) | (2.73) |
| *IVOL×POST* | -198.48$^{***}$ | -188.32$^{***}$ | -164.94$^{***}$ | -187.60$^{***}$ | -170.41$^{***}$ | -186.12$^{***}$ | -161.27$^{***}$ | -183.63$^{***}$ | -180.07$^{***}$ | -187.64$^{***}$ | -164.10$^{***}$ | -191.88$^{***}$ |
| | (-3.24) | (-3.60) | (-3.21) | (-3.66) | (-3.33) | (-3.69) | (-3.26) | (-3.68) | (-3.46) | (-3.70) | (-3.28) | (-3.77) |
| *SVOL×POST* | -272.14$^{**}$ | -246.91$^{**}$ | -259.90$^{**}$ | -258.95$^{**}$ | -238.99$^{**}$ | -240.51$^{**}$ | -255.59$^{**}$ | -258.25$^{**}$ | -260.60$^{**}$ | -256.96$^{**}$ | -272.23$^{***}$ | -272.94$^{***}$ |
| | (-2.49) | (-2.38) | (-2.50) | (-2.51) | (-2.44) | (-2.42) | (-2.54) | (-2.61) | (-2.61) | (-2.55) | (-2.67) | (-2.73) |
| *FILLIQ×POST* | -0.092$^{**}$ | | | | -0.119$^{**}$ | | | | -0.117$^{**}$ | | | |
| | (-2.56) | | | | (-2.56) | | | | (-2.25) | | | |
| *FILLIQ* | -0.014 | | | | -0.016 | | | | -0.021 | | | |
| | (-1.58) | | | | (-1.38) | | | | (-1.02) | | | |
| *POST* | 8.660$^{**}$ | | | | 11.141$^{**}$ | | | | 10.952$^{**}$ | | | |
| | (2.56) | | | | (2.55) | | | | (2.24) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ×POST | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×POST | 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-$R^2$ | 0.155 | 0.248 | 0.272 | 0.260 | 0.127 | 0.141 | 0.162 | 0.157 | 0.120 | 0.140 | 0.160 | 0.154 |
| # of obs. | 276,748 | 276,748 | 249,476 | 276,221 | 276,748 | 276,748 | 249,476 | 276,221 | 276,748 | 276,748 | 249,476 | 276,221 |

**Table 7. The Bond IVOL-Return Relation Around the Volcker Rule, Interacted with IG-to-NIG Downgrades**

This table reports the effects of investment grade (IG) to non-investment grade (NIG) 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 equal to one if the bond experiences a downgrade from investment grade (IG) to non-investment grade (NIG) at that month, and zero otherwise. The POST dummy is equal to one (zero) 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 size. Panel B has the same setting as in Panel A except that the dependent variables are cumulated over the next two months, i.e., the two-month cumulative excess and risk adjusted returns. 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. The $t$-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* | 0.597*** | 0.490*** | 0.730*** | 1.203*** | 0.370** | 0.390** | 0.592*** | 1.157*** | 0.366** | 0.408** | 0.602*** | 1.151*** |
| | (2.89) | (2.76) | (4.40) | (5.50) | (2.17) | (2.34) | (3.79) | (5.26) | (2.10) | (2.35) | (3.56) | (4.98) |
| *SVOL* | 0.582 | 0.443 | 0.435 | 0.448 | 0.363 | 0.366 | 0.357 | 0.586* | 0.129 | 0.270 | 0.259 | 0.470 |
| | (0.99) | (1.15) | (1.14) | (1.12) | (1.22) | (1.29) | (1.31) | (1.86) | (0.50) | (0.99) | (0.99) | (1.60) |
| *IVOL×DG* | 1.371 | 0.951 | 1.888* | 1.046 | 0.715 | 0.778 | 1.233 | 1.079 | 0.382 | 0.547 | 0.677 | 0.889 |
| | (1.20) | (0.97) | (1.68) | (1.34) | (0.71) | (0.81) | (1.17) | (1.45) | (0.36) | (0.53) | (0.80) | (0.97) |
| *SVOL×DG* | -5.409 | -3.921 | -4.123 | -4.027 | -3.851 | -3.667 | -3.057 | -4.147 | -3.589 | -3.873 | -3.201 | -4.463 |
| | (-1.63) | (-1.25) | (-1.55) | (-1.51) | (-1.23) | (-1.19) | (-1.18) | (-1.57) | (-1.09) | (-1.18) | (-1.26) | (-1.48) |
| ***IVOL×DG×POST*** | **3.782*** | **3.370*** | **2.351** | **2.944** | **3.358*** | **3.223** | **2.680** | **2.617** | **3.674*** | **3.367*** | **3.173** | **2.754** |
| | **(1.68)** | **(1.67)** | **(1.07)** | **(1.41)** | **(1.70)** | **(1.66)** | **(1.29)** | **(1.29)** | **(1.78)** | **(1.70)** | **(1.61)** | **(1.31)** |
| *SVOL×DG×POST* | 6.864 | 5.228 | 5.743 | 5.438 | 5.506 | 5.049 | 4.886 | 5.718 | 5.343 | 5.221 | 4.926 | 5.954 |
| | (0.90) | (0.70) | (0.75) | (0.73) | (0.74) | (0.68) | (0.64) | (0.76) | (0.71) | (0.70) | (0.65) | (0.78) |
| *IVOL×POST* | -0.012 | -0.038 | -0.187 | -0.274 | -0.006 | -0.009 | -0.141 | -0.252 | -0.040 | -0.022 | -0.152 | -0.247 |
| | (-0.03) | (-0.09) | (-0.55) | (-0.77) | (-0.02) | (-0.02) | (-0.46) | (-0.77) | (-0.12) | (-0.06) | (-0.50) | (-0.77) |
| *SVOL×POST* | 1.015 | 1.066 | 1.252 | 1.406 | 1.197 | 1.172 | 1.332* | 1.210 | 1.366* | 1.223 | 1.384** | 1.260 |
| | (1.02) | (1.21) | (1.51) | (1.66) | (1.57) | (1.57) | (1.95) | (1.58) | (1.83) | (1.67) | (2.06) | (1.65) |
| *DG×POST* | -0.016 | -0.016 | -0.008 | -0.016 | -0.019 | -0.015 | -0.010 | -0.016 | -0.017 | -0.016 | -0.013 | -0.017 |
| | (-0.51) | (-0.66) | (-0.34) | (-0.75) | (-0.67) | (-0.59) | (-0.38) | (-0.69) | (-0.59) | (-0.62) | (-0.48) | (-0.73) |
| *DG* | 0.005 | 0.005 | -0.004 | 0.003 | 0.008 | 0.006 | -0.001 | 0.004 | 0.008 | 0.008 | 0.003 | 0.006 |
| | (0.66) | (0.75) | (-0.96) | (0.50) | (1.08) | (0.88) | (-0.29) | (0.60) | (1.04) | (1.06) | (0.45) | (0.81) |
| *POST* | -0.005 | | | | -0.004 | | | | -0.004 | | | |
| | (-1.48) | | | | (-1.22) | | | | (-1.32) | | | |
| 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-$R^2$ | 0.043 | 0.162 | 0.186 | 0.179 | 0.031 | 0.046 | 0.067 | 0.068 | 0.028 | 0.049 | 0.068 | 0.068 |
| # of obs. | 276,748 | 276,748 | 249,476 | 276,221 | 276,748 | 276,748 | 249,476 | 276,221 | 276,748 | 276,748 | 249,476 | 276,221 |

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* | 0.957** | 0.856*** | 1.379*** | 2.398*** | 0.620* | 0.660** | 1.104*** | 2.295*** | 0.652** | 0.702** | 1.133*** | 2.286*** |
| | (2.62) | (2.67) | (4.57) | (6.32) | (1.96) | (2.15) | (3.79) | (6.00) | (2.03) | (2.24) | (3.76) | (5.81) |
| *SVOL* | 1.619** | 1.155** | 1.129** | 1.147** | 0.904** | 0.972** | 0.938** | 1.374*** | 0.402 | 0.757** | 0.706* | 1.080** |
| | (2.33) | (2.23) | (2.14) | (2.12) | (2.30) | (2.53) | (2.39) | (3.12) | (1.14) | (2.00) | (1.81) | (2.61) |
| *IVOL×DG* | 1.062 | 0.746 | 1.395 | 0.922 | 0.500 | 0.536 | 1.031 | 1.132 | 0.352 | 0.565 | 0.922 | 1.199 |
| | (0.86) | (0.62) | (1.22) | (0.91) | (0.40) | (0.45) | (0.94) | (1.27) | (0.26) | (0.43) | (0.78) | (1.10) |
| *SVOL×DG* | -6.225* | -4.734 | -4.053* | -4.646 | -4.564 | -4.434 | -3.624 | -5.178* | -4.140 | -4.442 | -3.849 | -5.256* |
| | (-1.71) | (-1.30) | (-1.67) | (-1.61) | (-1.22) | (-1.20) | (-1.43) | (-1.83) | (-1.06) | (-1.17) | (-1.37) | (-1.70) |
| ***IVOL×DG×POST*** | **7.953**** | **6.875**** | **5.966*** | **6.109*** | **6.274**** | **6.107**** | **5.367*** | **4.957** | **6.008*** | **5.868*** | **5.306*** | **4.785** |
| | **(2.22)** | **(2.18)** | **(1.79)** | **(1.72)** | **(2.09)** | **(2.09)** | **(1.77)** | **(1.51)** | **(2.01)** | **(2.05)** | **(1.79)** | **(1.48)** |
| *SVOL×DG×POST* | 9.140 | 7.481 | 6.591 | 7.840 | 8.076 | 7.505 | 6.720 | 8.875 | 7.817 | 7.493 | 6.837 | 8.790 |
| | (0.93) | (0.80) | (0.69) | (0.82) | (0.89) | (0.83) | (0.73) | (0.96) | (0.86) | (0.84) | (0.75) | (0.96) |
| *IVOL×POST* | 0.512 | 0.367 | -0.068 | -0.018 | 0.434 | 0.437 | 0.045 | 0.044 | 0.347 | 0.403 | 0.025 | 0.044 |
| | (0.75) | (0.52) | (-0.12) | (-0.03) | (0.71) | (0.70) | (0.09) | (0.08) | (0.60) | (0.69) | (0.05) | (0.09) |
| *SVOL×POST* | 1.369 | 1.688 | 2.205 | 2.093 | 1.883 | 1.802 | 2.264* | 1.623 | 2.221* | 1.918 | 2.390** | 1.800 |
| | (0.87) | (1.14) | (1.63) | (1.50) | (1.44) | (1.40) | (1.94) | (1.27) | (1.74) | (1.50) | (2.05) | (1.41) |
| *DG×POST* | -0.036 | -0.033 | -0.022 | -0.034 | -0.031 | -0.028 | -0.019 | -0.030 | -0.026 | -0.025 | -0.017 | -0.027 |
| | (-0.76) | (-0.96) | (-0.63) | (-1.25) | (-0.77) | (-0.77) | (-0.53) | (-1.02) | (-0.65) | (-0.65) | (-0.44) | (-0.87) |
| *DG* | 0.009 | 0.008 | -0.002 | 0.004 | 0.011 | 0.010 | 0.001 | 0.005 | 0.010 | 0.009 | 0.001 | 0.005 |
| | (0.94) | (0.89) | (-0.33) | (0.48) | (1.15) | (1.04) | (0.08) | (0.57) | (0.97) | (1.00) | (0.23) | (0.52) |
| *POST* | -0.011** | | | | -0.009 | | | | -0.010* | | | |
| | (-2.07) | | | | (-1.63) | | | | (-1.68) | | | |
| 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-$R^2$ | 0.080 | 0.188 | 0.228 | 0.242 | 0.060 | 0.072 | 0.108 | 0.137 | 0.054 | 0.071 | 0.107 | 0.134 |
| # of obs. | 267,350 | 267,350 | 241,619 | 266,826 | 267,350 | 267,350 | 241,619 | 266,826 | 267,350 | 267,350 | 241,619 | 266,826 |

# Internet Appendix A:

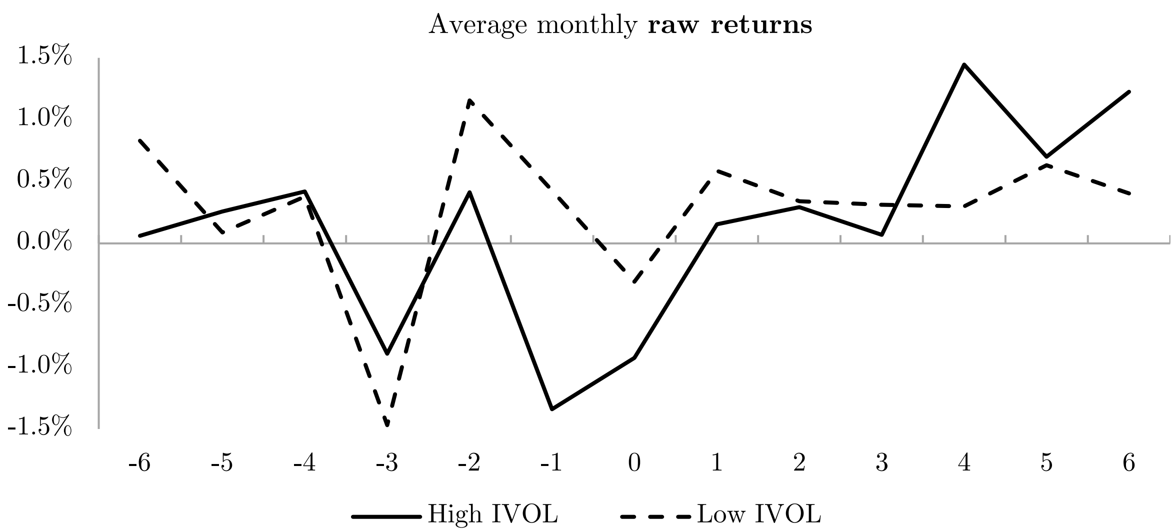
## Idiosyncratic Bond Volatility and Funding Liquidity

**Figure A1. The Bond IVOL Effects Around IG-NIG Downgrades**

This figure shows the average bond monthly raw and risk-adjusted returns with respect to the Fama and French (1993) five factors in the one-year period around investment-level (IG) to non-investment level (NIG) downgrades in three years before and three years after the Volcker Rule, in Figure A1a. and Figure A1b., respectively. Month 0 is the downgrade month. Month -t (t) is t month before (after) the downgrade month. Each month, we sort all bonds into five equal quintiles on bond IVOL and calculate the average raw and risk-adjusted returns of the bonds in the top (high IVOL) and bottom (low IVOL) quintiles.

