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Working Paper

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CFR Working Paper, No. 15-10

Provided in Cooperation with:
Centre for Financial Research (CFR), University of Cologne

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The Pricing of Different Dimensions of Liquidity: Evidence from Government Guaranteed Bank Bonds

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August 31, 2015

Abstract

Seminal market microstructure literature identifies at least three important dimensions of liquidity: trading costs, depth, and resiliency. We investigate the relevance of each of these three dimensions of liquidity – separately and in conjunction – for the pricing of corporate bonds. Unlike previous studies, our sample allows us to cleanly separate the default and non-default components of yield spreads. We find that each of the above three dimensions of liquidity impact non-default spreads, with trading costs and resiliency being more important than depth. We also find that both bond-specific and market-wide dimensions of liquidity are priced in non-default spreads. Finally, we find that, even though these three dimensions of liquidity account for virtually the entire non-default spread, there does exist in some periods a small residual non-default yield spread that is consistent with an additional "flight-to-extreme-liquidity" premium reflecting investor preference for assets that enable quickest possible disengagement from the market when necessary.

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The Pricing of Different Dimensions of Liquidity: Evidence from Government Guaranteed Bank Bonds

1. Introduction

Bank liabilities are often insured selectively by government programs of different countries.[1] The empirical analysis in this paper has been made possible because of one such program: the U.S. government Debt Guarantee Program of 2008. In an attempt to stem any bank contagion risk during the 2008 financial crisis, the FDIC instituted a program wherein bank-issued bonds were fully backed by the full faith and credit of the U.S. government, and thus made equivalent in credit quality to U.S. Treasury securities. While these bonds were as safe as Treasuries from a default perspective, they differed significantly from Treasuries, and from each other, in their liquidity. Thus, these bonds impounded a yield spread over comparable Treasuries that was arguably a significant function of liquidity, but independent of any default-related considerations. We use this unique situation to analyze how different dimensions of liquidity affect the pricing of corporate bonds: specifically, bonds issued by banks.

The yield spreads of corporate bonds (relative to Treasuries) have been shown by Elton, Gruber, Agrawal, and Mann (2001), among others, to be significantly larger than can be explained by default risk and state taxes. Chief among the factors shown to affect non-default spreads is liquidity. For example, Longstaff, Mithal, and Neis (2005) and Dick-Nielsen, Feldhütter, and Lando (2012) show that an important dimension of liquidity – the

[1] A common example is deposit insurance where, in the United States, the insuring agency is the Federal Deposit Insurance Agency (FDIC).

trading cost dimension as measured by the bid-ask spread – is priced in the non-default component of yield spreads. The focus of this paper is on the relative pricing relevance of different dimensions of liquidity. In this context, the early seminal literature in market microstructure – Garbade (1982), Kyle (1985), and Harris (1990, 2003) – identifies three main dimensions of liquidity: the trading cost dimension, the tradable quantity or the depth dimension, and the time dimension as manifested in the resiliency in liquidity subsequent to order-flow shocks.[2] In this paper, our main aim is to investigate whether these three different dimensions of liquidity are priced in government-guaranteed bank bond yields, estimate the relative importance of each of these liquidity dimensions for pricing, and determine the comparative pricing relevance of bond-specific and market-wide dimensions of liquidity.

Unlike previous studies, our sample allows us to cleanly separate the default and non-default components of yield spreads. We are accordingly able to contribute significantly to the extant literature on the pricing of liquidity in fixed income markets in several important ways. We are the first to examine whether the resiliency dimension of liquidity is priced in bond yields. Second, we are also the first to test whether the aforementioned three dimensions of liquidity – trading costs, depth, and resiliency – are priced *in conjunction*, as opposed to being priced separately. Third, an important methodological contribution we make is to use the principles underlying the empirical measure of resiliency developed (for limit-order-book markets) by Kempf, Mayston, Gehde-Trapp, and Yadav (2015) to define

[2]Holden, Jacobsen, and Subrahmanyam (2014) provide an excellent review of the empirical literature on liquidity. Specifically focusing on the three dimensions of liquidity mentioned above, see, for example: (a) Glosten and Milgrom (1985) and Stoll (1989) for the trading cost dimension; (b) Kyle (1985), Glosten and Harris (1988), Hasbrouck (1991), and Kempf and Korn (1999) for the depth dimension; and (c) Foucault, Kadan, and Kandel (2005), and Kempf, Mayston, Gehde-Trapp, and Yadav (2015) for the resiliency dimension.

and estimate a new measure for the resiliency of over-the-counter dealer markets (like corporate bond markets). Fourth, we analyze the relative pricing relevance of both bond-specific and market-wide dimensions of liquidity. Finally, we examine whether our bond-specific and market-wide dimensions of liquidity account for the entire non-default spread, or if there remains a residual non-default yield spread potentially arising either from an additional flight-to-extreme-liquidity premium over Treasuries, or a "quality" spread related in some way to the probability of the government guarantee being invoked.

Because the liquidity risk of a security and the default risk of a firm are endogenously related, separating the two has been problematic and involved measurement error. Intuitively, and according to Ericcson and Renault (2006), among others, variation in default risk leads to variation in liquidity risk; also, He and Xiong (2012) and He and Milbradt (2014) show that variation in liquidity risk can lead to further variation in default risk through the rollover channel. In this study, we use a sample of bonds in which liquidity risk is exogenously separated from default risk, since the sample bonds do not carry any default risk above that of US Treasury bonds. This allows us to analyze the non-default component of the yield spread (hereafter "non-default spread" or "NDS") without the potential for measurement error induced by using models for the default spread, as has been done in earlier studies. The absence of measurement error in our sample allows us to cleanly and accurately determine the magnitude of the non-default spread.

We calculate bid-ask spread to proxy for the trading cost dimension of liquidity following the methods of Hong and Warga (2000). We proxy the depth dimension of liquidity by using the Amihud (2002) illiquidity measure, which is a direct measure of the price impact of trading volume, and consistent with Kyle (1985). Finally, we develop a measure for the resiliency dimension of liquidity in OTC dealer markets based on the rate of mean reversion of aggregate dealer inventories – following the conceptual notion of resiliency in Garbade (1982) and the principles underlying the empirical resiliency measure developed (for limit-order book markets) by Kempf, Mayston, Gehde-Trapp, and Yadav (2015). We find that each of the three dimensions of liquidity – trading costs, depth, and resiliency – are priced factors in the non-default spread. We find that the non-default spread is impacted to the greatest extent, and impacted significantly, by the trading cost and resiliency dimensions, while the impact of the depth dimension is smaller, albeit statistically significant in most specifications and sub-samples. Overall, a one percent change in trading costs, resiliency, and depth lead to a change in non-default spreads of about six basis points, five basis points, and one basis point, respectively.

Commonality in liquidity has been examined in several studies (see, for example, Chordia, Roll, and Subrahmanyam (2000a, 2000b), Pástor and Stambaugh (2003), Acharya and Pedersen (2005), Lin, Wang, Wu (2011), and Bao, Pan, and Wang (2011)). These articles suggest that market-wide liquidity factors may affect the non-default spread more than their idiosyncratic counterparts. In this context, we create indices that measure the trading costs, depth, and resiliency of the Treasury bond market as a whole. We construct a market liquidity index based on the liquidity of Treasuries because the “market” for our government-guaranteed bank bonds is arguably much more comparable to the market for bonds carrying the same credit risk (i.e., the market for Treasuries), rather than the market for other corporate bonds carrying credit risk. We find that each of the three dimensions of market-wide liquidity has significant pricing relevance over our full sample period. When we control for the possibility of different liquidity pricing relationships during the financial crisis (as suggested by Dick-Nielsen, et al. (2012) and Friewald, Jankowitsch, and, Subrahmanyam (2012)), we find that only the market-wide trading cost dimension is significantly priced during the crisis, in addition to bond-specific resiliency and bond-specific trading costs. However, in the post-crisis subsample, each of the three bond-specific and market-wide liquidity dimensions is significantly priced.

Finally, we find that, even though our three dimensions of liquidity account for virtually the entire non-default spread, there does exist in some periods a small, yet statistically significant, residual non-default yield spread over and above the yield of comparable Treasuries after accounting for our three dimensions of liquidity. In this context, Longstaff (2004) has earlier investigated government guaranteed Refcorp bonds, and found (like we do for our sample bonds) a non-default spread between these government guaranteed Refcorp bonds and Treasuries, even though they had the same credit risk. Longstaff (2004) concluded that this non-default spread was a "flight-to-liquidity" spread. However, Longstaff (2004) did not incorporate any controls (as we do in this paper) for differences in (time-varying measures of) liquidity between Treasuries and his sample of guaranteed bonds, arguing that the differences (for example) in bid-ask spreads are too small in magnitude to explain the large yield spreads of Refcorp bonds. Our results in this paper show that most of the Longstaff (2004) "flight-to-liquidity" premium is a liquidity premium directly related to the conventional measures of liquidity – spreads, depth, and resiliency. However, we also find that the non-default spread in some periods, particularly periods of crisis, impounds a tiny additional "flight-to-extreme-liquidity" premium that, in the spirit of the quote of former Federal Reserve Bank Chairman Alan Greenspan cited at the start of

Longstaff (2004), reflects a strong investor preference for assets that enable quickest possible disengagement from the market if circumstances make that necessary.[3] Furthermore, we find that the residual non-default yield spread (after accounting for our measures of liquidity) is *not* a positive function of issuer default risk, and hence unlikely to represent a "quality spread" potentially arising because these bonds are guarantees rather than direct obligations of the U.S. Treasury. This last result is consistent with the indirect evidence in this regard in Longstaff (2004).[4]

The remainder of the paper proceeds as follows. In Section 2, we develop the hypotheses tested in the paper. Section 3 describes the sample used for our empirical analysis, including details of the FDIC's Debt Guarantee Program, and the estimation processes we use for the three liquidity dimensions. We report our empirical results in Section 4. Finally, Section 5 contains our concluding remarks.

2. Development of Hypotheses

The most researched aspect of liquidity in extant literature is the trading cost dimension, typically estimated by the bid-ask spread of a security. In the bond market, Longstaff, Mithal, and Neis (2005) split corporate yield spreads into default and non-default components and find that, among other factors, bid-ask spreads are indeed priced

[3] Longstaff (2004) quotes former Federal Reserve Bank Chairman Alan Greenspan as saying the following on October 7, 1998: "*But what is crucial… is that the individuals who were moving from, let's assume, the illiquid U.S. Treasuries to the liquid on-the-run liquid issues, are basically saying, 'I want out. I don't want to know anything about whether a particular investment is risky or not. I just want to disengage.' And the reason you go into these liquid instruments is that that is the vehicle which enables one to disengage as quickly as possible.*"

[4] Longstaff (2004) investigated the government guaranteed bonds of only one entity – Refcorp. Hence, his conclusion in this regard was based on the absence of a positive dependence of the non-default spread on the yield difference between AAA and BBB bonds (proxying for a possible perception of default risk in guaranteed Refcorp bonds).

in the non-default component. Dick-Nielsen, Feldhutter, and Lando (2012) also find that bid-ask spreads are priced in the non-default spreads of corporate bonds. We therefore base Hypothesis 1a on those studies.

H1a: *The trading cost dimension is priced in the non-default spread of bank bonds.*

Research has also analyzed the pricing of the depth dimension of liquidity. For equity markets, Brennan and Subrahmanyam (1996) document that an estimate of Kyle's λ – the depth dimension – is a priced risk factor in equities. In the bond market, Dick-Nielsen, et al. (2012) find that the Amihud (2002) measure of depth is priced in the non-default spread. These studies motivate Hypothesis 1b.

H1b: *The depth dimension is priced in the non-default spread of bank bonds.*

Kempf, Mayston, Gehde-Trapp, and Yadav (2015) first developed a measure of the resiliency dimension for limit-order-book markets, using Garbade (1982) as the basis for modeling resiliency as the mean reversion of order-flow. Kempf, et al. (2015) model time varying liquidity using a mean reverting model, $\Delta L_t = \alpha - \phi L_{t-1} + \varepsilon_t$, where L_t is the level of liquidity at time t. ϕ, the intensity of mean reversion, is their estimate of resiliency in liquidity. Using this measure of resiliency, Obizaeva and Wang (2013) show that an optimal strategy of trading a given security depends largely on the resiliency of the security. We could not find any research studies on the pricing relevance of resiliency in liquidity – neither for stocks nor for bonds. However, Dong, Kempf, and Yadav (2010) provide evidence that price resiliency predicts the cross-section of stock returns. Also, Pástor and Stambaugh (2003) show the pricing relevance of an illiquidity measure based on equity return reversals, and hence closely related to price resiliency. We accordingly postulate Hypothesis 1c, and are the first to explore this dimension of bond market liquidity.

H1c: *The resiliency dimension is priced in the non-default spread of bank bonds.*

Commonality in liquidity has been widely explored in the existing microstructure literature, beginning with Chordia, Roll, and Subrahmanyam (2000a; 2000b) who show that the bid-ask spreads of securities covary with one another, and that the depths of securities also co-move with one another. In their seminal work, Pástor and Stambaugh (2003) show that a market-wide illiquidity measure is priced in stocks. Similarly, Acharya and Pedersen (2005) demonstrate that a stock's return depends on its relationships with market liquidity. In the bond markets, Lin, Wang, and Wu (2011) show that investors in corporate bonds are compensated for their exposure to general market illiquidity. Moreover, Bao, Pan, and Wang (2011) show that for high-rated bonds, market illiquidity actually explains more than credit risk. These findings collectively motivate Hypothesis 2.

H2: *The non-default spread varies also with market-wide liquidity dimensions.*

Finally, we turn our attention to the residual component, if any, of the non-default spread that remains after accounting for the non-default spread arising from state-level taxes and the three (aforementioned) dimensions of liquidity we analyze.[5] If the non-default spread is driven entirely by state taxes and these dimensions of liquidity, this residual yield spread should be zero. If there is a significantly positive residual non-default yield spread, it could be a "quality spread" related to the risk of issuer default, arising

[5] While the non-default spread has also been explained empirically using variables like maturity, market uncertainty, and certain debt covenants, these factors should affect the value of the bond only through illiquidity or state taxes as a channel.

because government guarantees may be considered inferior to direct government obligations because of possible procedural and time delays when the guarantee is actually invoked.[6] Alternatively, following Longstaff (2004), the residual non-default yield spread could also be a "flight-to-extreme-liquidity premium" related to the fear of future volatility, reflecting investor preference for assets that enable quickest possible disengagement from the market if that becomes necessary – an aspect of liquidity not necessarily fully captured by our time-varying measures of our three dimensions of liquidity. Accordingly, we propose Hypothesis 3a, 3b, and 3c.