Figure A1a. Monthly Raw and Risk-adjusted Returns Around Downgrades,

**Before** the Volcker Rule



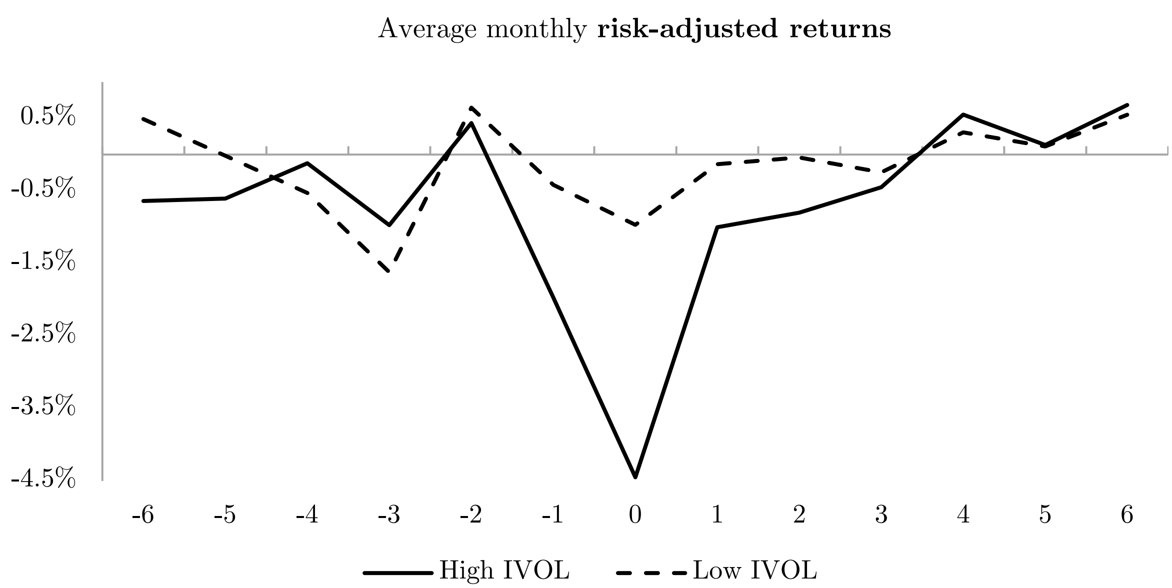
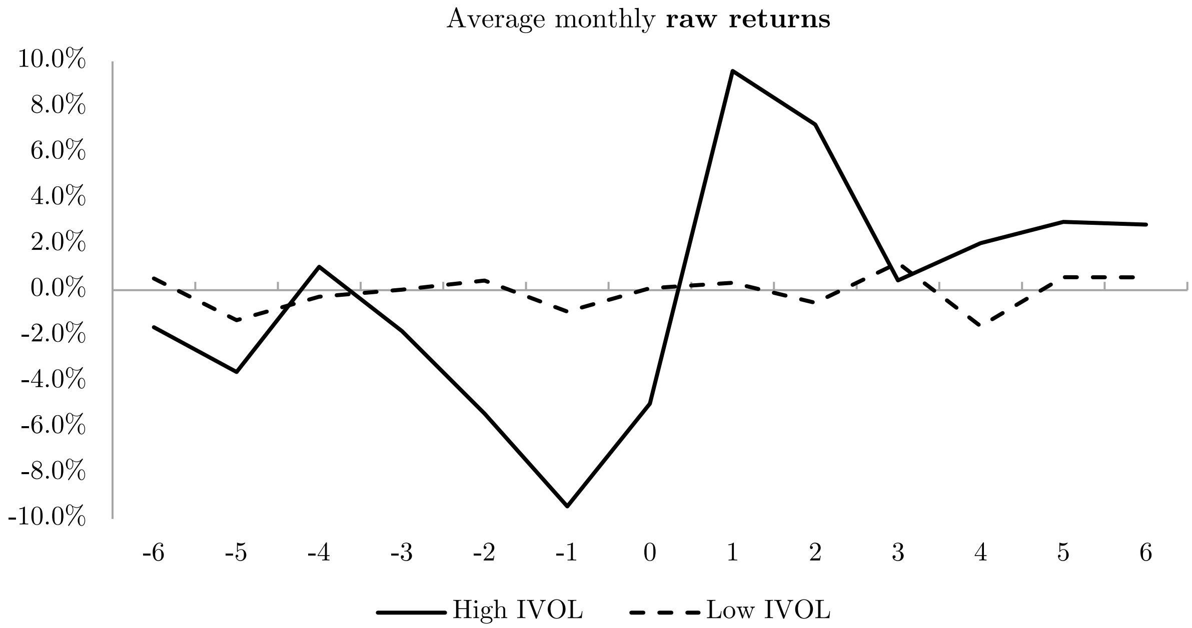
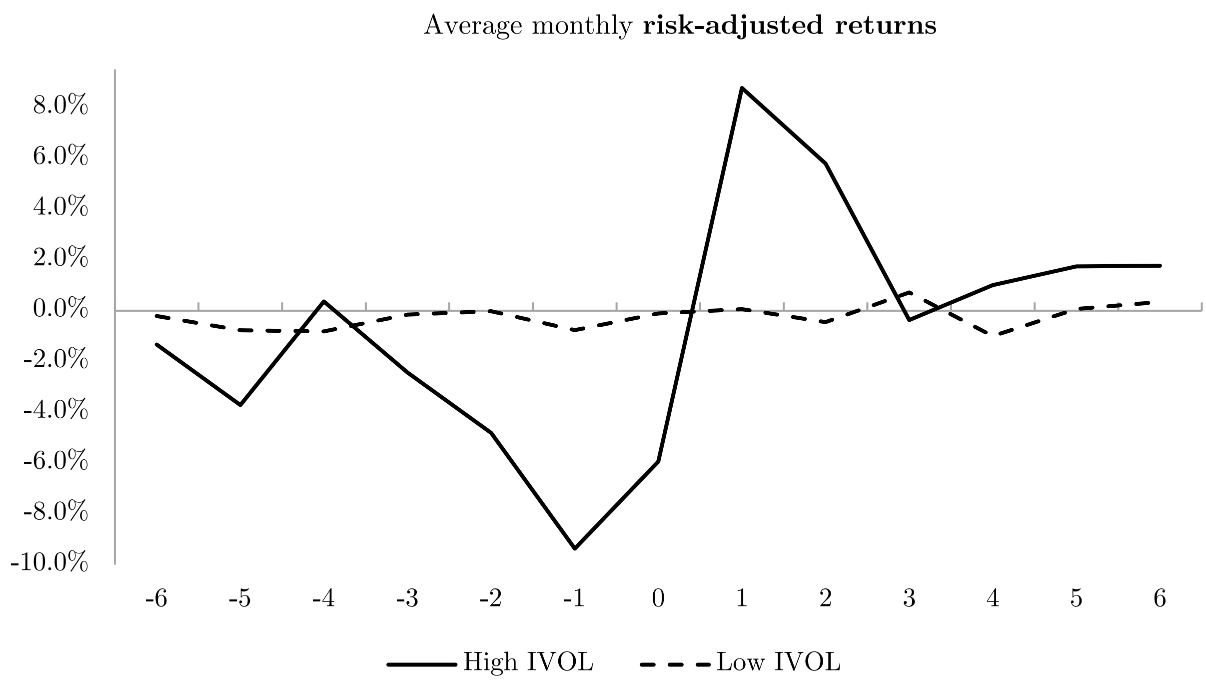



Figure A1b. Monthly Raw and Risk-adjusted Returns Around Downgrades,

**After** the Volcker Rule



## Table A1. Additional Results for the Baseline Regressions

In this table, we regress the one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), FILLIQ defined as (1-ICR) multiplied by 100, and their interactions as well as controls. 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. Panel A reports the coefficients on control variables including bond rating, bond illiquidity (ILLIQ), lagged one-month bond return (RET1), bond momentum, maturity, age, coupon, size, and their interactions with FILLIQ. In Panel B, we use an alternative measure of bond liquidity: the monthly average of daily Imputed Round-trip Costs (IRC) measure in Dick-Nielsen, Feldhutter, and Lando (2012). We replicate the baseline regressions using the IRC measure and its interaction with FILLIQ. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. The $t$-statistics are reported in parenthesis below coefficients. The sample period is from July 2002 to December 2019.

**Panel A: Coefficients on the Control 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) |
| *Rating* | -0.025 | -0.012 | -0.025 | -0.022 | -0.016 | -0.011 | -0.025 | -0.020 | -0.037* | -0.019 | -0.028 | -0.024 |
| | (-1.42) | (-0.57) | (-1.06) | (-0.99) | (-0.88) | (-0.53) | (-1.11) | (-0.94) | (-1.73) | (-0.90) | (-1.25) | (-1.15) |
| *ILLIQ* | 0.001 | 0.001 | -0.004 | 0.001 | 0.001 | 0.001 | -0.004 | 0.001 | -0.008 | -0.007 | -0.010 | -0.004 |
| | (0.19) | (0.19) | (-0.58) | (0.15) | (0.13) | (0.15) | (-0.67) | (0.11) | (-0.70) | (-0.61) | (-0.75) | (-0.35) |
| *RET1* | 3.630 | 3.221 | 3.201 | 2.559 | 1.801 | 2.354 | 2.143 | 1.703 | 4.163* | 4.927* | 5.139* | 4.533* |
| | (1.37) | (1.27) | (1.05) | (0.99) | (0.78) | (0.97) | (0.73) | (0.69) | (1.78) | (1.93) | (1.70) | (1.75) |
| *MOM* | 1.449* | 1.666*** | 1.566** | 1.121 | 1.606** | 1.730*** | 1.597** | 1.189* | 1.559** | 2.089** | 2.081** | 2.041** |
| | (1.76) | (2.63) | (2.12) | (1.55) | (2.54) | (2.84) | (2.31) | (1.70) | (2.29) | (2.57) | (2.40) | (2.38) |
| *Maturity* | -0.002 | -0.000 | 0.001 | -0.000 | 0.000 | 0.002 | 0.003 | 0.003 | -0.000 | 0.004 | 0.005 | 0.005 |
| | (-0.51) | (-0.04) | (0.21) | (-0.08) | (0.14) | (0.75) | (1.01) | (0.98) | (-0.03) | (1.18) | (1.30) | (1.27) |
| *Age* | 0.003 | 0.009** | 0.010* | 0.016** | 0.006 | 0.009** | 0.009* | 0.016** | 0.003 | 0.010** | 0.012** | 0.009 |
| | (0.56) | (2.12) | (1.80) | (2.27) | (1.65) | (2.17) | (1.80) | (2.38) | (0.73) | (2.32) | (2.15) | (1.52) |
| *Coupon* | 0.041* | 0.000 | -0.001 | | 0.018 | 0.005 | 0.007 | | 0.042* | -0.002 | -0.004 | |
| | (1.94) | (0.01) | (-0.05) | | (1.11) | (0.20) | (0.33) | | (1.85) | (-0.06) | (-0.21) | |
| *Size* | -0.058* | -0.046* | -0.069** | | -0.047 | -0.055* | -0.075** | | -0.072** | -0.085** | -0.103*** | |
| | (-1.85) | (-1.73) | (-2.32) | | (-1.55) | (-1.76) | (-2.31) | | (-2.14) | (-2.42) | (-3.01) | |
| *Rating*×*FILLIQ* | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000* | 0.000 | 0.000 | 0.000 |
| | (1.43) | (0.58) | (1.10) | (1.08) | (0.90) | (0.55) | (1.16) | (1.03) | (1.74) | (0.90) | (1.29) | (1.24) |
| *ILLIQ*×*FILLIQ* | -0.000 | -0.000 | 0.000 | -0.000 | -0.000 | -0.000 | 0.000 | -0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (-0.19) | (-0.18) | (0.57) | (-0.15) | (-0.12) | (-0.14) | (0.66) | (-0.11) | (0.69) | (0.61) | (0.74) | (0.35) |
| *RET1*×*FILLIQ* | -0.039 | -0.035 | -0.035 | -0.028 | -0.020 | -0.026 | -0.024 | -0.019 | -0.045* | -0.053* | -0.055* | -0.049* |
| | (-1.37) | (-1.30) | (-1.08) | (-1.03) | (-0.81) | (-1.00) | (-0.77) | (-0.73) | (-1.80) | (-1.95) | (-1.72) | (-1.79) |
| *MOM*×*FILLIQ* | -0.015* | -0.018*** | -0.017** | -0.012 | -0.017** | -0.018*** | -0.017** | -0.013* | -0.016** | -0.022** | -0.022** | -0.022** |
| | (-1.74) | (-2.61) | (-2.11) | (-1.56) | (-2.52) | (-2.82) | (-2.31) | (-1.71) | (-2.28) | (-2.56) | (-2.41) | (-2.38) |
| *Maturity*×*FILLIQ* | 0.000 | 0.000 | -0.000 | 0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (0.51) | (0.04) | (-0.21) | (0.18) | (-0.19) | (-0.79) | (-1.05) | (-0.87) | (-0.01) | (-1.22) | (-1.34) | (-1.14) |
| $Age \times FILLIQ$ | -0.000 | -0.000** | -0.000* | -0.000** | -0.000* | -0.000** | -0.000* | -0.000*** | -0.000 | -0.000** | -0.000** | -0.000** |
| | (-0.55) | (-2.11) | (-1.81) | (-2.58) | (-1.66) | (-2.17) | (-1.82) | (-2.74) | (-0.73) | (-2.32) | (-2.16) | (-2.29) |
| $Coupon \times FILLIQ$ | -0.000* | -0.000 | 0.000 | 0.000 | -0.000 | -0.000 | -0.000 | 0.000 | -0.000* | 0.000 | 0.000 | 0.000 |
| | (-1.95) | (-0.02) | (0.05) | (0.85) | (-1.14) | (-0.22) | (-0.34) | (0.75) | (-1.86) | (0.05) | (0.20) | (0.85) |
| $Size \times FILLIQ$ | 0.001* | 0.001* | 0.001** | 0.000** | 0.001 | 0.001* | 0.001** | 0.000** | 0.001** | 0.001** | 0.001*** | 0.001*** |
| | (1.88) | (1.77) | (2.36) | (2.01) | (1.62) | (1.82) | (2.36) | (2.30) | (2.20) | (2.48) | (3.07) | (2.97) |
| 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 |