> ***H3a:*** *The residual non-default yield spread that remains after accounting for the trading cost, depth, and resiliency dimensions of liquidity, is zero.*
>
> ***H3b:*** *The residual non-default yield spread that remains after accounting for the trading cost, depth, and resiliency dimensions of liquidity, is a "quality spread" related to the risk of issuer default.*
>
> ***H3c:*** *The residual non-default yield spread that remains after accounting for the trading cost, depth, and resiliency dimensions of liquidity, is a "flight-to-extreme-liquidity spread" related to the fear of future volatility.*

3. Sample and Research Design

In order to isolate the non-default spread of bonds, we must control for default risk. To do this, we use a special set of corporate bonds with the same default risk as the US Treasury. This special set of bonds comes out of the financial crisis and Debt Guarantee Program (DGP), in which the FDIC insured bank debt against default with the full faith and credit of the United States government. The FDIC's backing is reflected in the highest

[6] There could be good reasons for this. For example, in the formation of the Debt Guarantee Program, the FDIC initially claimed it would issue bondholders checks for the full amount of the guaranteed debt within days of a default; however, in the finalized program in November 2008, the FDIC stated that it would continue to make the scheduled payments of the defaulted debt issue (Federal Registrar, 2008).

possible ratings in the rating system, i.e., AAA ratings, for each of these guaranteed bond issuances, even though this was not necessarily the case for other bonds of the same issuer, with ratings varying all the way down to BB.[7]

These fixed-rate insured bonds provide a very clean setting in which to analyze the yield spreads of corporate debt. This is because these insured bonds should have default risk equal to that of US Treasuries and, therefore, no additional default premium. By subtracting the yields of Treasury debt from the yields of these insured bonds, we can observe the implied non-default component of the yield spread without relying on the kind of measurement-error-inducing models that are used in extant literature.

Transaction-level data for this study comes from the TRACE (Trade Reporting and Compliance Engine) Enhanced dataset. The sample collected from TRACE includes all transactions of DGP bonds with fixed or zero coupons. The program began in October 2008 and continued through December 2012. That is, guaranteed bonds could be issued between October 14, 2008 and October 31, 2009 where the government guarantee on these issuances expired December 31, 2012. In practice, all of the bonds issued under the DGP matured prior to this deadline. Bond-level data for the bonds in the sample was obtained from the Mergent Fixed Investment Securities Database (FISD) and merged by CUSIP. To eliminate erroneous entries in the TRACE data, the transactions are filtered according to the methods outlined by Dick-Nielsen (2009). We also employ the agency filter from Dick-Nielsen (2009) to remove paired agency trades. The data are then processed further using a 10% median filter as described by Friewald, et al. (2012). Following Bessembinder, Kahle,

[7] Panel C of Table 1 shows the credit ratings of the issuers of these guaranteed bonds.

Maxwell, and Xu (2009), daily yields are obtained by weighting individual trade prices by volume, and finding the yield from the resulting price.

Daily Treasury yields are obtained from the H-15 release data from the Federal Reserve and maturity-adjusted for each observation using linear interpolation, following Dick-Nielsen, et al. (2012). The non-default spread is then estimated by subtracting these Treasury yields from the yields of the government-guaranteed bonds. After later merging these non-default spreads with the different measures of liquidity, we are left with 10,122 bond-day observations. To test the aforementioned hypotheses, we calculate proxies for each of the three dimensions of liquidity. The TRACE Enhanced dataset makes this possible by providing non-truncated volumes and a buy/sell indicator.

As a measure of the trading cost dimension, we follow Hong and Warga (2000) and approximate the daily bid-ask spread for each bond by taking the difference between the daily volume-weighted averages of the buy and sell prices. The effective half-spread is then scaled by the midpoint of the average buy and sell prices as follows:

$$Spread_{id} = \frac{\frac{\sum_{D=1} q_{itd} p_{itd}}{\sum_{D=1} q_{itd}} - \frac{\sum_{D=-1} q_{itd} p_{itd}}{\sum_{D=-1} q_{itd}}}{\left(\frac{\sum_{D=1} q_{itd} p_{itd}}{\sum_{D=1} q_{itd}} + \frac{\sum_{D=-1} q_{itd} p_{itd}}{\sum_{D=-1} q_{itd}}\right)}, \tag{1}$$

where q_{itd} is the volume of trade t for bond i on day d, p_{itd} is the price of that trade, and D equals 1 for all public buys and -1 for all public sales.

Similar to Dick-Nielsen, et al. (2012) we use the Amihud (2002) illiquidity measure as a proxy for price impact of trades, and thus the depth dimension of liquidity. We estimate the Amihud measure as the following:

$$Amihud_{id} = \frac{100}{T} \times \sum_{t=2}^{T} \frac{abs\left(ln(p_{itd}) - ln(p_{i,t-1,d})\right)}{q_{itd}/1{,}000{,}000}, \tag{2}$$

where T represents the number of trades of that particular bond on day d. This measure captures the change in price for a given quantity traded. To the extent that overall quantity traded (rather than signed order flow) represents the order flow in Kyle (1985), this is a theoretically valid measure of depth, and is extensively used as such in recent literature.

The empirical measure of resiliency in liquidity that has been used in the literature is the Kempf, et al. (2015) measure for limit order book markets based on the principles outlined by Garbade (1982). In this framework, resiliency in liquidity (i.e., trading cost or depth) is the extent to which distortions in liquidity (trading cost or depth as the case may be) get neutralized within a pre-specified time. Based on this framework, we construct a measure of resiliency for over-the-counter dealer markets, like U.S. corporate bond markets. Since the change in aggregate dealer inventories represents the overall signed order flow in a dealer market, we define resiliency in liquidity as the extent to which distortions in dealers' aggregate inventory get neutralized by the change in inventory within a pre-specified period. Dealers target a given inventory level, and will give attractive prices to buyers and unattractive prices to sellers when they have relatively high inventory levels, and vice versa when their inventory levels are relatively low (see Amihud and Mendelson, 1980; Ho and Stoll, 1981, 1983; Hansch, Naik, and Viswanathan, 1998). Hence, the stronger the mean reversion in aggregate dealer inventories, the higher the resiliency. Accordingly, to estimate a bond's resiliency, we measure the extent of mean reversion in aggregate dealer inventories; i.e., the relationship between the level of dealer inventory at time t and the change in dealer inventory from time t to time $t+1$. The daily ϕ measure from the following regression is used as our resiliency measure in further analysis:

$$\Delta Inv_{itd} = \alpha_{id} - \phi_{id} Inv_{i,t-1,d} + \varepsilon_{itd}. \tag{3}$$

Consistent with earlier literature (e.g., Naik and Yadav, 2003), we assume that aggregate dealer inventory is zero at the beginning of the sample, and adjust aggregate dealer inventory for each trade over the life of the bond. ϕ_{id}, our measure of resiliency, is a mean reversion parameter, and should theoretically be between 0 and 1, with 0 indicating that dealer inventory is a random walk with no mean reversion, and 1 indicating perfect resiliency, meaning that dealers are always at their target inventory, which eliminates any liquidity-related pressures on prices to deviate from their intrinsic value. Therefore, the higher the value of ϕ, the greater the resiliency in liquidity.