## Panel B: Replicate the Baseline Regressions with the IRC Measure

| | 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* | -21.165*** | -20.126*** | -17.989*** | -21.242*** | -16.811*** | -18.592*** | -16.140*** | -19.681*** | -14.364** | -16.731*** | -15.130** | -17.158** |
| | (-2.89) | (-3.55) | (-2.93) | (-3.48) | (-2.79) | (-3.34) | (-2.72) | (-3.33) | (-2.40) | (-2.74) | (-2.34) | (-2.57) |
| *SVOL* | 14.321 | 10.100 | 1.054 | 10.128 | 8.219 | 7.450 | -2.585 | 7.806 | 18.479 | 14.837 | 9.041 | 19.013 |
| | (0.86) | (0.82) | (0.07) | (0.73) | (0.60) | (0.69) | (-0.19) | (0.65) | (1.49) | (1.29) | (0.58) | (1.41) |
| ***IVOL×FILLIQ*** | **0.230*** | **0.218*** | **0.195*** | **0.231*** | **0.183*** | **0.202*** | **0.175*** | **0.214*** | **0.157** | **0.183*** | **0.165** | **0.188** |
| | **(2.88)** | **(3.55)** | **(2.91)** | **(3.47)** | **(2.79)** | **(3.34)** | **(2.71)** | **(3.32)** | **(2.42)** | **(2.76)** | **(2.35)** | **(2.60)** |
| *SVOL×FILLIQ* | -0.149 | -0.104 | -0.007 | -0.104 | -0.084 | -0.076 | 0.032 | -0.079 | -0.195 | -0.155 | -0.093 | -0.199 |
| | (-0.84) | (-0.78) | (-0.04) | (-0.70) | (-0.57) | (-0.65) | (0.22) | (-0.61) | (-1.48) | (-1.28) | (-0.57) | (-1.39) |
| *FILLIQ* | -0.007 | | | | -0.008 | | | | -0.012** | | | |
| | (-1.25) | | | | (-1.44) | | | | (-2.02) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.050 | 0.159 | 0.178 | 0.176 | 0.045 | 0.076 | 0.093 | 0.095 | 0.038 | 0.058 | 0.076 | 0.072 |
| # of obs. | 697,423 | 697,423 | 614,015 | 696,511 | 697,423 | 697,423 | 614,015 | 696,511 | 639,159 | 639,159 | 561,650 | 638,236 |

**Table A2. The Effects of Funding Illiquidity on Bond IVOL-Return Relation, NIG bonds**

This table presents the effects of funding illiquidity on the cross-sectional relationship between IVOL and expected returns in the corporate bond market, for NIG (non-investment-grade) and IG (investment-grade) bonds. We use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. Funding illiquidity (FILLIQ) is defined as (1-ICR) multiplied by 100. We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), FILLIQ which proxies for funding illiquidity, the dummy NIG equal to one (zero) for NIG (non-NIG) bonds, and their interactions. 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, size, and their interactions with FILLIQ. 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. The $t$-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* | -10.445 | -6.341 | -6.631 | -5.179 | -3.524 | -4.855 | -4.852 | -3.716 | 2.235 | -1.864 | -2.084 | -0.275 |
| | (-1.61) | (-1.32) | (-1.24) | (-1.05) | (-0.86) | (-1.05) | (-0.94) | (-0.79) | (0.46) | (-0.31) | (-0.33) | (-0.05) |
| *SVOL* | 6.618 | -1.975 | -1.271 | -7.381 | -4.237 | -4.209 | -4.056 | -8.676 | -0.474 | -3.028 | -2.765 | -6.341 |
| | (0.70) | (-0.23) | (-0.15) | (-0.87) | (-0.59) | (-0.51) | (-0.49) | (-1.08) | (-0.06) | (-0.37) | (-0.32) | (-0.75) |
| $IVOL\times FILLIQ$ | 0.113 | 0.068 | 0.072 | 0.056 | 0.038 | 0.052 | 0.053 | 0.040 | -0.023 | 0.022 | 0.024 | 0.005 |
| | (1.60) | (1.31) | (1.24) | (1.05) | (0.85) | (1.03) | (0.94) | (0.79) | (-0.44) | (0.34) | (0.35) | (0.08) |
| $SVOL\times FILLIQ$ | -0.067 | 0.025 | 0.017 | 0.082 | 0.049 | 0.049 | 0.046 | 0.096 | 0.006 | 0.035 | 0.031 | 0.070 |
| | (-0.66) | (0.28) | (0.19) | (0.89) | (0.64) | (0.55) | (0.52) | (1.10) | (0.08) | (0.39) | (0.33) | (0.77) |
| $\boldsymbol{IVOL\times FILLIQ}$ | **0.195**$^{**}$ | **0.239**$^{***}$ | **0.208**$^{***}$ | **0.277**$^{***}$ | **0.244**$^{***}$ | **0.236**$^{***}$ | **0.206**$^{***}$ | **0.273**$^{***}$ | **0.275**$^{***}$ | **0.247**$^{***}$ | **0.235**$^{***}$ | **0.285**$^{***}$ |
| $\boldsymbol{\times NIG}$ | **(2.54)** | **(2.99)** | **(2.69)** | **(3.11)** | **(3.37)** | **(3.09)** | **(2.82)** | **(3.24)** | **(3.54)** | **(3.13)** | **(3.26)** | **(3.30)** |
| $SVOL\times FILLIQ$ | -0.115 | -0.213 | -0.078 | -0.307 | -0.216 | -0.210 | -0.070 | -0.294 | -0.312 | -0.302 | -0.274 | -0.439$^{*}$ |
| $\times NIG$ | (-0.49) | (-0.86) | (-0.25) | (-1.18) | (-0.99) | (-0.90) | (-0.25) | (-1.21) | (-1.35) | (-1.29) | (-0.90) | (-1.84) |
| $IVOL\times NIG$ | -17.886$^{**}$ | -21.947$^{***}$ | -19.090$^{***}$ | -25.423$^{***}$ | -22.435$^{***}$ | -21.692$^{***}$ | -18.931$^{***}$ | -25.117$^{***}$ | -25.374$^{***}$ | -22.761$^{***}$ | -21.693$^{***}$ | -26.313$^{***}$ |
| | (-2.52) | (-2.98) | (-2.68) | (-3.11) | (-3.36) | (-3.08) | (-2.81) | (-3.24) | (-3.51) | (-3.11) | (-3.25) | (-3.28) |
| $SVOL\times NIG$ | 10.779 | 19.862 | 7.484 | 28.753 | 20.226 | 19.701 | 6.833 | 27.602 | 29.353 | 28.382 | 26.257 | 41.426$^{*}$ |
| | (0.50) | (0.87) | (0.26) | (1.20) | (1.00) | (0.91) | (0.26) | (1.23) | (1.36) | (1.30) | (0.92) | (1.86) |
| $FILLIQ\times NIG$ | -0.003$^{**}$ | -0.003$^{*}$ | -0.003 | -0.004$^{*}$ | -0.004$^{**}$ | -0.003$^{*}$ | -0.003$^{*}$ | -0.004$^{*}$ | -0.004$^{**}$ | -0.003 | -0.003 | -0.003 |
| | (-2.03) | (-1.69) | (-1.57) | (-1.69) | (-2.21) | (-1.83) | (-1.68) | (-1.81) | (-2.02) | (-1.65) | (-1.52) | (-1.45) |
| *NIG* | 0.305$^{**}$ | 0.277$^{*}$ | 0.305 | 0.346$^{*}$ | 0.336$^{**}$ | 0.289$^{*}$ | 0.311$^{*}$ | 0.360$^{*}$ | 0.335$^{**}$ | 0.270 | 0.278 | 0.304 |
| | (2.01) | (1.68) | (1.55) | (1.68) | (2.19) | (1.82) | (1.67) | (1.80) | (2.00) | (1.64) | (1.51) | (1.44) |
| *FILLIQ* | -0.006 | | | | -0.006 | | | | -0.009$^{*}$ | | | |
| | (-1.41) | | | | (-1.37) | | | | (-1.79) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.054 | 0.165 | 0.184 | 0.180 | 0.052 | 0.082 | 0.100 | 0.099 | 0.045 | 0.063 | 0.082 | 0.076 |
| # of obs. | 698,730 | 698,730 | 615,107 | 697,812 | 698,730 | 698,730 | 615,107 | 697,812 | 640,373 | 640,373 | 562,654 | 639,439 |

**Table A3. The Effects of Funding Illiquidity versus Market Liquidity on Bond IVOL-Return Relation**

This table presents results from a panel regression of one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), funding illiquidity (FILLIQ), market liquidity, and their interactions as well as controls. We use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. FILLIQ is defined as (1-ICR) multiplied by 100. We use the "noise" measure in Hu, Pan, and Wang (2013) to proxy for the market-wide liquidity. The daily noise measure is averaged in each month. In Panel A, we include the "noise" measure and its interaction with IVOL and SVOL. In Panel B, we additionally control for three liquidity risk measures (i.e., liquidity betas) in Acharya and Pedersen (2005) and their interactions with FILLIQ, specifically i) commonality in asset's illiquidity with the market illiquidity; (ii) asset's return sensitivity to market illiquidity; and (iii) asset's illiquidity sensitivity to market returns. 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, size, and their interactions with FILLIQ. 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. The $t$-statistics are reported in parenthesis below coefficients. The sample period is from July 2002 to December 2019.

## Panel A: Funding Illiquidity and Market Liquidity

| | 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* | -24.005*** | -20.210*** | -20.478*** | -24.792*** | -18.155*** | -18.658*** | -18.420*** | -22.939*** | -17.924*** | -19.231*** | -22.247*** | -26.663*** |
| | (-3.92) | (-4.06) | (-3.48) | (-4.28) | (-3.82) | (-3.84) | (-3.19) | (-4.04) | (-2.79) | (-2.63) | (-2.69) | (-3.13) |
| *SVOL* | 0.719 | -6.934 | -8.360 | -7.564 | -0.248 | -3.628 | -5.827 | -3.937 | -0.596 | -5.742 | -0.367 | 0.711 |
| | (0.03) | (-0.41) | (-0.40) | (-0.41) | (-0.01) | (-0.24) | (-0.33) | (-0.24) | (-0.03) | (-0.35) | (-0.02) | (0.04) |
| ***IVOL×FILLIQ*** | **0.262*** ** | **0.220*** ** | **0.224*** ** | **0.271*** ** | **0.198*** ** | **0.203*** ** | **0.201*** ** | **0.251*** ** | **0.197*** ** | **0.212*** ** | **0.245*** ** | **0.295*** ** |
| | **(3.87)** | **(4.00)** | **(3.42)** | **(4.22)** | **(3.75)** | **(3.77)** | **(3.13)** | **(3.98)** | **(2.80)** | **(2.63)** | **(2.68)** | **(3.13)** |
| *SVOL×FILLIQ* | -0.002 | 0.082 | 0.095 | 0.088 | 0.008 | 0.045 | 0.067 | 0.048 | 0.011 | 0.067 | 0.008 | -0.003 |
| | (-0.01) | (0.44) | (0.42) | (0.43) | (0.04) | (0.28) | (0.34) | (0.27) | (0.06) | (0.38) | (0.04) | (-0.01) |
| *IVOL×Noise* | -0.025 | -0.011 | -0.028 | -0.040 | -0.006 | -0.006 | -0.022 | -0.033 | -0.029 | -0.035 | -0.064 | -0.079 |
| | (-0.38) | (-0.20) | (-0.45) | (-0.69) | (-0.10) | (-0.11) | (-0.34) | (-0.57) | (-0.52) | (-0.58) | (-0.90) | (-1.15) |
| *SVOL×Noise* | -0.045 | -0.079 | -0.039 | -0.066 | -0.033 | -0.053 | -0.013 | -0.041 | -0.052 | -0.069 | -0.019 | -0.042 |
| | (-0.33) | (-0.81) | (-0.31) | (-0.60) | (-0.32) | (-0.64) | (-0.13) | (-0.45) | (-0.65) | (-0.98) | (-0.22) | (-0.54) |
| *FILLIQ* | -0.011* | | | | -0.010* | | | | -0.017** | | | |
| | (-1.87) | | | | (-1.74) | | | | (-2.56) | | | |
| *Noise* | -0.000 | | | | -0.001 | | | | -0.001 | | | |
| | (-0.25) | | | | (-0.77) | | | | (-1.46) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.051 | 0.161 | 0.179 | 0.177 | 0.046 | 0.076 | 0.093 | 0.095 | 0.044 | 0.060 | 0.078 | 0.075 |
| # of obs. | 698,730 | 698,730 | 615,107 | 697,812 | 698,730 | 698,730 | 615,107 | 697,812 | 640,373 | 640,373 | 562,654 | 639,439 |