After we estimate the non-default spread, bid-ask spread, Amihud measure, and resiliency measure for each bond-day, we winsorize each of these variables at the 1st and 99th percentiles. Then, to correct for skewness and – more importantly for this study – to improve interpretability of regression coefficients, we take the natural logarithm of the winsorized bid-ask spreads, Amihud measures, and resiliency measures. Finally, in order to test the relationship of these three dimensions independent of the others, we orthogonalize the three liquidity dimension variables by regressing them on the other two, and keeping the residual from these three regressions.[8] Because resiliency decreases as illiquidity increases, we lastly multiply the resiliency value by -1, so that it, as well as the bid-ask spread, the Amihud measure, and the non-default spread, are all increasing with illiquidity.

[8] For example, these residuals give us the variation in the depth dimension of liquidity while controlling for the bid-ask spread and resiliency, and likewise for the other two dimensions. This is important because the price impact of a trade is affected by more factors than just volume, like the bid-ask spread, for example.

Market-wide liquidity measures are obtained from GOVPX, which provides trades and quotes for US Treasuries, from 2008 through 2012. For observations in 2008, we limit our Treasury sample to those indicated as "Active," or on-the-run. Similarly, for all other years, we limit our sample to Type 151 and 153 instruments, which are "Active Notes and Bonds" and "Active Treasury Bills," respectively[9].

The best bid and ask prices for US Treasuries are provided by GOVPX. We first use these values to calculate the inside half-spread, and then average these values for every bond-day to get one bid-ask spread observation per bond-day. For consistency with the TRACE dataset, we estimate our market-wide depth and resiliency dimension proxies – Amihud illiquidity measure and our resiliency measure respectively – using only on-the-run Treasury trade data. We construct both the Amihud and resiliency measures as we do for the guaranteed bonds above, on a bond-day basis. We then winsorize the bid-ask spread, Amihud, and resiliency variables at the 1 and 99 percentile levels before averaging across days to construct three daily time series. Finally, we take the natural log of these three series to construct *ln(Market Spread)*$_t$*, ln(Market Amihud)*$_t$*, and ln(Market Resiliency)*$_t$*.* Similar to the individual bond measures, we change the sign of resiliency so that it is increasing in illiquidity.

Following Elton, et al. (2001) we use a bond's coupon rate to control for the state tax premium. Due to constitutional law in the United States, state and federal governments cannot tax income from one another. This is most commonly illustrated in municipal bonds, wherein the income is exempt from federal taxation. However, the roles are reversed for

[9] We do this because the GOVPX dataset is split into years 2008 and prior, and 2009 and after, with slightly different variables in the two subsets.

Treasury bonds. States cannot tax the income from Treasuries. They can, however, tax the income (coupon payments) from corporate bonds; therefore corporate bonds, even those of equal default and liquidity risk, will have a slight yield spread over Treasuries, due to this "state tax premium". When analyzing the residual non-default yield spread, we use the daily VIX level (obtained from the CBOE indices database) as well as S&P firm ratings (obtained from Compustat). Descriptive statistics for these measures are in Panel A of Table 1. Panel B contains the correlations of these variables.

4. Empirical Results

4.1 Pricing of Bond-Specific Liquidity Dimensions

We begin our empirical analysis by testing Hypotheses 1a through 1c: whether the three liquidity dimensions are priced factors in these bonds. We do so using the following regression model:

$$NDS_{id} = \alpha + \beta_1 ln(Spread)_{id} + \beta_2 ln(Amihud)_{id} + \beta_3(-ln(Resil))_{id} + \boldsymbol{\beta}'\boldsymbol{X} + \varepsilon_{id}, \quad (4)$$

where $\boldsymbol{X}$ is a vector of control variables, including coupon and fixed-effects in various specifications. For this model, we use robust standard errors clustered two-ways, as suggested by Pedersen (2009), by day and bond. This corrects the standard errors for autocorrelation within firms, heteroskedasticity between bonds, and heteroskedasticity in the residuals.

The results of these regressions are reported in Table 2. In Model 1, we use no fixed-effects and find that for a one percent increase in bid-ask spread, non-default spreads increase by about 6 basis points. Similarly, for a one percent decrease in resiliency, non-default spreads increase by about 5 basis points.[10] Both effects are statistically significant. However, the dependence on the Amihud measure is not statistically significant in this preliminary specification, although it is in the expected direction. Consistent with Elton, et al. (2001) we find that state taxes are roughly 4.12 percent on the margin.

Next, in order to control for time-invariant, bond-specific effects, we use bond fixed effects in Model 2, which allows us to analyze the central research question of this paper, i.e., the impact of the time-series variation in the liquidity dimensions *of a particular bond* on the non-default spread of that bond, while ignoring any variation between bonds. In this model, we see that the effect of the bid-ask spread and resiliency on non-default spreads remains statistically significant and roughly unchanged in economic magnitude – about 6 basis points and about 5 basis points for one percent changes in the liquidity variables. However, the effect of the depth dimension is now also strongly statistically significant, but the magnitude is still considerably less than the effect of bid-ask spread and resiliency – a one percent increase in the Amihud measure is associated with about a one basis point increase in the non-default spread.

In Model 3, we employ time (day) fixed effects to explore the effect on the non-default spread of the cross-sectional differences in liquidity of different bonds *within a given day* (rather than within bonds over time.) This model controls for day-specific effects that don't change across bonds, in particular, all market-wide variables. The effect it measures is different from Model 2: the coefficients in Model 3 measure the impact of a cross-sectional

[10] Recall that the sign of resiliency is changed in the presentation of the regression results.

difference in liquidity between bonds on non-default spread on a particular day. All three dimensions in this model are again statistically significant. A one percent difference (between different bonds) in spreads, depth and resiliency changes the non-default spread of the bond by about 0.64, 0.44, and 0.37 basis points respectively. We see again that investors price the trading cost and resiliency dimensions of liquidity relatively more than the depth dimension.

Finally, as a check for robustness, we utilize firm-fixed effects in Model 4 to control for any time-invariant effects which affect firms' bonds differentially. In this model, we find results strikingly similar to those of the bond-fixed effect model. This shows that the effect of liquidity of the cost of debt is not firm-dependent. Again, these results indicate that the trading cost and resiliency dimensions of liquidity affect the non-default spread considerably more than the depth dimension, though the depth dimension remains statistically significant.

Overall, these results offer strong evidence in support of Hypothesis 1a, 1b, and 1c – that the trading cost, resiliency, and depth dimensions are each priced factors in the non-default spread of bonds. Furthermore, the trading cost dimension and the resiliency dimension are clearly more important to traders than the depth dimension.

4.2 Pricing of Market-wide Liquidity Dimensions

As discussed previously, the importance of market-wide liquidity has been well documented in the literature. Because of this, we test Hypothesis 2, which states that the non-default spread varies also with market-wide liquidity measures. We do this by creating the aforementioned market liquidity variables from Treasury bond data. We then utilize these variables in our analysis of the non-default spread. Rather than estimating multiple liquidity "market models" to estimate the market and idiosyncratic components of liquidity, we opt instead to include both bond-specific and market-wide liquidity measures in the same regression. This parsimonious strategy reduces estimation error by assuming that the effect of market liquidity on bond-specific liquidity is constant over the entire sample.