## Panel B: Funding Illiquidity, Market Liquidity, and Liquidity Betas

| | 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 | -24.142*** | -20.303*** | -20.594*** | -24.873*** | -18.428*** | -19.091*** | -18.992*** | -23.383*** | -18.476*** | -19.914*** | -23.298*** | -27.305*** |
| | (-3.94) | (-4.07) | (-3.47) | (-4.25) | (-3.86) | (-3.89) | (-3.25) | (-4.06) | (-2.88) | (-2.70) | (-2.79) | (-3.17) |
| SVOL | 1.428 | -6.261 | -7.749 | -7.717 | 0.008 | -3.383 | -5.669 | -4.602 | 0.237 | -5.088 | 0.629 | 0.683 |
| | (0.06) | (-0.36) | (-0.36) | (-0.40) | (0.00) | (-0.22) | (-0.31) | (-0.27) | (0.01) | (-0.30) | (0.03) | (0.04) |
| ***IVOL×FILLIQ*** | **0.263*** ** | **0.221*** ** | **0.225*** ** | **0.272*** ** | **0.200*** ** | **0.208*** ** | **0.207*** ** | **0.256*** ** | **0.203*** ** | **0.219*** ** | **0.257*** ** | **0.302*** ** |
| | **(3.88)** | **(4.01)** | **(3.41)** | **(4.19)** | **(3.79)** | **(3.83)** | **(3.19)** | **(4.00)** | **(2.88)** | **(2.70)** | **(2.78)** | **(3.17)** |
| SVOL×FILLIQ | -0.009 | 0.075 | 0.089 | 0.089 | 0.006 | 0.043 | 0.065 | 0.055 | 0.002 | 0.060 | -0.002 | -0.002 |
| | (-0.04) | (0.39) | (0.38) | (0.42) | (0.03) | (0.26) | (0.32) | (0.30) | (0.01) | (0.33) | (-0.01) | (-0.01) |
| IVOL×Noise | -0.025 | -0.011 | -0.029 | -0.040 | -0.006 | -0.008 | -0.024 | -0.035 | -0.030 | -0.039 | -0.068 | -0.082 |
| | (-0.39) | (-0.20) | (-0.45) | (-0.69) | (-0.11) | (-0.15) | (-0.38) | (-0.60) | (-0.55) | (-0.63) | (-0.96) | (-1.18) |
| SVOL×Noise | -0.044 | -0.078 | -0.038 | -0.066 | -0.032 | -0.052 | -0.013 | -0.041 | -0.049 | -0.067 | -0.016 | -0.041 |
| | (-0.32) | (-0.79) | (-0.30) | (-0.59) | (-0.31) | (-0.63) | (-0.13) | (-0.44) | (-0.62) | (-0.94) | (-0.19) | (-0.52) |
| FILLIQ | -0.014*** | | | | -0.011** | | | | -0.016*** | | | |
| | (-2.95) | | | | (-2.30) | | | | (-3.25) | | | |
| Noise | -0.000 | | | | -0.001 | | | | -0.001 | | | |
| | (-0.22) | | | | (-0.83) | | | | (-1.52) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| $\beta_{LIQ}$ | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| $\beta_{LIQ}$ ×FILLIQ | 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-$R^2$ | 0.052 | 0.161 | 0.179 | 0.177 | 0.047 | 0.077 | 0.094 | 0.095 | 0.045 | 0.061 | 0.079 | 0.075 |
| # of obs. | 698,730 | 698,730 | 615,107 | 697,812 | 698,730 | 698,730 | 615,107 | 697,812 | 640,373 | 640,373 | 562,654 | 639,439 |

**Table A4. The Risk Premium of the Intermediary Capital Risk Factor**

This table shows price estimates of the intermediary capital risk factor (ICRF) for excess returns of bond decile IVOL portfolios. The intermediary capital risk factor is the shock to intermediary capital ratio (ICR) in levels and defined as the innovation of AR (1) process of ICR divided by the lagged capital ratio. ICR is the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies. Each month, we form value-weighted IVOL portfolios by sorting corporate bonds into deciles based on bond IVOL. IVOL,1 (IVOL, 10) is the decile portfolio with the lowest (highest) average IVOL. Then, we estimate alphas and betas from time-series regressions of next-month IVOL portfolio excess returns on various factor models, including Model 1 (MKT_bond), Model 2 (MKT_Stock, SMB, HML, TERM, and DEF), and Model 3 (MKT_bond, DRF, CRF, and LRF), controlling for the within-portfolio averages of bond characteristics including bond systematic volatility (SVOL), rating, illiquidity (ILLIQ), lagged one-month return (RET1), MOM, maturity, age, coupon, and size. We also run cross-sectional regressions of portfolio excess returns on the risk exposures (estimated betas), with the same sets of average bond characteristics within portfolios. The risk premium of ICRF is the mean slope of period-by-period cross-sectional regressions. In Panel A, we report the alphas of the long-short IVOL portfolio (IVOL,10 – IVOL,1) from time-series regressions, with and without ICRF being added to Model 1, 2, and 3, respectively. We also show the $p$-values of GRS tests for each factor model under the null hypothesis that all of the alphas across the IVOL portfolios are jointly zero. Panel B shows the premium of the intermediary capital risk factor, with ICRF being added to Model 1, 2, and 3, respectively. Newey-West (1987) adjusted $t$-statistics are reported in the parenthesis. The sample period is from July 2002 to December 2019.

| Factor Model | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Panel A: Alphas for the Long-Short IVOL Portfolio (IVOL,10 – IVOL,1) | | | |
| Without ICRF | 0.55 | 0.05 | 0.44 |
| | (1.41) | (0.09) | (0.87) |
| *p-values of the GRS tests* | 0.03 | 0.03 | 0.21 |
| With ICRF | 0.43 | 0.34 | 0.45 |
| | (1.14) | (0.95) | (0.82) |
| *p-values of the GRS tests* | 0.02 | 0.03 | 0.19 |
| Panel B: The Risk Premium of ICRF for Decile IVOL Portfolios | | | |
| With ICRF | 0.14 | -0.02 | 0.29 |
| | (1.12) | (-0.10) | (0.68) |

**Table A5. The Effects of Funding Illiquidity and Investor Risk Aversion 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, controlling for the effects of investor risk aversion. We use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. Funding illiquidity (FILLIQ) is defined as (1-ICR) multiplied by 100. The time-series of investor risk aversion (RR) reflects the relative risk aversion of the marginal investor in a generalized habit-like model with preference shocks (Bekaert, Engstrom, and Xu (2022)). We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), interacted with FILLIQ and RR. 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, size, and their interactions with FILLIQ. 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. The $t$-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* | -15.976** | -16.756*** | -17.305** | -22.264*** | -10.999* | -14.373** | -14.396** | -19.522*** | -11.038 | -14.544* | -15.720* | -21.754** |
| | (-2.25) | (-2.79) | (-2.37) | (-3.21) | (-1.94) | (-2.45) | (-2.05) | (-2.89) | (-1.45) | (-1.66) | (-1.68) | (-2.33) |
| *SVOL* | -8.392 | -10.678 | -12.222 | -9.753 | -15.994 | -13.014 | -15.899 | -12.511 | -17.958 | -17.737 | -11.737 | -10.600 |
| | (-0.57) | (-0.90) | (-0.89) | (-0.79) | (-1.16) | (-1.11) | (-1.20) | (-1.04) | (-1.17) | (-1.28) | (-0.66) | (-0.66) |
| ***IVOL×FILLIQ*** | **0.171**** | **0.180***** | **0.188**** | **0.244***** | **0.115*** | **0.154**** | **0.156*** | **0.213***** | **0.122** | **0.161** | **0.175** | **0.244**** |
| | **(2.13)** | **(2.65)** | **(2.27)** | **(3.09)** | **(1.81)** | **(2.32)** | **(1.95)** | **(2.78)** | **(1.41)** | **(1.61)** | **(1.63)** | **(2.29)** |
| *SVOL×FILLIQ* | 0.111 | 0.134 | 0.145 | 0.122 | 0.194 | 0.159 | 0.185 | 0.152 | 0.209 | 0.206 | 0.138 | 0.128 |
| | (0.67) | (1.00) | (0.94) | (0.88) | (1.24) | (1.20) | (1.23) | (1.13) | (1.24) | (1.36) | (0.71) | (0.73) |
| *IVOL×RR* | 0.086 | 0.063 | 0.001 | -0.047 | 0.133 | 0.085 | 0.028 | -0.020 | -0.001 | -0.031 | -0.069 | -0.166 |
| | (0.52) | (0.47) | (0.00) | (-0.31) | (1.00) | (0.65) | (0.16) | (-0.13) | (-0.01) | (-0.15) | (-0.31) | (-0.77) |
| *SVOL×RR* | -0.441 | -0.401* | -0.268 | -0.335 | -0.476* | -0.408* | -0.284 | -0.357* | -0.428** | -0.413*** | -0.271 | -0.318* |
| | (-1.43) | (-1.74) | (-0.93) | (-1.45) | (-1.72) | (-1.89) | (-1.10) | (-1.70) | (-2.52) | (-2.71) | (-1.23) | (-1.92) |
| *FILLIQ* | -0.009** | | | | -0.010** | | | | -0.017*** | | | |
| | (-1.99) | | | | (-2.05) | | | | (-3.00) | | | |
| *RR* | 0.002 | | | | -0.001 | | | | -0.002 | | | |
| | (1.07) | | | | (-0.53) | | | | (-0.81) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.051 | 0.161 | 0.179 | 0.177 | 0.047 | 0.077 | 0.093 | 0.096 | 0.044 | 0.061 | 0.078 | 0.075 |
| # of obs. | 698,730 | 698,730 | 615,107 | 697,812 | 698,730 | 698,730 | 615,107 | 697,812 | 640,373 | 640,373 | 562,654 | 639,439 |

## Table A6. The Effects of Funding Illiquidity on Bond IVOL-Return Relation, Robustness

In this table, we replicate the tests in Table 3. We additionally include bond long-term return reversal and its interaction with funding illiquidity (FILLIQ) as controls in Panel A. The long-term reversal is defined as past 36-month cumulative returns from month $t$-48 to month $t$-13, skipping the 12-month momentum and 1-month short-term reversal. In Panel B, 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, and DEF) plus $\Delta$VIX in past 36-month. In Panel C, we use VIX as the alternative proxy for intermediary funding illiquidity. High VIX stands for high funding illiquidity. The dependent variable for Columns (1) to (4) is next one-month excess return. For Columns (5) to (8) and Columns (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 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, size, and their interactions with the proxy for funding illiquidity. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond and time. The $t$-statistics are reported in parenthesis below coefficients. The sample period is from July 2002 to December 2019.

Panel A: Controlling for Bond Long-term Return Reversal

| | 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* | -19.007*** | -18.914*** | -17.660*** | -20.754*** | -15.411*** | -17.154*** | -15.552** | -19.062*** | -13.549** | -17.038*** | -15.858** | -17.639** |
| | (-2.84) | (-3.28) | (-2.75) | (-3.27) | (-2.80) | (-3.01) | (-2.51) | (-3.08) | (-2.42) | (-2.73) | (-2.38) | (-2.57) |
| *SVOL* | 12.047 | 8.846 | 2.918 | 9.962 | 6.177 | 5.388 | -1.492 | 7.179 | 20.293** | 16.513* | 11.651 | 20.121* |
| | (0.80) | (0.84) | (0.22) | (0.76) | (0.53) | (0.60) | (-0.13) | (0.64) | (1.98) | (1.79) | (1.01) | (1.70) |
| ***IVOL×FILLIQ*** | **0.208*** | **0.207*** | **0.193*** | **0.227*** | **0.169*** | **0.188*** | **0.171** | **0.209*** | **0.149** | **0.186*** | **0.174** | **0.194*** |
| | **(2.84)** | **(3.27)** | **(2.75)** | **(3.27)** | **(2.81)** | **(3.01)** | **(2.51)** | **(3.08)** | **(2.45)** | **(2.76)** | **(2.40)** | **(2.61)** |
| *SVOL×FILLIQ* | -0.127 | -0.092 | -0.029 | -0.104 | -0.064 | -0.056 | 0.018 | -0.074 | -0.214** | -0.174* | -0.122 | -0.211* |
| | (-0.79) | (-0.83) | (-0.20) | (-0.75) | (-0.52) | (-0.58) | (0.15) | (-0.63) | (-1.98) | (-1.79) | (-1.00) | (-1.70) |
| *FILLIQ* | -0.007* | | | | -0.008* | | | | -0.010* | | | |
| | (-1.66) | | | | (-1.66) | | | | (-1.96) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.062 | 0.179 | 0.200 | 0.185 | 0.052 | 0.090 | 0.111 | 0.098 | 0.043 | 0.065 | 0.085 | 0.073 |
| # of obs. | 545,782 | 545,782 | 479,363 | 544,979 | 545,782 | 545,782 | 479,363 | 544,979 | 520,186 | 520,186 | 456,270 | 519,383 |

Panel B: 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* | -8.966** | -7.188** | -6.481* | -5.378 | -7.881*** | -7.170** | -6.425* | -5.012 | -6.766** | -7.037* | -7.962* | -6.842 |
| | (-2.50) | (-2.37) | (-1.81) | (-1.41) | (-2.66) | (-2.47) | (-1.89) | (-1.40) | (-2.04) | (-1.95) | (-1.93) | (-1.22) |
| *SVOL* | -13.917 | -7.227 | -18.545** | -14.911 | -8.603 | -4.438 | -16.349* | -12.546 | -4.196 | -6.718 | -13.210 | -8.342 |
| | (-1.39) | (-1.05) | (-2.14) | (-1.35) | (-1.06) | (-0.65) | (-1.96) | (-1.20) | (-0.46) | (-0.79) | (-1.29) | (-0.63) |
| ***IVOL×FILLIQ*** | **0.097**** | **0.078**** | **0.070*** | **0.058** | **0.086***** | **0.078**** | **0.070*** | **0.055** | **0.074**** | **0.077*** | **0.087*** | **0.075** |
| | **(2.49)** | **(2.35)** | **(1.80)** | **(1.41)** | **(2.65)** | **(2.46)** | **(1.89)** | **(1.40)** | **(2.04)** | **(1.96)** | **(1.93)** | **(1.23)** |
| *SVOL×FILLIQ* | 0.156 | 0.083 | 0.205** | 0.166 | 0.097 | 0.052 | 0.180** | 0.140 | 0.047 | 0.074 | 0.145 | 0.092 |
| | (1.45) | (1.12) | (2.20) | (1.41) | (1.11) | (0.71) | (2.01) | (1.25) | (0.48) | (0.82) | (1.32) | (0.66) |
| *FILLIQ* | -0.009** | | | | -0.008 | | | | -0.013** | | | |
| | (-1.98) | | | | (-1.57) | | | | (-2.39) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.050 | 0.161 | 0.186 | 0.177 | 0.046 | 0.080 | 0.105 | 0.100 | 0.043 | 0.060 | 0.086 | 0.079 |
| # of obs. | 812,893 | 812,893 | 712,982 | 811,600 | 812,893 | 812,893 | 712,982 | 811,600 | 746,407 | 746,407 | 653,357 | 745,064 |

Panel C: 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* | -0.882*** | -0.751*** | -0.735** | -0.771*** | -0.786*** | -0.696*** | -0.674** | -0.729*** | -0.342 | -0.381 | -0.397 | -0.196 |
| | (-2.85) | (-3.19) | (-2.53) | (-2.98) | (-3.02) | (-3.12) | (-2.43) | (-3.00) | (-1.39) | (-1.56) | (-1.34) | (-0.67) |
| *SVOL* | 1.716** | 1.443** | 1.102 | 1.400** | 1.455** | 1.263** | 0.914 | 1.287** | 1.423*** | 1.360*** | 1.232** | 1.435*** |
| | (2.36) | (2.51) | (1.60) | (2.23) | (2.20) | (2.35) | (1.47) | (2.23) | (2.77) | (2.75) | (2.20) | (2.66) |
| ***IVOL×VIX*** | **0.041*** ** | **0.034*** ** | **0.034** ** | **0.036*** ** | **0.035*** ** | **0.031*** ** | **0.031** ** | **0.034*** ** | **0.029** ** | **0.033*** ** | **0.033** ** | **0.029** ** |
| | **(2.99)** | **(3.29)** | **(2.48)** | **(3.08)** | **(3.10)** | **(3.20)** | **(2.35)** | **(3.04)** | **(2.37)** | **(2.62)** | **(2.07)** | **(2.20)** |
| *SVOL×VIX* | -0.049* | -0.034* | -0.021 | -0.033* | -0.036 | -0.029 | -0.015 | -0.028 | -0.047*** | -0.043*** | -0.033** | -0.041*** |
| | (-1.93) | (-1.78) | (-0.92) | (-1.67) | (-1.60) | (-1.60) | (-0.74) | (-1.59) | (-3.29) | (-3.30) | (-2.21) | (-3.18) |
| *VIX* | 0.001 | | | | 0.000 | | | | -0.001 | | | |
| | (0.62) | | | | (0.19) | | | | (-0.54) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×VIX | 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-$R^2$ | 0.064 | 0.167 | 0.189 | 0.182 | 0.050 | 0.081 | 0.101 | 0.098 | 0.048 | 0.066 | 0.088 | 0.079 |
| # of obs. | 698,730 | 698,730 | 615,107 | 697,812 | 698,730 | 698,730 | 615,107 | 697,812 | 640,373 | 640,373 | 562,654 | 639,439 |

# Internet Appendix B:

## Idiosyncratic Bond Volatility and Funding Liquidity

In this appendix, we reconcile our results with those of Bai, Bali, and Wen (2021) (henceforth BBW21) 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 BBW21. Each month we compute IVOL using past six months of daily returns adjusted with respect to the daily Fama and French (1993) factors plus $\Delta$VIX while BBW21 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.[36] 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.

Bali and Cakici (2008) find that the data frequency used to estimate idiosyncratic volatility plays a critical role in determining the existence and significance of a relation between IVOL and the cross section of expected stock returns. Specifically, they show that in the stock market, there is a negative and significant relation between IVOL estimated with daily returns over the previous month and the cross section of expected returns, whereas the cross-sectional relation between IVOL computed based on the previous monthly returns and expected returns is flat. In what follows, we change our

[36] 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.

computation methodology one component at a time to nail down the reasons for the differences in results in this paper and those in BBW21.

Panel B of the Internet Appendix Table A6 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 the Internet Appendix Table B1 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 $\Delta$VIX.

Finally, we use both sets of the monthly factors in Panels C and D of the Internet Appendix Table B1 to confirm the result in BBW21 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. Furthermore, we replicate the main finding using IVOL calculated from rolling regressions of monthly excess returns on the monthly IPCA factors (Kelly, Palhares, and Pruitt (2023)) over the past 36 months, from August 2003 (the beginning of the factors) to December 2019 (the end of our sample period). Results are presented in the Internet Appendix Table B2. The IVOL measure based on the monthly IPCA factors has a high cross-sectional correlation with IVOL measures obtained from alternative monthly factor models, and still does not significantly predict next the month return even for periods following low funding liquidity.

Panel E of the Internet Appendix Table B1 shows that even if we compute IVOL using daily returns (as in Panel B) and restrict the sample to non-missing IVOL using monthly data (as in Panel C), we still find evidence of the 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.

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 than that computed from monthly returns, as the return fluctuations are smoothed out at lower frequencies. The Internet Appendix Table B3 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 $\Delta$VIX to compute IVOL. In addition, we can observe the differences in IVOL over time when computed using different methods in the Internet Appendix Figure B1.

A second potential reason why the bond IVOL-return relation established with IVOL computed at the daily frequency is impacted by the funding liquidity could be because the equity capital of the primary dealers (used to calculate ICR) changes at a high frequency with changes in stock prices.

Overall, it is the frequency of returns over which IVOL is measured that drives the differences in the results of this paper and those in BBW21.

**Figure B1.**
**Time Series of Cross-Sectional Averages of Different Bond IVOL Measures**

This figure shows time-series of cross-sectional average of different bond IVOL measures in the sample period from December 2004 to December 2019 during which all the six measures are non-missing. Bond 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 $\Delta$VIX 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 $\Delta$VIX 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 $\Delta$VIX 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 $\sqrt{22}$.

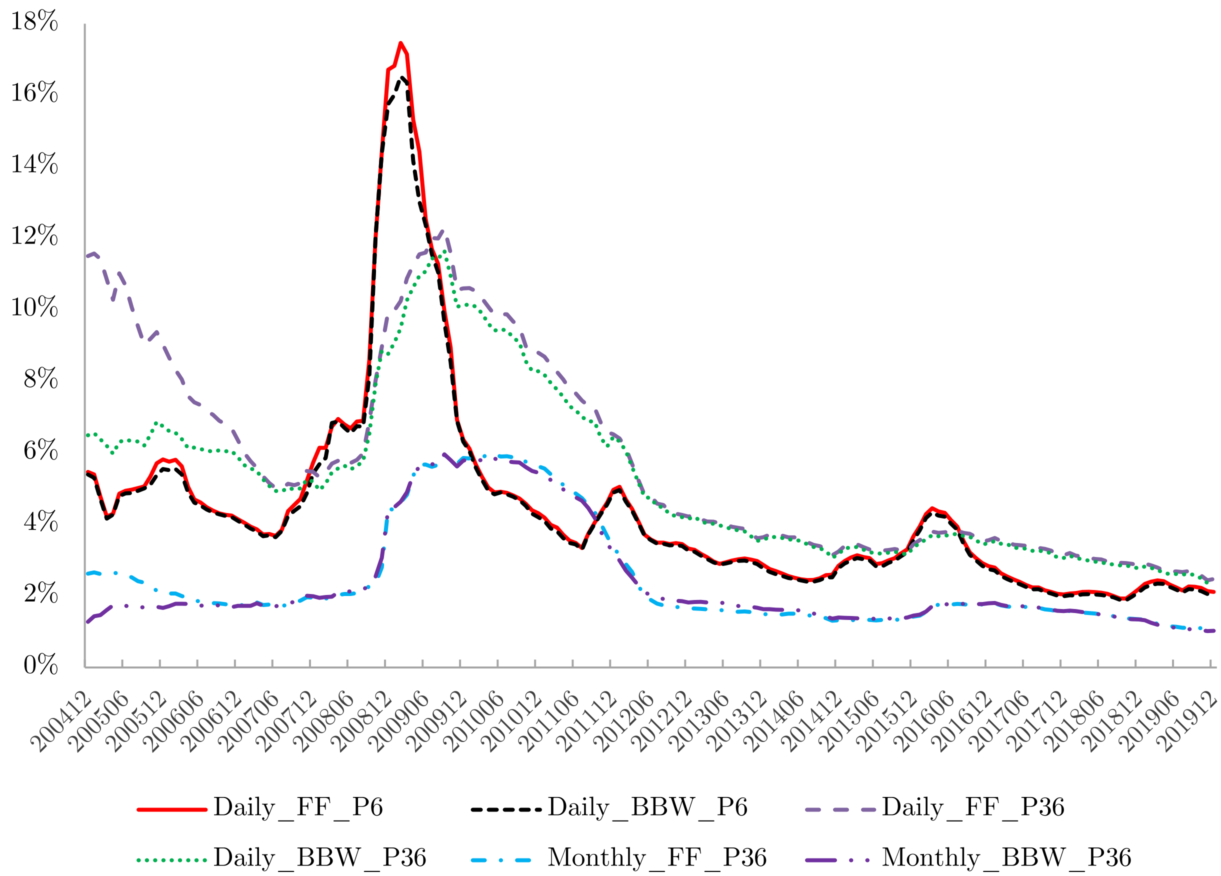


**Table B1. Reconciliation of the Bond IVOL-Return Relation with Bai, Bali, and Wen (2021)**

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) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. Funding illiquidity (FILLIQ) is defined as (1-ICR) multiplied by 100. We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), FILLIQ, and their interactions. 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, and DEF) plus $\Delta$VIX over past 36-month; iv) monthly bond excess returns on monthly BBW factors over past 36 months. Panel E reports results using the IVOL measure in Panel B while limiting the sample to observations with non-missing IVOL measure in Panel C. 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 momentum, maturity, age, coupon, size, and their interactions with FILLIQ. 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. The $t$-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* | -15.139** | -13.527** | -14.167** | -14.796** | -10.906** | -12.668** | -13.058** | -13.694** | -10.140** | -13.611*** | -14.794*** | -14.932*** |
| | (-2.17) | (-2.50) | (-2.49) | (-2.54) | (-2.28) | (-2.55) | (-2.56) | (-2.59) | (-2.19) | (-2.72) | (-3.09) | (-2.77) |
| *SVOL* | 6.691 | 0.553 | 0.918 | 3.735 | 1.051 | -0.510 | -0.795 | 2.884 | 12.500 | 8.323 | 10.817 | 13.699 |
| | (0.48) | (0.04) | (0.07) | (0.27) | (0.09) | (-0.05) | (-0.07) | (0.23) | (0.93) | (0.62) | (0.73) | (0.92) |
| ***IVOL×FILLIQ*** | **0.166**** | **0.148**** | **0.155**** | **0.163**** | **0.119**** | **0.138**** | **0.142**** | **0.151***** | **0.111**** | **0.148***** | **0.160***** | **0.164***** |
| | **(2.20)** | **(2.53)** | **(2.51)** | **(2.60)** | **(2.31)** | **(2.57)** | **(2.57)** | **(2.64)** | **(2.23)** | **(2.76)** | **(3.10)** | **(2.83)** |
| *SVOL×FILLIQ* | -0.066 | 0.001 | -0.002 | -0.034 | -0.005 | 0.012 | 0.016 | -0.025 | -0.127 | -0.082 | -0.107 | -0.139 |
| | (-0.44) | (0.01) | (-0.01) | (-0.23) | (-0.04) | (0.10) | (0.13) | (-0.19) | (-0.89) | (-0.58) | (-0.68) | (-0.88) |
| *FILLIQ* | -0.008 | | | | -0.010* | | | | -0.012** | | | |
| | (-1.44) | | | | (-1.74) | | | | (-2.19) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.055 | 0.175 | 0.195 | 0.185 | 0.048 | 0.083 | 0.104 | 0.096 | 0.038 | 0.058 | 0.077 | 0.071 |
| # of obs. | 652,422 | 652,422 | 573,391 | 651,560 | 652,422 | 652,422 | 573,391 | 651,560 | 640,372 | 640,372 | 562,653 | 639,438 |

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* | -14.989** | -7.849 | -10.619** | -11.608** | -9.403** | -7.094 | -9.181** | -9.950* | -6.661 | -7.593 | -10.330** | -11.408* |
| | (-2.45) | (-1.63) | (-2.22) | (-1.98) | (-2.05) | (-1.54) | (-2.03) | (-1.79) | (-1.52) | (-1.62) | (-2.29) | (-1.80) |
| *SVOL* | -4.505 | -7.053 | -11.545 | -3.665 | -6.968 | -5.857 | -11.712 | -3.013 | -3.776 | -4.867 | -9.210 | -0.054 |
| | (-0.49) | (-0.87) | (-1.30) | (-0.36) | (-0.81) | (-0.75) | (-1.39) | (-0.31) | (-0.42) | (-0.55) | (-0.89) | (-0.00) |
| ***IVOL×FILLIQ*** | **0.163**** | **0.086*** | **0.116**** | **0.127**** | **0.103**** | **0.078** | **0.100**** | **0.109*** | **0.073** | **0.083** | **0.113**** | **0.125*** |
| | **(2.47)** | **(1.66)** | **(2.23)** | **(2.01)** | **(2.07)** | **(1.57)** | **(2.05)** | **(1.83)** | **(1.55)** | **(1.65)** | **(2.31)** | **(1.84)** |
| *SVOL×FILLIQ* | 0.053 | 0.080 | 0.129 | 0.043 | 0.078 | 0.066 | 0.130 | 0.035 | 0.043 | 0.055 | 0.102 | 0.003 |
| | (0.54) | (0.91) | (1.34) | (0.40) | (0.84) | (0.78) | (1.43) | (0.34) | (0.44) | (0.58) | (0.93) | (0.03) |
| *FILLIQ* | -0.010* | | | | -0.010* | | | | -0.013** | | | |
| | (-1.94) | | | | (-1.76) | | | | (-2.23) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.058 | 0.177 | 0.204 | 0.189 | 0.051 | 0.089 | 0.117 | 0.104 | 0.044 | 0.062 | 0.089 | 0.079 |
| # of obs. | 759,366 | 759,366 | 664,877 | 758,093 | 759,366 | 759,366 | 664,877 | 758,093 | 746,198 | 746,198 | 653,176 | 744,869 |