Model 1 in Table 3 presents results without any fixed effects in the regression specification, while Model 2 presents results with bond fixed effects, which is what is directly relevant for the research question we are investigating. Models 1 and 2 cover the entire sample period. Interestingly, the inclusion of the market-wide liquidity proxies in the regression model does not materially affect the previous bond-specific results. We see that, over the full sample period, even after controlling for market-wide liquidity dimensions, a one percent increase to a bond's bid-ask spread is associated with an increase in non-default spread of about 5 basis points; a one percent decrease in a bond's resiliency is associated with an increase in non-default spread of about 4 basis points; and an increase in a bond's depth is associated with an increase in non-default spread of about one basis point; furthermore, each of them is statistically significant at the 1% level.

The effects of the market-wide liquidity dimensions are also significant and large in magnitude over the full sample period. Focusing on the more relevant Model 2, we see that, even after controlling for bond-specific liquidity dimensions, a one percent increase in market-wide trading costs, one percent increase in market-wide depth, and one percent decrease in market-wide resiliency is accompanied by an increase in non-default spread of about 0.5, 2.5, and 15.5 basis points respectively; and again, each of them are statistically significant at the 1% level.

Dick-Nielsen, et al. (2012), as well as Friewald, et al. (2012), show a dichotomy in liquidity pricing between crisis and non-crisis times. In light of this finding, we split our overall sample into crisis and post-crisis subsamples, and present the corresponding results (with bond fixed effects) in Models 3 and 4 respectively. Model 3 includes only the financial crisis period and Model 4 includes only the post-financial-crisis period. We classify transactions from 2008 and 2009 as being within the "crisis" subsample and transactions in 2010 and later as being in the "post-crisis" subsample. The results confirm a strong contrast in the two pricing regimes. We see that during the post-crisis period (Model 4), the pricing relevance of each of the dimensions of both bond-specific and market-wide liquidity remain highly significant, and qualitatively similar to what we have for the overall period. However, during the crisis period (Model 3) the situation is different. Bond-specific trading costs, market-wide trading costs, and bond-specific resiliency are the only liquidity dimensions that remain statistically and economically significant.

4.3 Residual non-default spread

Our results thus far show that the non-default component of the yield spread in our sample of FDIC-guaranteed DGP bonds depends significantly on the three widely accepted dimensions of liquidity – spreads, depth, and resiliency – and also reflect state taxes, as they should, since these bonds are subject to state taxes while U.S. Treasuries are not. In this sub-section, we examine if there is any residual non-default spread that remains unaccounted for after accounting for state taxes and the three dimensions of liquidity we have investigated.

The results of our tests for this residual non-default yield spread are reported in Table 4. In this table, we again regress the non-default spread on the three liquidity dimension proxies – trading costs, depth, and resiliency – and the coupon rate; but the important difference from earlier tables is that the liquidity dimension proxies in the regressions reported in this table have been transformed so that the constant can be interpreted as the remaining non-default spread when the various liquidity dimension variables represent perfect liquidity. We do this by multiplying the liquidity variables by 100, adding 1 and taking the natural logarithm, except that for resiliency, we multiply "1 minus resiliency" by 100 and add 1 then take the logarithm. The intercept provides the residual non-default yield spread since it is the conditional mean of the dependent variable of the regression (the non-default spread) when all of the other variables are zero. This specification allows us to interpret the intercept term as the residual non-default yield spread remaining after controlling for state taxes and the three dimensions of liquidity we analyze, while keeping the distributions of the liquidity variables similar to previous analysis. Therefore, by using these transformed variables, the intercept estimates the mean value of the non-default spread when the bid-ask spread is zero (i.e., perfect liquidity from a trading cost perspective), the Amihud measure is zero (i.e., perfect liquidity from a depth perspective), and the resiliency is 1 – or more accurately "1 minus resiliency" is zero (i.e., perfect liquidity from a resiliency perspective). By including the coupon rate, we also control for the state tax premium.

Model 1 in Table 4 presents the results of running the above regression for the overall sample with only bond-specific liquidity dimensions. We find that the residual non-default yield spread is not significantly different from zero despite a sample of over 10,000 bond-day observations, indicating that our three dimensions of liquidity account for virtually the entire non-default spread.

To further explore the robustness of our conclusion, we employ more specifications and controls. First, since Dick-Nielsen, et al. (2012) show that liquidity is priced differently in crisis and non-crisis periods, we run, in Models 2 and 3 respectively, separate regressions for the crisis (2008-2009) and post-crisis (2010-2012) portions of our sample. When we account for potentially different dependence on liquidity measures in different periods, we do find statistically significant residual non-default yield spreads of about 8 basis points in both the crisis sample and the post-crisis sample. We then run the regression for the overall sample but control for market-wide liquidity dimensions in Model 4 of Table 4. Even when we include our three market-wide liquidity dimension proxies, we find, similar to Model 1, no statistically significant residual non-default yield spread for the overall sample. However, when we split the regression sample into the crisis and post-crisis time periods in Models 5 and 6, we again find a residual non-default yield spread of about 8 basis points in each sub-period, though the p-value in the crisis subsample is only 0.13, i.e., not significant at the conventionally used levels of significance.

Overall, our results thus far indicate that, after we control for state taxes and for the trading cost, depth, and resiliency dimensions of liquidity, the residual non-default spread is, on average, zero or minuscule in magnitude; but it may not be appropriate to definitively rule it out in its entirety in each period. We accordingly explore two possible reasons for such a residual non-default spread.[11]

First, we note that, although our DGP bonds were backed by the full faith and credit of the United States government, they differed from Treasuries in that they were only guarantees and not direct obligations; and hence, there could potentially exist a "quality spread" reflecting possible procedural and time delays, related arguably to the market-perceived risk of actual issuer default, as it should closely proxy for the probability of the guarantee actually being invoked.

Second, a residual non-default yield spread could also arise because of variables we may have omitted in our regression specifications, or variables that we may have specified in a functional form that did not fully reflect the dependence of the non-default spread. In particular, in the spirit of the Alan Greenspan quote from Longstaff (2004) cited in footnote 3 above, the residual non-default yield spread could potentially be driven, for example, by a "flight-to-extreme-liquidity" premium reflecting a strong investor preference for assets that enable quickest possible disengagement from the market if circumstances make that necessary.

In light of the previous results, we further analyze the residual non-default yield spread to determine whether or not this yield spread can be driven by a flight-to-extreme-liquidity or by the difference in quality between government guarantees and government obligations. Longstaff (2004) suggests that the yield spread between these bonds and

[11] Since the residual non-default yield spread is not the primary focus of this paper, our analysis is largely exploratory, leaving an in-depth investigation of the reasons driving the observed residual non-default yield spread for future research.

Treasuries is driven by flight-to-liquidity, which is spawned by a general market fear motivating investors to place their capital in securities which allow them to disengage from the market as easily as possible. We therefore include a proxy for general market fear factor – the VIX level – in the residual non-default yield spread regression specification. We demean the VIX for each regression specification in order to keep the intercept coefficients interpretable as before. This does not affect the covariance of the non-default spread and the VIX, thus the associated regression coefficients on the VIX are unaffected. Our regression results are in Table 5.

As we see in Table 5, the VIX is positively related to non-default spreads after controlling for liquidity and state taxes, and the dependence is statistically significant. This is consistent with the residual non-default yield spread being indeed driven by this general market fear factor, as Longstaff (2004) suggests. Specifically, we find that a one unit increase in the VIX is associated with a 1.75 basis point increase in residual non-default yield spreads. This effect is increased to 2.22 basis points per unit increase during the crisis period, and reduced to 0.34 basis points per unit increase in the post-crisis period – which is consistent with a flight-to-liquidity premium being more important in times of crisis. We find that, even after controlling for this market fear, the conditional mean of residual non-default yield spreads in the post-crisis period remains at 8 basis points. However, the conditional mean of the residual non-default yield spread in the crisis period rises to about 29 basis points, driven by the VIX level of 31.84 that existed in that period. Over our full sample, we find residual non-default yield spread levels of around 12 basis points.

We finally examine whether this residual non-default yield spread could also be caused by a market perception that these guaranteed bonds are of inferior quality to Treasury bonds. Thus, we investigate whether the residual non-default yield spread is a function of market-perceived default risk. To do this, we include issuer credit rating fixed effects in the three regressions modeled in Table 5. These fixed effects are graphically represented in Figure 1. When looking at the full and post-crisis samples, we find absolutely no evidence that the residual non-default yield spread is a function of market-perceived default risk. Specifically, we show that the residual non-default yield spread does not increase as issuer credit ratings worsen. This is also shown for the crisis subsample, for bonds of all credit ratings, albeit with one single exception. Two bonds, both issued by New York Community Bank, which had a "BBB-" Standard & Poor's credit rating during the crisis sample period – the worst rating of any bond in that period and hence one most likely to default – have much higher non-default spreads than their liquidity and VIX levels would suggest. This could be interpreted as indicating that, during the stressful crisis period, investors became wary of guaranteed bonds with the highest probability of default – possibly due to the uncertainty of guarantee payments in the event of default, or the possible red tape involved in receiving payments – and priced that risk accordingly. Alternatively, these two extreme observations from one particular bank in one particular sub-period could just be outliers. Thus, while we cannot completely rule out the conjecture that the residual non-default yield spread is due to a perceived inferiority of guaranteed bonds to direct obligation bonds, our overall results are clearly not consistent with that view – a conclusion that is consistent with the earlier indirect evidence in Longstaff (2004).

Taken in conjunction, our results indicate that, while most of the Longstaff (2004) "flight-to-liquidity" premium is a liquidity premium arising from the conventional measures of liquidity – spreads, depth, and resiliency – the non-default spread could also impound, particularly in periods of crisis, a tiny additional "flight-to-extreme-liquidity" premium reflecting, as suggested by Longstaff (2004), a strong investor preference for assets that enable quickest possible disengagement from the market if necessary.

4.4 *Robustness Tests*

We document a strong relationship between the non-default spread and each of the three dimensions of liquidity – trading costs, depth, and resiliency. The direction of causality in this relationship should arguably be from liquidity to non-default spreads, since it is difficult to think of a credible economic rationale for higher (lower) yields to *cause* correspondingly lower (higher) levels of liquidity. However, without a shock to bond liquidity that is exogenous to yields, we cannot formally test the causal direction of the relationships we document between non-default spread and liquidity. Instead, we attempt to address this empirically using: (a) a changes specification; (b) vector autoregressions; and (c) impulse response functions. All of these suggest that shocks to the non-default spread do not cause changes to the three liquidity dimensions, and point instead to causality from the three liquidity dimensions to the non-default spread.

We begin by analyzing the relationship of daily *changes* in the non-default spread and the liquidity dimensions using the following regression model:

$$\Delta NDS_{id} = \alpha + \beta_1 ln(Spread)_{id} + \beta_2 ln(Amihud)_{id} - \beta_3 (ln(Resil))_{id} + \beta_4 NDS_{i,d-1} + \boldsymbol{\beta}'\boldsymbol{X} + \varepsilon_{id}. \quad (5)$$

Because the non-default spread is arguably an integrated time-series – specifically the sum of a collection of previous shocks to the non-default spread – which is suggested by Longstaff (2004), we include the lagged level of the non-default spread. While this changes the interpretation of the regression coefficients, if we find that the levels of the liquidity dimensions affect the shocks to non-default spreads, it suggests that the liquidity dimensions causally affect non-default spreads, and not the contrary. The results of these regression specifications can be found in Table 6. In Model 1 of Table 6, we see that, as in the levels specification (Table 2), the effect of the bid-ask spread is larger on the non-default spread than the effect of the other two liquidity dimensions. When we control for time-invariant, bond-specific factors by including bond fixed-effects in Model 2 of Table 6, these results still hold. Next, we include market liquidity variables (as in Table 3) in Model 3 and find that while the market variables are significantly positively correlated with shocks to the non-default spreads, the bond-specific liquidity dimensions remain strongly significant. Finally, we split the sample into crisis and post-crisis. We again find a reduced effect of liquidity on the non-default spread during the crisis period. We find that the non-default spread has much less mean reversion during the crisis than in other periods (indicated by a smaller absolute value of the regression coefficient on the lagged NDS level). Thus, the non-default spread could still be a function of liquidity levels but in this specification, the lagged NDS already impounds previously-observed liquidity levels. In the post-crisis subsample, we find that all six liquidity dimensions are significantly priced, and the non-default spread is largely mean-reverting. Once again, we find that the level of market resiliency has a larger effect on the non-default spread than any other dimension.

These results largely confirm our earlier analysis and dissuade any concerns that the previous regressions suffered from misspecification.

Typically, in the extant literature, it is assumed that the non-default spread is affected by the contemporaneous level of liquidity. We examine the following vector autoregression of the non-default spread and the liquidity dimension variables, in order to examine whether the lagged level of the liquidity dimensions affects the non-default spread, as well as investigate the reverse causality possibility:

$$\mathbf{V_{id}} = \boldsymbol{\alpha}' + \boldsymbol{\beta}_1'\mathbf{V_{i,d-1}} + \boldsymbol{\beta}'\boldsymbol{X} + \boldsymbol{\varepsilon}_{\mathbf{id}}. \tag{6}$$

where $\mathbf{V_{id}}$ is a vector containing the *non-default spread, ln(Spread), ln(Amihud), and ln(Resiliency)* for bond *i* on day *d*. The lagged liquidity dimensions are excellent proxies for the contemporaneous liquidity dimensions because their exogeneity is difficult to argue – the non-default spread on day *d* cannot affect the level of liquidity on day *d-1*, especially after controlling for the non-default spread in day *d-1*. We also attempt to control for any remaining residual non-default yield spread using the contemporaneous VIX level as variable proxy for the "fear factor". We display the VAR for the crisis subsample in Panel A of Table 7 and the VAR for the post-crisis subsample in Panel B of Table 7. In the crisis subsample we see that all three dimensions of liquidity are priced when we use lagged dimension levels as proxies, confirming that in the crisis liquidity levels and non-default spreads were very persistent. More importantly, we see that the lagged non-default spread has a much smaller statistical effect on the contemporaneous liquidity dimensions than the effect of the lagged liquidity levels on the non-default spread. This goes a long way in dissuading a reverse causality argument, albeit without a properly identified exogenous event. We confirm this when we include contemporaneous variables into the VAR to examine the impulse responses of these four variables. Visual representations of the impulse response functions during the crisis period are provided in Panel A of Figure 1. From these impulse responses, we see that the liquidity dimensions have a much smaller response to a one standard deviation shock to the non-default spread than the non-default spread has to a one standard deviation shock to the liquidity dimensions, once again weakening the reverse causality argument. These results hold when we examine the impulse response functions during the post-crisis period in Panel B of Figure 1. Interestingly, when we examine the VAR during the post-crisis period in Panel B of Table 6, we see that the lagged liquidity dimensions are not significantly priced in the non-default spread after we control for the lagged non-default spread and the VIX level. In conjunction with the changes specifications, this suggests that during the crisis, non-default spreads and liquidity levels were very persistent, but in the calmer, less uncertain environment of the post-crisis period, the non-default spread is more mean reverting and is a function of contemporaneous liquidity levels. Irrespective, overall, these results strongly point towards causality from the three liquidity dimensions to the non-default spread.