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 | 5.771 | 4.003 | 4.575 | 6.366 | 4.835 | 3.559 | 4.030 | 5.727 | 4.074 | 3.836 | 4.301 | 6.388 |
| | (1.02) | (0.82) | (0.61) | (0.72) | (0.96) | (0.79) | (0.59) | (0.70) | (0.99) | (0.98) | (0.71) | (0.89) |
| SVOL | -15.098* | -12.859* | -17.300* | -17.322* | -14.058** | -12.892** | -17.599* | -17.598** | -9.676* | -10.674* | -14.105* | -14.585* |
| | (-1.81) | (-1.88) | (-1.72) | (-1.83) | (-2.08) | (-2.08) | (-1.96) | (-2.05) | (-1.78) | (-1.94) | (-1.77) | (-1.87) |
| ***IVOL×FILLIQ*** | **-0.062** | **-0.043** | **-0.048** | **-0.069** | **-0.052** | **-0.038** | **-0.043** | **-0.062** | **-0.043** | **-0.041** | **-0.045** | **-0.069** |
| | **(-1.02)** | **(-0.82)** | **(-0.60)** | **(-0.72)** | **(-0.96)** | **(-0.79)** | **(-0.58)** | **(-0.71)** | **(-0.98)** | **(-0.98)** | **(-0.70)** | **(-0.89)** |
| *SVOL×FILLIQ* | 0.162* | 0.138* | 0.187* | 0.186* | 0.150** | 0.138** | 0.189* | 0.189** | 0.103* | 0.114* | 0.152* | 0.156* |
| | (1.82) | (1.89) | (1.73) | (1.85) | (2.09) | (2.09) | (1.97) | (2.06) | (1.79) | (1.95) | (1.78) | (1.88) |
| FILLIQ | 0.001 | | | | 0.000 | | | | -0.006 | | | |
| | (0.10) | | | | (0.00) | | | | (-0.68) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.080 | 0.199 | 0.232 | 0.205 | 0.072 | 0.120 | 0.158 | 0.128 | 0.065 | 0.089 | 0.124 | 0.097 |
| # of obs. | 419,645 | 419,645 | 368,348 | 419,073 | 419,645 | 419,645 | 368,348 | 419,073 | 416,253 | 416,253 | 365,433 | 415,663 |

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* | -0.070 | 0.236 | 0.738 | -0.496 | 0.699 | 0.110 | 0.388 | -0.801 | 0.502 | 0.136 | 0.684 | 0.072 |
| | (-0.01) | (0.04) | (0.09) | (-0.06) | (0.12) | (0.02) | (0.05) | (-0.10) | (0.10) | (0.03) | (0.10) | (0.01) |
| *SVOL* | -9.544 | -9.038 | -12.129 | -9.925 | -10.077 | -9.507 | -12.829 | -10.708* | -6.263 | -7.046 | -9.330 | -7.814 |
| | (-1.29) | (-1.34) | (-1.32) | (-1.44) | (-1.58) | (-1.52) | (-1.53) | (-1.68) | (-1.18) | (-1.26) | (-1.25) | (-1.36) |
| ***IVOL×FILLIQ*** | **0.001** | **-0.002** | **-0.007** | **0.006** | **-0.007** | **-0.000** | **-0.003** | **0.010** | **-0.004** | **-0.001** | **-0.006** | **0.000** |
| | **(0.02)** | **(-0.03)** | **(-0.08)** | **(0.07)** | **(-0.11)** | **(-0.01)** | **(-0.04)** | **(0.11)** | **(-0.08)** | **(-0.01)** | **(-0.09)** | **(0.00)** |
| *SVOL×FILLIQ* | 0.102 | 0.096 | 0.131 | 0.105 | 0.107 | 0.101 | 0.138 | 0.113* | 0.066 | 0.074 | 0.100 | 0.082 |
| | (1.29) | (1.34) | (1.33) | (1.45) | (1.57) | (1.52) | (1.54) | (1.68) | (1.17) | (1.26) | (1.26) | (1.36) |
| *FILLIQ* | -0.001 | | | | -0.002 | | | | -0.007 | | | |
| | (-0.12) | | | | (-0.19) | | | | (-0.91) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.080 | 0.200 | 0.232 | 0.204 | 0.073 | 0.121 | 0.159 | 0.127 | 0.066 | 0.090 | 0.125 | 0.096 |
| # of obs. | 413,702 | 413,702 | 363,000 | 413,131 | 413,702 | 413,702 | 363,000 | 413,131 | 410,310 | 410,310 | 360,085 | 409,721 |

Panel E: IVOL from Regressing Daily Returns on Daily BBW Factors, Past 36-Month, non-missing IVOL measure in Panel C

| | 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* | -8.798 | -3.706 | -12.571* | -11.294 | -3.385 | -2.159 | -9.957 | -7.930 | -3.223 | -4.515 | -12.334* | -9.194 |
| | (-1.01) | (-0.43) | (-1.68) | (-1.04) | (-0.46) | (-0.27) | (-1.46) | (-0.78) | (-0.46) | (-0.59) | (-1.84) | (-0.94) |
| *SVOL* | -31.757 | -30.095 | -30.783 | -35.939 | -34.674 | -30.234 | -32.884 | -38.063 | -20.939 | -21.050 | -20.658 | -27.378 |
| | (-1.05) | (-1.22) | (-1.12) | (-1.09) | (-1.36) | (-1.33) | (-1.34) | (-1.23) | (-1.01) | (-1.05) | (-0.97) | (-1.00) |
| ***IVOL×FILLIQ*** | **0.097** | **0.043** | **0.138*** | **0.126** | **0.039** | **0.026** | **0.110** | **0.090** | **0.037** | **0.051** | **0.135*** | **0.103** |
| | **(1.04)** | **(0.46)** | **(1.72)** | **(1.09)** | **(0.50)** | **(0.31)** | **(1.51)** | **(0.83)** | **(0.50)** | **(0.62)** | **(1.89)** | **(0.99)** |
| *SVOL×FILLIQ* | 0.340 | 0.322 | 0.332 | 0.382 | 0.370 | 0.323 | 0.353 | 0.403 | 0.223 | 0.224 | 0.222 | 0.290 |
| | (1.06) | (1.23) | (1.14) | (1.10) | (1.36) | (1.33) | (1.35) | (1.24) | (1.01) | (1.06) | (0.98) | (1.01) |
| *FILLIQ* | -0.003 | | | | -0.002 | | | | -0.008 | | | |
| | (-0.26) | | | | (-0.15) | | | | (-0.76) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.076 | 0.195 | 0.223 | 0.202 | 0.068 | 0.115 | 0.147 | 0.124 | 0.063 | 0.086 | 0.117 | 0.096 |
| # of obs. | 419,644 | 419,644 | 368,347 | 419,072 | 419,644 | 419,644 | 368,347 | 419,072 | 416,252 | 416,252 | 365,432 | 415,662 |

**Table B2. The Bond IVOL-Return Relation, with IVOL from Monthly IPCA Factors**

In this table, we use IVOL obtained from regressing monthly returns on the IPCA factors in Kelly, Palhares, and Pruitt (2023), and repeat the tests in Table 3. We use the intermediary capital ratio (ICR) in He, Kelly, and Manela (2017) to proxy for the aggregate intermediary funding liquidity. Funding illiquidity (FILLIQ) is defined as (1-ICR) multiplied by 100. We regress one-month-ahead corporate bond returns on bond idiosyncratic volatility (IVOL), bond systematic volatility (SVOL), FILLIQ, and their interactions. The dependent variable in Columns (1) to (4) is the next one-month excess return. In Columns (5) to (8) and Column (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 momentum, maturity, age, coupon, size, and their interactions with FILLIQ. 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. The $t$-statistics are reported in parenthesis below coefficients. The sample period is from August 2003 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* | -4.713 | -6.154 | -10.518 | -10.714 | -3.593 | -5.985 | -10.213 | -10.603 | -4.381 | -4.736 | -8.195 | -8.263 |
| | (-0.75) | (-1.18) | (-1.53) | (-1.25) | (-0.63) | (-1.21) | (-1.61) | (-1.32) | (-0.95) | (-1.10) | (-1.48) | (-1.17) |
| *SVOL* | -5.391 | -2.595 | -0.811 | 0.893 | -6.599 | -3.505 | -2.392 | -0.474 | -1.163 | -1.997 | -0.457 | 1.119 |
| | (-0.51) | (-0.36) | (-0.09) | (0.10) | (-0.82) | (-0.54) | (-0.30) | (-0.06) | (-0.19) | (-0.35) | (-0.07) | (0.15) |
| ***IVOL×FILLIQ*** | **0.050** | **0.065** | **0.113** | **0.113** | **0.038** | **0.064** | **0.110** | **0.111** | **0.047** | **0.050** | **0.088** | **0.087** |
| | **(0.75)** | **(1.19)** | **(1.54)** | **(1.23)** | **(0.63)** | **(1.21)** | **(1.62)** | **(1.30)** | **(0.95)** | **(1.11)** | **(1.49)** | **(1.15)** |
| *SVOL×FILLIQ* | 0.058 | 0.028 | 0.010 | -0.007 | 0.070 | 0.038 | 0.027 | 0.007 | 0.013 | 0.022 | 0.006 | -0.010 |
| | (0.52) | (0.37) | (0.11) | (-0.07) | (0.82) | (0.55) | (0.32) | (0.08) | (0.19) | (0.35) | (0.08) | (-0.13) |
| *FILLIQ* | -0.001 | | | | -0.002 | | | | -0.007 | | | |
| | (-0.08) | | | | (-0.15) | | | | (-0.89) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×FILLIQ | 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-$R^2$ | 0.077 | 0.198 | 0.230 | 0.203 | 0.070 | 0.118 | 0.156 | 0.126 | 0.064 | 0.088 | 0.122 | 0.095 |
| # of obs. | 419,645 | 419,645 | 368,348 | 419,073 | 419,645 | 419,645 | 368,348 | 419,073 | 416,253 | 416,253 | 365,433 | 415,663 |

**Table B3. 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 5$^{th}$ percentile, lower quartile (Q1), median, upper quartile (Q3), and the 95$^{th}$ 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, and 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, and 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 | 5$^{th}$ | Q1 | Median | Q3 | 95$^{th}$ |
|---|---|---|---|---|---|---|---|---|
| *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 |

# Internet Appendix C:

## Idiosyncratic Bond Volatility and Funding Liquidity

In this appendix, we investigate the IVOL-return relation around two extreme shocks, specifically the Global Financial Crisis (GFC) in September 2008 and the COVID-19 (Covid) crisis in March 2020. In both cases, there was an initial negative shock to the dealer capital followed by the Federal Reserve (Fed) expansionary intervention that restored funding liquidity. For example, Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018) find that the dealer capital commitments and average trade size declined during the financial crisis, especially for bank-affiliated dealers. Moreover, O'Hara and Zhou (2021) show that dealers even shifted from buying bonds to selling them during the COVID-19 crisis.

Our aim is to observe return dynamics for high IVOL bonds during low and high funding liquidity periods. The hypothesis is that bonds with high IVOL experience extreme price declines during the crises followed by subsequent reversals due to improving funding liquidity after the Fed interventions. The caveat is that with the GFC and the Covid crises, there was a serious economic dislocation that impacted not only funding liquidity but other macro factors that could have impacted the demand for risky securities. Nevertheless, we will try to isolate the impact on funding liquidity by exploiting not only the shock to dealer capital but also the subsequent expansionary intervention by the Fed.

Given the short span of the crises, we switch to weekly frequency for analysis. We first examine the price dynamics around the peak of the crisis and after Federal Reserve intervention. We plot the average weekly raw and abnormal returns for bonds with IVOL in the highest and lowest quintiles, during the period of Global Financial Crisis and

COVID-19 crisis, in Figure C1a. and in Figure C1b., respectively.[37] For the high IVOL bonds, there is an initial drop in prices when the funding liquidity is constrained (from week 0 to week 3), compared to the pre-crisis period (from week -4 to week -1). Afterwards, when the funding liquidity constraint is relaxed due to the easing of monetary policy by the Federal Reserve, prices increase (from week 4 to week 7). In the following sub-sections, we describe the Global Financial Crisis and COVID-19 crisis in detail and formally test the IVOL-return relation around the two crisis periods.

*C.1. The Global Financial Crisis*

There was the broad deterioration in liquidity in the corporate bond market during the GFC in September 2008 around the Lehman bankruptcy. 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 began to ease monetary policy by lowering the interest rates to less than 0.25% and did not raise rates until December 2015. The Fed's goal was to increase the amount of money available in the economy and spur economic growth. After the Fed intervention, we expect to see return reversals in high IVOL bonds that were impacted by funding illiquidity during the crisis.

In Table C1, we examine the IVOL-return relation around the 2008 Global Financial Crisis. In Panel A, we regress the contemporaneous weekly raw and abnormal returns on the most recent available bond IVOL and SVOL, interacted with a dummy variable GFC equal to one (zero) for the four weeks after (before) September 8, 2008, the start of the crisis. The sample period spans from August 11, 2008 to October 3, 2008. In Panel B, we

[37] The weekly abnormal return is computed as the difference between the raw returns and the value-weighted average return of the pool of bonds sharing similar credit ratings and time to maturity at the beginning of each week following Jiang, Li, Sun, and Wang (2022). The detailed definition is provided in the Appendix.

interact IVOL and SVOL with a dummy variable, Rate_down, equal to one (zero) for the four weeks after (before) the decrease in the Fed funds rate on October 8. This sample is from September 8, 2008 to October 31, 2008. IVOL and SVOL are computed as of the month-end prior to each week. The control variables in both panels include the most recent available bond rating, bond illiquidity, lagged one-week bond return, maturity, age, coupon, size, and their interactions with the corresponding time dummy. Standard errors are clustered at the bond level.

Panel A of Table C1 reports significantly negative coefficients on the interaction term IVOL×GFC, suggesting that bonds with high IVOL indeed tend to be particularly vulnerable and suffer larger decreases in prices in 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 level by about 1.34% (1.29%×(-1.041)), with bond and time fixed effects. When we use weekly abnormal return as the dependent variable, the coefficients on IVOL×GFC are negative and significant in columns (7) and (8). A one- standard-deviation increase in IVOL leads to a decrease of 1.01% (1.29%×(-0.783)) in the weekly abnormal return.

The significantly positive coefficients on the interaction term of IVOL×Rate_down, in Panel B of Table C1, point to the positive returns for the high IVOL bonds after Fed's easing of monetary policy. In Columns (4) and (8), a one-standard-deviation increase in IVOL is associated with an increase in weekly raw and abnormal return from the pre-intervention level by about 2.35% (1.29% × (1.819)) and 2.19% (1.29% × (1.699)), respectively.

Given that we focus on weekly regressions and that there may be a delay in the impact of the crisis and the following Federal Reserve intervention, 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 C2 using the same setting of Table C1. The results remain robust. There is a decline in returns of the high IVOL bonds when funding liquidity deteriorates due to GFC and a reversal in returns when funding liquidity improves after the Federal Reserve intervention.