5. Concluding Remarks

The seminal market microstructure literature – Garbade (1982), Kyle (1985), and Harris (1990, 2003) – identifies three important dimensions of liquidity: trading costs, depth, and resiliency. This is the first study to investigate the relevance of each of these three dimensions of liquidity – separately and in conjunction – for the pricing of corporate bonds, specifically, bank bonds. Unlike previous studies, our sample allows us to cleanly separate the default and non-default components of yield spreads. We find that each of the above three dimensions of liquidity are priced factors in the non-default spread. Both bond-specific and market-wide dimensions of liquidity are priced. The trading cost and resiliency dimensions are relatively more important than the depth dimension as determinants of the level of the non-default spread. Finally, we find that, even though these three dimensions of liquidity account for virtually the entire non-default spread, there does exist in some periods a small residual non-default yield spread that is consistent with an additional "flight-to-extreme-liquidity" premium (related to the fear of future volatility, and consistent with Longstaff (2004)) reflecting investor preference for assets that enable quickest possible disengagement from the market when necessary.

This paper contributes to the extant literature in several important and significant ways. We are the first to examine whether the resiliency dimension of liquidity is priced in bond yields. Second, we are also the first to test whether the aforementioned three dimensions of liquidity – trading costs, depth, and resiliency – are priced *in conjunction*, as opposed to being priced separately. Third, an important methodological contribution we make is to use the principles underlying the empirical measure of resiliency developed (for limit-order-book markets) by Kempf, Mayston, Gehde-Trapp, and Yadav (2015) to define and estimate a new measure for the resiliency of over-the-counter dealer markets (like corporate bond markets). Fourth, we analyze the relative pricing relevance of both bond-specific and market-wide dimensions of liquidity. Fifth, we show that most of the Longstaff (2004) "flight-to-liquidity" premium is a liquidity premium directly related to the conventional measures of liquidity – spreads, depth, and resiliency. However, we also do find that the non-default spread in some periods, particularly periods of crisis, impounds a tiny additional “flight-to-extreme-liquidity” premium that, in the spirit of the quote of former Federal Reserve Bank Chairman Alan Greenspan cited at the start of Longstaff (2004), reflects a strong investor preference for assets that enable quickest possible disengagement from the market when necessary. Finally, consistent with Longstaff (2004), we do not find significant evidence of a “quality spread” arising from government guaranteed bonds being perceived inferior to direct government obligations.

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Table 1: Variable Descriptions

Panel A: Descriptive Statistics

	Obs.	**Mean**	**Std. Dev.**	**Min.**	**Med.**	**Max.**
Non-Default Spread	38,106	0.2072	0.2280	-0.2177	0.1492	1.2779
Bid-Ask Spread	19,386	0.0016	0.0021	0.0000	0.0008	0.0119
Amihud	40,752	10.839	34.436	0.0000	0.373	250.31
Resiliency	14,925	0.4713	0.2681	0.0210	0.4457	0.9978
Market Bid-Ask Spread	45,712	6.9E-06	8.3E-06	0.0000	4.2E-06	7.5E-05
Market Amihud	46,710	0.0003	0.0007	0.0000	0.0001	0.0078
Market Resiliency	45,602	0.1135	0.1809	-0.5313	0.0662	1.1116
Coupon	47,145	2.0223	0.8045	0.2305	2.1250	3.2500
VIX	47,135	24.848	8.177	13.450	22.660	68.510
Volume	47,145	1.4E+07	6.4E+07	5.0000	2.7E+06	8.4E+09

Panel B: Correlation Matrix *(Bond-specific liquidity variables have been orthogonalized to each other after logarithms are calculated)*

	Non-Default Spread	*ln(Bid-Ask Spread)*	*ln (Amihud)*	*ln (Resil)*	*ln(Market Bid-Ask Spread)*	*Ln (Market Amihud)*	*Ln (Market Resil)*	*Coupon*	*VIX*	*Volume*
Non-Default Spread	1.000	0.292	-0.040	0.140	0.156	0.196	-0.122	0.086	0.771	0.169
ln(Bid-Ask Spread)	0.292	1.000	-0.253	-0.072	0.088	0.108	-0.065	-0.021	0.225	-0.078
ln (Amihud)	-0.040	-0.253	1.000	-0.089	-0.020	-0.003	0.021	0.230	-0.087	-0.152
ln (Resil)	0.140	-0.072	-0.089	1.000	0.033	0.035	-0.014	0.121	0.122	0.103
ln(Market Bid-Ask Spread)	0.156	0.088	-0.020	0.033	1.000	0.103	-0.007	0.005	0.143	0.027
ln(Market Amihud)	0.196	0.108	-0.003	0.035	0.103	1.000	-0.021	0.035	0.170	0.047
ln(Market Resil)	-0.122	-0.065	0.021	-0.014	-0.007	-0.021	1.000	0.022	-0.061	-0.002
Coupon	0.086	-0.021	0.230	0.121	0.005	0.035	0.022	1.000	0.046	-0.064
VIX	0.771	0.225	-0.087	0.122	0.143	0.170	-0.061	0.046	1.000	0.151
Volume	0.169	-0.078	-0.152	0.103	0.027	0.047	-0.002	-0.064	0.151	1.000

Panel C: Observations from Issuer Credit Ratings

Rating	*AAA*	*AA+*	*AA*	*AA-*	*A+*	*A*	*A-*	*BBB+*	*BBB*	*BBB-*	*BB+*	*WORSE*
Bonds	8	20	5	7	35	83	43	10	4	6	3	0
Obs.	193	6,670	261	1,549	7,199	20,925	2,889	1,711	219	740	320	0

Table 2: Pricing of Liquidity Dimensions – Trading Costs, Depth, and Resiliency

This table displays results for the multivariate analysis of the pricing of the three dimensions of liquidity in the non-default spread (NDS). Each of the three proxies for the liquidity dimensions – bid-ask spread, Amihud measure, and resiliency – have been orthoganalized to the other two. Following Elton, et al. (2001), the coupon rate controls for state taxes within the non-default spread. Bond-, Day-, and Firm-fixed effects are used as controls in Models (2), (3), and (4), respectively.