*C.2. The Covid crisis*

Another large exogenous shock to funding liquidity especially in the corporate bond market is the Covid crisis in March 2020, which started with mounting concerns about the pandemic and quickly spiraled into a full-blown crisis within a couple of weeks with a surge in selling activity, especially of the illiquid and risky bonds. Jiang, Li, Sun, and Wang (2022) 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. For instance, 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 even dealers shifted from buying bonds to selling them, exacerbating market illiquidity. The shift was probably driven by a cumulative negative $8 billion inventory position for the dealer community.

The Fed intervened with the announcement of the primary dealer credit facility (PDCF) on Tuesday March 17, 2020 which started operations on Friday March 20, 2020.[38] By offering term funding to primary dealers, PDCF aimed to improve market liquidity through enhancing funding conditions particularly for corporate bond dealers to fund their inventories. The facility effectively increased intermediation from dealers and stabilized the corporate bond market (e.g., Kargar, Lester, Lindsay, Liu, Weill, and Zúñiga (2021); O'Hara and Zhou (2021); and Boyarchenko, Kovner, and Shachar (2022)). Therefore, we

[38] The PDCF offered overnight and term funding with maturities up to 90 days to primary dealers at the discount rate offered by the Fed. All credit extended by the PDCF had to be collateralized by a broad range of investment-grade debt securities, including investment-grade corporate bonds, municipal bonds, and commercial paper. O'Hara and Zhou (2021) show that dealers increase their inventories after PDCF started operating on March 20, 2020.

expect bonds with high IVOL to see the most price declines during the early stages of the crisis and reverse later after the start of operations of the PDCF.

Table C3 presents results based on tests similar to the above. The sample period spans from January 27, 2020 to March 20, 2020 in Panel A, including the pre-Covid period from January 27, 2020 to February 24, 2020. The dummy variable COVID is equal to one for the four weeks after February 24, 2020, and zero otherwise. In Panel B, the PDCF dummy is equal to one (zero) in the four weeks after (before) the PDCF operations, and the sample period is from February 24, 2020 to April 17, 2020.

Panel A of Table C3 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 crisis but before the PDCF started operations. With time and bond fixed effects, a one-standard-deviation increase in IVOL is accompanied with the decrease of about 0.56% (0.61%×(-0.915)) and 0.66% (0.61%×(-1.077)) in the weekly raw and abnormal returns, respectively.[39]

On the other hand, after the start of PDCF operations, dealers are more willing to provide 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 C3. Coefficients on the interaction term IVOL×PDCF are significantly positive. Results with the next one-week raw and abnormal returns as the dependent variables are provided in the Internet Appendix Table C4 and are essentially unchanged.

With these two crises, we are able to observe the return dynamics for high IVOL bonds during low and high funding liquidity periods in details. In sum, bonds with high IVOL have significantly negative returns in several weeks during the Global Financial Crisis and the Covid crisis when the aggregate intermediary funding liquidity deteriorated. Later, after the Fed eased monetary policy and funding liquidity improved, the high IVOL bonds earned positive returns.

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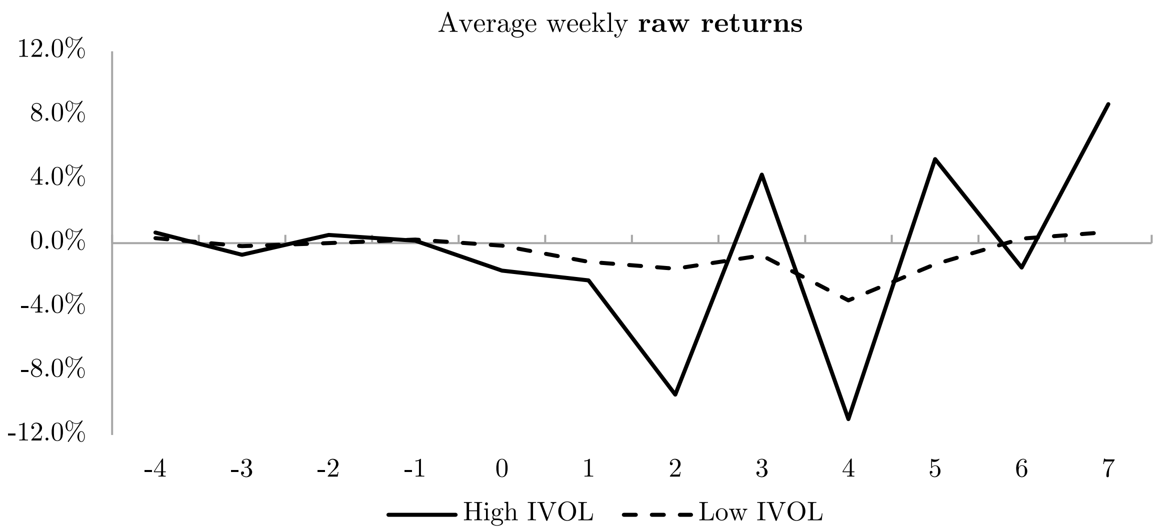
[39] The standard deviation of IVOL is 0.61% in the sample of the Covid crisis.

**Figure C1. The Bond IVOL Effects During Periods of Stress**

This figure shows the average weekly raw and abnormal returns for bonds with high and low IVOL, during the period around the Global Financial Crisis in Figure C1a. and the COVID-19 crisis in Figure C1b., respectively. The weekly abnormal return is computed as the weekly raw return subtracted by the value-weighted average return of the pool of bonds that share similar credit ratings and time to maturity at the beginning of each week. In Figure C1a., week 0 is the week of the spark of the Global Financial Crisis on September 8, 2008, and week 4 is the week of the Fed announcement of the decrease in interest rates on October 8, 2008. In Figure C1b., week 0 is the week of the spark of the COVID-19 crisis on February 24, 2020, and week 4 is the first week after the PDCF operations on March 20, 2020. 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 average raw and abnormal returns for bonds in the top (high IVOL) and bottom (low IVOL) quintiles.

Figure C1a. Weekly Raw and Abnormal Returns, Around the **Global Financial Crisis**



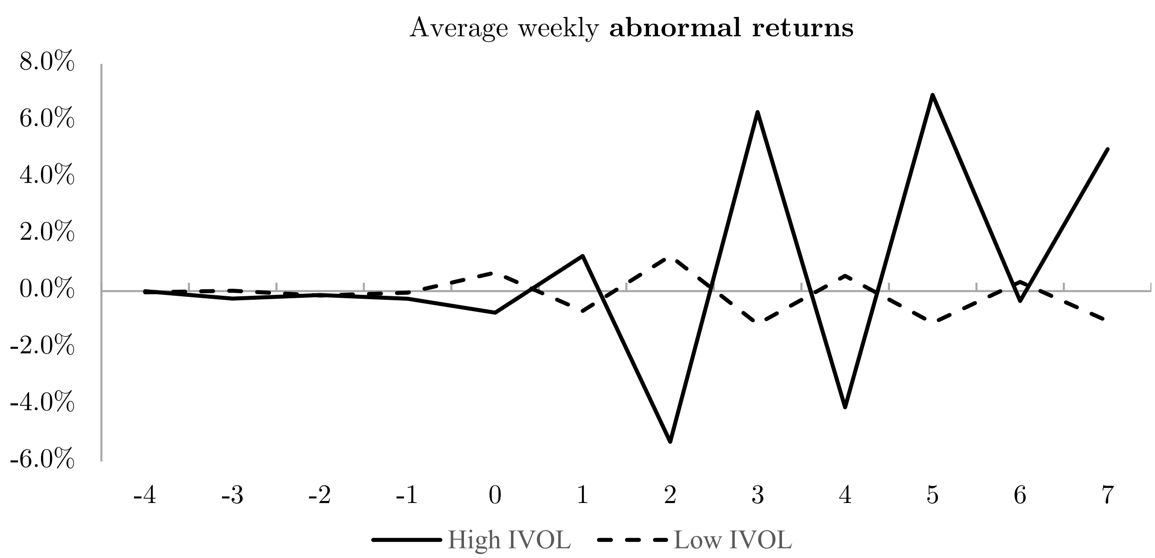
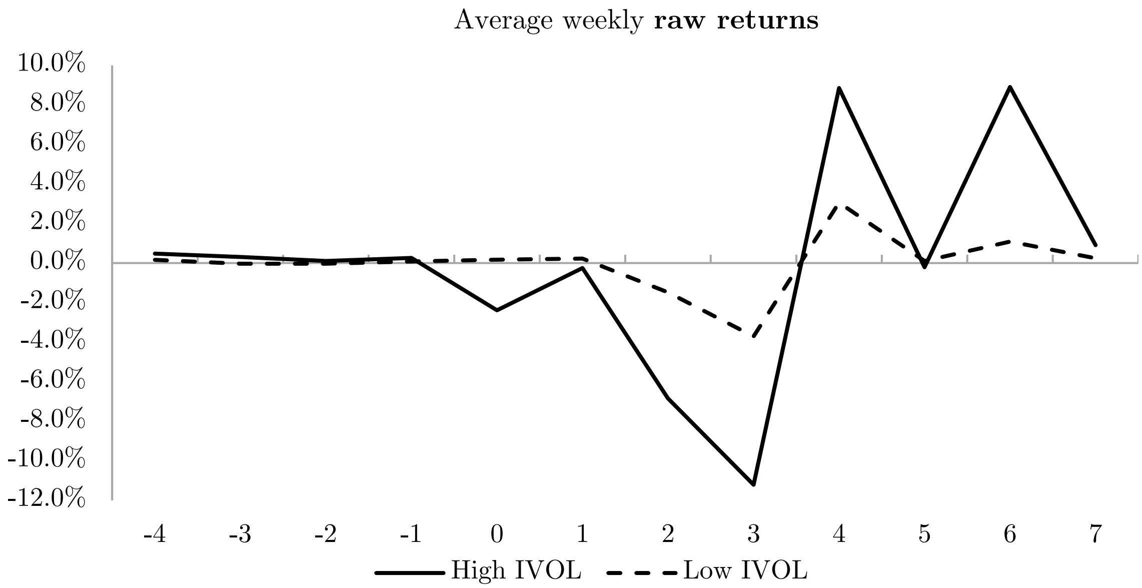



Figure C1b. Weekly Raw and Abnormal Returns, Around the **COVID-19 Crisis**



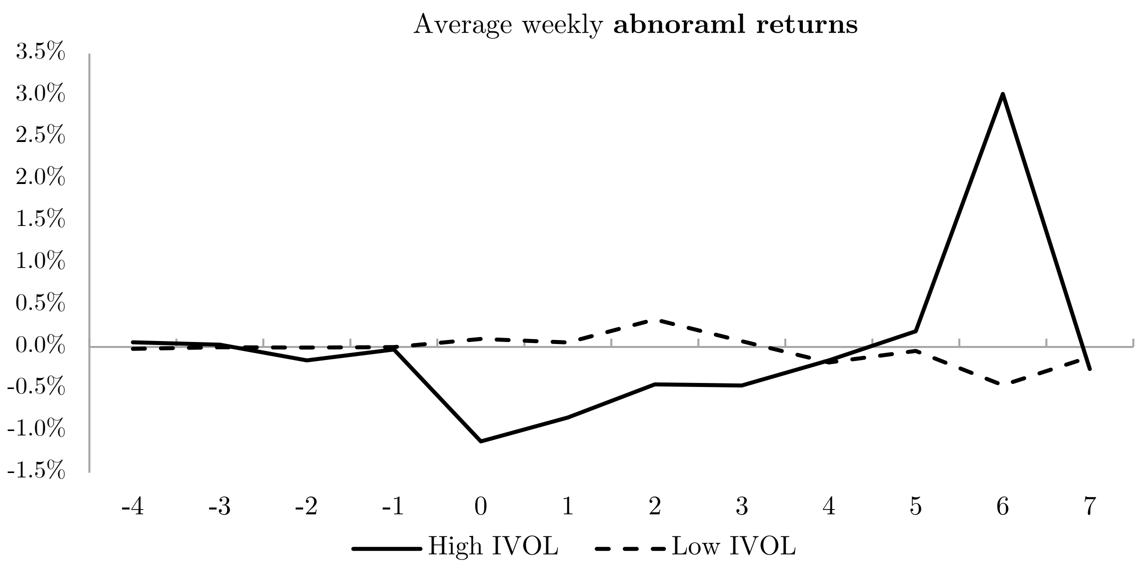



**Table C1. The Bond IVOL-Return Relation Around the Global Financial Crisis**

This table reports results from panel 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 is from August 11, 2008 to October 3, 2008. The GFC dummy is equal to one (zero) for the four weeks after (before) September 8, 2008. In Panel B, the sample period is from September 8, 2008 to October 31, 2008. The Rate_down dummy is equal to one (zero) for the four weeks after (before) October 8, 2008. The dependent variables in Columns (1) to (4), and Columns (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 value-weighted average weekly returns of bonds in the same rating and maturity buckets as that of the bond at the beginning of each week. 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, size, and their interactions with the time dummy. 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. The $t$-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the GFC

| | Weekly raw returns | | | | Weekly abnormal returns | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *IVOL* | 0.008 | 0.009 | 0.432** | 1.856 | 0.047 | 0.049 | 0.403** | 1.709 |
| | (0.09) | (0.10) | (2.58) | (1.41) | (0.53) | (0.55) | (2.41) | (1.30) |
| *SVOL* | -0.153 | -0.161 | 0.222 | 4.260 | -0.229 | -0.232 | 0.230 | 4.631* |
| | (-0.76) | (-0.81) | (0.84) | (1.56) | (-1.16) | (-1.18) | (0.87) | (1.70) |
| ***IVOL×GFC*** | **-0.714** | **-0.778** | **-1.076*** ** | **-1.041** ** | **-0.483** | **-0.630** | **-0.965*** ** | **-0.783* ** |
| | **(-1.11)** | **(-1.15)** | **(-3.50)** | **(-2.30)** | **(-0.75)** | **(-0.93)** | **(-3.17)** | **(-1.77)** |
| *SVOL×GFC* | 4.678 | 4.790 | 0.510 | 2.504 | 4.200 | 4.685 | 0.304 | 2.127 |
| | (1.48) | (1.45) | (0.86) | (1.01) | (1.32) | (1.42) | (0.51) | (0.85) |
| *GFC* | -0.079 | | | | -0.086 | | | |
| | (-1.10) | | | | (-1.19) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×GFC | 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-$R^2$ | 0.088 | 0.099 | 0.192 | 0.127 | 0.064 | 0.070 | 0.122 | 0.101 |
| # of obs. | 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* | -0.705 | -0.769 | -0.566* | 0.762 | -0.436 | -0.580 | -0.462 | 0.956 |
| | (-1.10) | (-1.14) | (-1.69) | (0.58) | (-0.68) | (-0.86) | (-1.36) | (0.73) |
| *SVOL* | 4.525 | 4.629 | 0.860 | 7.804* | 3.972 | 4.453 | 0.637 | 7.637* |
| | (1.44) | (1.41) | (1.46) | (1.72) | (1.26) | (1.36) | (1.07) | (1.68) |
| ***IVOL×Rate_down*** | **2.414*** ** | **2.530*** ** | **1.120*** ** | **1.819** ** | **2.246*** ** | **2.395*** ** | **1.064*** ** | **1.699** ** |
| | **(3.38)** | **(3.41)** | **(3.00)** | **(2.22)** | **(3.18)** | **(3.25)** | **(2.91)** | **(2.09)** |
| *SVOL×Rate_down* | -5.784* | -5.855* | -0.698 | -5.401 | -5.246* | -5.724* | -0.522 | -5.308 |
| | (-1.95) | (-1.88) | (-1.01) | (-1.47) | (-1.76) | (-1.84) | (-0.76) | (-1.45) |
| *Rate_down* | 0.055 | | | | 0.069 | | | |
| | (0.78) | | | | (0.99) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×Rate_down | 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-$R^2$ | 0.049 | 0.086 | 0.188 | 0.096 | 0.043 | 0.047 | 0.096 | 0.060 |
| # of obs. | 11,960 | 11,960 | 10,002 | 11,694 | 11,948 | 11,948 | 9,993 | 11,687 |

**Table C2.**

**The Bond IVOL Effects Around the Global Financial Crisis, Next Week Returns**

This table has the same setting as the tests in Table C1. 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 is equal to one (zero) 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 equal to one (zero) for the four weeks after (before) October 8, 2008. The dependent variable in Columns (1) to (4), and Columns (5) to (8) are raw return and abnormal return in the next week, respectively. The weekly abnormal return of a bond is calculated as the difference between the raw return and the value-weighted average weekly returns of bonds in the same rating and maturity buckets as that of the bond at the beginning of each week. 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, size, and their interactions with the time dummy. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond. The $t$-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the GFC

| | Weekly raw returns | | | | Weekly abnormal returns | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *IVOL* | 0.017 | 0.022 | 0.548** | -0.747 | 0.061 | 0.062 | 0.536** | -0.680 |
| | (0.21) | (0.27) | (2.24) | (-0.68) | (0.75) | (0.76) | (2.17) | (-0.61) |
| *SVOL* | -0.148 | -0.166 | -0.070 | -1.456 | -0.234 | -0.236 | -0.056 | -0.858 |
| | (-0.74) | (-0.83) | (-0.19) | (-0.65) | (-1.17) | (-1.18) | (-0.15) | (-0.38) |
| ***IVOL×GFC*** | **-0.635*** | **-0.674*** | **-1.054**** | **-0.962**** | **-0.492** | **-0.534** | **-0.918**** | **-0.733*** |
| | **(-1.73)** | **(-1.83)** | **(-2.54)** | **(-2.27)** | **(-1.35)** | **(-1.45)** | **(-2.25)** | **(-1.74)** |
| *SVOL×GFC* | 1.589 | 1.616 | 2.091 | 2.417 | 1.340 | 1.329 | 1.880 | 1.971 |
| | (1.10) | (1.12) | (1.15) | (1.10) | (0.93) | (0.92) | (1.04) | (0.89) |
| *GFC* | -0.006 | | | | -0.018 | | | |
| | (-0.11) | | | | (-0.38) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×GFC | 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-$R^2$ | 0.053 | 0.065 | 0.105 | 0.052 | 0.036 | 0.039 | 0.081 | 0.024 |
| # of obs. | 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* | -0.618* | -0.652* | -0.324 | -0.224 | -0.431 | -0.472 | -0.206 | 0.105 |
| | (-1.73) | (-1.81) | (-0.78) | (-0.18) | (-1.21) | (-1.32) | (-0.49) | (0.09) |
| *SVOL* | 1.441 | 1.450 | 1.547 | 4.594** | 1.106 | 1.094 | 1.289 | 3.572* |
| | (1.02) | (1.02) | (0.99) | (2.44) | (0.79) | (0.78) | (0.82) | (1.88) |
| ***IVOL×Rate_ down*** | **2.348***** | **2.428***** | **0.868*** | **1.937***** | **2.247***** | **2.293***** | **0.837*** | **1.543**** |
| | **(3.81)** | **(3.94)** | **(1.80)** | **(2.70)** | **(3.67)** | **(3.74)** | **(1.75)** | **(2.15)** |
| *SVOL×Rate_ down* | -2.708* | -2.683* | -1.288 | -4.559* | -2.382* | -2.365* | -1.089 | -3.680 |
| | (-1.94) | (-1.91) | (-0.83) | (-1.90) | (-1.70) | (-1.69) | (-0.70) | (-1.53) |
| *Rate_ down* | -0.018 | | | | 0.003 | | | |
| | (-0.34) | | | | (0.05) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×Rate_down | 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-$R^2$ | 0.032 | 0.070 | 0.150 | 0.056 | 0.029 | 0.031 | 0.109 | 0.017 |
| # of obs. | 11,939 | 11,939 | 10,033 | 11,680 | 11,939 | 11,939 | 10,033 | 11,680 |

**Table C3. The Bond IVOL-Return Relation Around the Covid Crisis**

This table reports results from panel 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 is from January 27, 2020 to March 20, 2020. The COVID dummy is equal to one (zero) for the four weeks after (before) February 24, 2020. In Panel B, the sample period is from February 24, 2020 to April 17, 2020. The PDCF dummy is equal to one (zero) for the four weeks after (before) the PDCF operations on March 20, 2020. The dependent variables in Columns (1) to (4), and Columns (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 value-weighted average weekly returns of bonds in the same rating and maturity buckets as that of the bond at the beginning of each week. 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, size, and their interactions with the time dummy. 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. The *t*-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the Covid Crisis

| | Weekly raw returns | | | | Weekly abnormal returns | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *IVOL* | 0.031 | 0.037 | 0.671*** | 1.805* | -0.038 | -0.038 | 0.728*** | 1.459 |
| | (0.28) | (0.34) | (3.38) | (1.78) | (-0.34) | (-0.35) | (3.44) | (1.41) |
| *SVOL* | -0.500*** | -0.481*** | 0.520* | 5.417*** | -0.385*** | -0.385*** | 0.890*** | 4.087** |
| | (-3.50) | (-3.37) | (1.81) | (3.05) | (-2.70) | (-2.69) | (2.96) | (2.23) |
| ***IVOL×COVID*** | **-0.217** | **-0.926*****| **-1.714***** | **-0.915**** | **-1.112***** | **-1.066***** | **-1.830***** | **-1.077***** |
| | **(-0.71)** | **(-2.81)** | **(-4.65)** | **(-2.30)** | **(-3.28)** | **(-3.16)** | **(-4.81)** | **(-2.68)** |
| *SVOL×COVID* | -0.129 | -0.186 | 0.364 | -1.175* | -0.375 | -0.342 | 0.155 | -1.009 |
| | (-0.19) | (-0.26) | (0.50) | (-1.85) | (-0.50) | (-0.46) | (0.21) | (-1.51) |
| *COVID* | 0.050*** | | | | 0.049*** | | | |
| | (6.24) | | | | (5.38) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×COVID | 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-$R^2$ | 0.302 | 0.494 | 0.517 | 0.481 | 0.031 | 0.032 | 0.085 | 0.046 |
| # of obs. | 35,062 | 35,062 | 30,009 | 34,708 | 35,049 | 35,049 | 29,997 | 34,696 |

Panel B: Before and After the PDCF Operations

| | Weekly raw returns | | | | Weekly abnormal returns | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *IVOL* | -0.186 | -0.889*** | -1.400*** | -0.800 | -1.149*** | -1.104*** | -1.545*** | -0.938 |
| | (-0.65) | (-2.88) | (-3.44) | (-1.09) | (-3.58) | (-3.46) | (-3.80) | (-1.32) |
| *SVOL* | -0.629 | -0.667 | 1.566* | 2.994** | -0.760 | -0.727 | 1.694** | 3.471*** |
| | (-0.95) | (-0.93) | (1.94) | (2.52) | (-1.01) | (-0.98) | (2.14) | (3.00) |
| ***IVOL×PDCF*** | **0.695*** | **1.506***** | **2.032***** | **2.177***** | **1.634***** | **1.571***** | **2.056***** | **2.107***** |
| | **(1.86)** | **(3.83)** | **(3.99)** | **(3.21)** | **(4.09)** | **(3.92)** | **(4.10)** | **(3.14)** |
| *SVOL×PDCF* | 0.656 | 0.980 | -1.043 | -2.004* | 1.260 | 1.194 | -0.965 | -2.109* |
| | (0.94) | (1.30) | (-1.26) | (-1.74) | (1.61) | (1.55) | (-1.18) | (-1.89) |
| *PDCF* | -0.126*** | | | | -0.111*** | | | |
| | (-10.02) | | | | (-8.71) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×PDCF | 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-$R^2$ | 0.389 | 0.495 | 0.517 | 0.496 | 0.038 | 0.040 | 0.075 | 0.046 |
| # of obs. | 34,323 | 34,323 | 29,300 | 33,891 | 34,296 | 34,296 | 29,274 | 33,859 |

**Table C4. The Bond IVOL Effects Around the Covid Crisis, Next Week Returns**

This table has the same setting as the tests in Table C3. 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 is equal to one (zero) 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 PDCF dummy is equal to one (zero) for the four weeks after (before) the PDCF operations on March 20, 2020. The dependent variable in Columns (1) to (4), and Columns (5) to (8) are raw return and abnormal return in the next week, respectively. The weekly abnormal return of a bond is calculated as the difference between the raw return and the value-weighted average weekly returns of bonds in the same rating and maturity buckets as that of the bond at the beginning of each week. 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, size, and their interactions with the time dummy. All independent variables are winsorized at the 0.5% level each month. Standard errors are clustered by bond. The $t$-statistics are reported in parenthesis below coefficients.

Panel A: Before and After the Covid Crisis

| | Weekly raw returns | | | | Weekly abnormal returns | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *IVOL* | 0.011 | 0.009 | $0.738^{***}$ | $1.879^{*}$ | -0.067 | -0.068 | $0.713^{***}$ | 0.152 |
| | (0.09) | (0.08) | (3.55) | (1.80) | (-0.57) | (-0.58) | (3.26) | (0.14) |
| *SVOL* | $-0.424^{***}$ | $-0.409^{***}$ | $0.719^{**}$ | $7.349^{***}$ | $-0.315^{**}$ | $-0.315^{**}$ | $1.106^{***}$ | $6.597^{***}$ |
| | (-2.87) | (-2.77) | (2.28) | (3.40) | (-2.15) | (-2.15) | (3.39) | (2.98) |
| ***IVOL×COVID*** | **0.254** | **$-1.048^{***}$** | **$-1.853^{***}$** | **$-1.188^{***}$** | **$-1.346^{***}$** | **$-1.299^{***}$** | **$-2.089^{***}$** | **$-1.443^{***}$** |
| | **(0.75)** | **(-2.88)** | **(-4.50)** | **(-2.72)** | **(-3.66)** | **(-3.54)** | **(-5.01)** | **(-3.31)** |
| *SVOL×COVID* | $-1.741^{**}$ | -0.243 | 0.379 | $-1.645^{**}$ | -0.032 | -0.021 | 0.507 | $-1.170^{*}$ |
| | (-2.44) | (-0.31) | (0.46) | (-2.57) | (-0.04) | (-0.03) | (0.60) | (-1.76) |
| *COVID* | $0.044^{***}$ | | | | $0.050^{***}$ | | | |
| | (5.34) | | | | (5.22) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×COVID | 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-$R^2$ | 0.304 | 0.493 | 0.516 | 0.484 | 0.029 | 0.030 | 0.085 | 0.051 |
| # of obs. | 34,862 | 34,862 | 29,849 | 34,486 | 34,862 | 34,862 | 29,849 | 34,486 |

Panel B: Before and After the PDCF Operations

| | Weekly raw returns | | | | Weekly abnormal returns | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *IVOL* | 0.265 | $-1.039^{***}$ | $-1.378^{***}$ | -0.637 | $-1.413^{***}$ | $-1.367^{***}$ | $-1.778^{***}$ | $-1.297^{*}$ |
| | (0.82) | (-3.02) | (-3.31) | (-0.82) | (-4.04) | (-3.91) | (-4.26) | (-1.71) |
| *SVOL* | $-2.165^{***}$ | -0.652 | $2.012^{**}$ | $3.164^{**}$ | -0.347 | -0.336 | $2.203^{**}$ | $3.327^{**}$ |
| | (-3.09) | (-0.85) | (2.13) | (2.28) | (-0.44) | (-0.43) | (2.41) | (2.49) |
| ***IVOL×PDCF*** | **0.393** | **$1.698^{***}$** | **$2.298^{***}$** | **$2.402^{***}$** | **$1.995^{***}$** | **$1.993^{***}$** | **$2.609^{***}$** | **$2.711^{***}$** |
| | **(0.90)** | **(3.73)** | **(4.01)** | **(3.41)** | **(4.32)** | **(4.29)** | **(4.55)** | **(3.84)** |
| *SVOL×PDCF* | $2.491^{***}$ | $1.339^{*}$ | -1.148 | $-2.398^{*}$ | 0.320 | 0.688 | $-1.628^{*}$ | $-2.857^{**}$ |
| | (3.34) | (1.66) | (-1.18) | (-1.80) | (0.39) | (0.85) | (-1.73) | (-2.22) |
| *PDCF* | $-0.123^{***}$ | | | | $-0.108^{***}$ | | | |
| | (-9.92) | | | | (-8.35) | | | |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls×PDCF | 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-$R^2$ | 0.395 | 0.498 | 0.521 | 0.500 | 0.033 | 0.038 | 0.075 | 0.042 |
| # of obs. | 34,129 | 34,129 | 29,159 | 33,732 | 34,129 | 34,129 | 29,159 | 33,732 |