The sample for this unbalanced panel regression consists of bonds guaranteed by the FDIC under the DGP. Standard errors are clustered by bond and date. Two-tailed *p*-values are in parenthesis. ***, **, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Variable	(1) NDS	(2) NDS	(3) NDS	(4) NDS
Ln(Bid-Ask Spread)	0.0590***	0.0597***	0.0064***	0.0597***
orthogonalized	(0.000)	(0.000)	(0.000)	(0.000)
Ln(Amihud)	0.0026	0.0089***	0.0044***	0.0067**
orthogonalized	(0.312)	(0.000)	(0.000)	(0.011)
–Ln(Resiliency)	0.0460***	0.0503***	0.0037**	0.0514***
orthogonalized	(0.000)	(0.000)	(0.034)	(0.000)
Coupon	0.0412***	*Subsumed by*	0.0051	0.0189
	(0.004)	*Fixed Effects*	(0.591)	(0.175)
Constant	0.1467***	*Subsumed by Fixed Effects*		
	(0.000)			
Adj. R^2	0.130	0.183	0.874	0.157
Bonds	65	65	65	65
Days	958	958	958	958
Obs.	10,122	10,122	10,122	10,122
Fixed Effects	None	Bond	Day	Firm

Table 3: Pricing of Market-wide Liquidity Dimensions

This table displays results for the multivariate analysis of the pricing of market-wide dimensions of liquidity in the non-default spread (NDS). Each of the three proxies for the bond-specific liquidity dimensions – bid-ask spread, Amihud measure, and resiliency – have been orthoganalized to the other two. Following Elton, et al. (2001), the coupon rate controls for state taxes within the non-default spread. Model 1 presents results without any fixed effects in the regression model specification. Models 2, 3, and 4 present results with bond fixed effects, which is what is directly relevant for the research question being investigated. Models 1 and 2 cover the entire sample period, while Model 3 includes only the financial crisis period and Model 4 includes only the post-financial-crisis period.

The sample for this unbalanced panel regression consists of bonds guaranteed by the FDIC under the DGP. Standard errors are clustered by bond and date. Two-tailed *p*-values are in parenthesis. ***, **, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Variable	(1) NDS	(2) NDS	(3) NDS	(4) NDS
Ln(Bid-Ask Spread)	0.0485***	0.0501***	0.0326***	0.0184***
Orthogonalized	(0.000)	(0.000)	(0.000)	(0.000)
Ln(Amihud)	0.0030	0.0081***	0.0003	0.0067***
Orthogonalized	(0.192)	(0.000)	(0.928)	(0.000)
–Ln(Resiliency)	0.0403***	0.0450***	0.0411***	0.0096***
Orthogonalized	(0.000)	(0.000)	(0.000)	(0.000)
Ln(Market Spread)	0.0051***	0.0045***	0.0083***	0.0012***
	(0.000)	(0.000)	(0.000)	(0.001)
Ln(Market Amihud)	0.0296***	0.0263***	0.0128	0.0103***
	(0.000)	(0.000)	(0.370)	(0.000)
–Ln(Market Resiliency)	0.1604***	0.1550***	0.0631	0.0512***
	(0.000)	(0.000)	(0.702)	(0.001)
Coupon	0.0329***	*Subsumed by Fixed Effects*		
	(0.000)			
Constant	0.5028***	*Subsumed by Fixed Effects*		
	(0.006)			
Adj. R^2	0.164	0.212	0.173	0.138
Bonds	65	65	64	64
Days	887	887	254	633
Obs.	9,419	9,419	3,842	5,577
Sample	Full	Full	Crisis	Post-Crisis
Fixed Effects	None	Bond	Bond	Bond

Table 4: Test for the Existence of a Residual Non-Default Yield Spread

This table displays results for testing whether the non-default spread (NDS) impounds a residual non-default yield spread. In order to directly interpret the constant as a residual non-default yield spread, the liquidity variables have been monotonically transformed so that the constant will evaluate the remaining non-default spread when liquidity variables are taken at values corresponding with perfect liquidity. Each of the three proxies for the bond-specific liquidity dimensions – bid-ask spread, Amihud measure, and resiliency – have been orthoganalized to the other two. Following Elton, et al. (2001), the coupon rate controls for state taxes within the non-default spread. Following Dick-Nielsen, et al. (2012) and others, we control for the differential in liquidity pricing during crisis periods by splitting the sample into crisis (2008-09) and post-crisis (2010-12) subsamples. Models 1 and 4 cover the entire sample period, while Models 2 and 5 include only the financial crisis period and Models 3 and 6 include only the post-financial-crisis period.

The sample for this unbalanced panel regression consists of bonds guaranteed by the FDIC under the DGP. Standard errors are clustered by bond and date. Two-tailed *p*-values are in parenthesis. ***, **, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**NDS**	**NDS**	**NDS**	**NDS**	**NDS**	**NDS**
Constant	0.0097	0.0838*	0.0831***	-0.0064	0.0871	0.0768***
	(0.759)	(0.071)	(0.000)	(0.840)	(0.130)	(0.000)
ln(100×Bid-Ask Spread+1)	0.4482***	0.2242***	0.1509***	0.3549***	0.1684**	0.1434***
orthoganolized	(0.000)	(0.004)	(0.000)	(0.000)	(0.013)	(0.000)
ln(100×Amihud+1)	0.0017	-0.0041	0.0072***	0.0031	-0.0004	0.0071***
orthoganolized	(0.554)	(0.224)	(0.000)	(0.212)	(0.902)	(0.000)
ln(100×(1-Resiliency)+1)	0.0243***	0.0267***	0.0066***	0.0213***	0.0234***	0.0063***
orthoganolized	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(100×Market Spread+1)				62.112***	64.655***	17.842***
				(0.000)	(0.000)	(0.000)
ln(100×Market Amihud+1)				0.4852***	0.2474	0.1161***
				(0.002)	(0.271)	(0.001)
ln(100×(1-Market Resiliency)+1)				-0.0016	-0.0095	-0.0013
				(0.685)	(0.215)	(0.392)
Coupon	0.0462***	0.0925***	-0.0048	0.0314***	0.0706***	-0.0050
	(0.001)	(0.000)	(0.205)	(0.009)	(0.000)	(0.201)
Adj. R2	0.089	0.067	0.053	0.161	0.128	0.073
Bonds	65	64	64	65	6	64
Days	958	275	683	904	256	648
Obs.	10,144	4,108	6,036	9,601	3,882	5,719
Sample	Full	Crisis	Post-Crisis	Full	Crisis	Post-Crisis
Fixed Effects	None	None	None	None	None	None

Table 5: Analysis of the Residual Non-Default Yield Spread”

This table displays results for regression specifications analyzing the residual non-default yield spread within the non-default spread (NDS). In order to directly interpret the constant as a residual non-default yield spread, the liquidity variables have been monotonically transformed so that the constant will evaluate the remaining non-default spread when liquidity variables are taken at values corresponding with perfect liquidity. The VIX level has been demeaned so that the intercept can be interpreted as the residual non-default yield spread when the VIX is taken at the mean of the regression sample. Each of the three proxies for the bond-specific liquidity dimensions – bid-ask spread, Amihud measure, and resiliency – have been orthoganalized to the other two. Following Elton, et al. (2001), the coupon rate controls for state taxes within the non-default spread. Following Dick-Nielsen, et al. (2012) and others, we control for the differential in liquidity pricing during crisis periods by splitting the sample into crisis (2008-09) and post-crisis (2010-12) subsamples. Model 1 covers the entire sample period, while Model 2 includes only the financial crisis period and Model 3 includes only the post-financial-crisis period.

The sample for this unbalanced panel regression consists of bonds guaranteed by the FDIC under the DGP. Standard errors are clustered by bond and date. Two-tailed *p*-values are in parenthesis. ***, **, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Variable	**(1)** **NDS**	**(2)** **NDS**	**(3)** **NDS**
Constant	0.1188***	0.2855***	0.0801***
	(0.000)	(0.000)	(0.000)
VIX	0.0175***	0.0222***	0.0034***
demeaned	(0.000)	(0.000)	(0.000)
ln(100×Bid-Ask Spread+1)	0.1473***	-0.0234	0.1368***
orthoganolized	(0.000)	(0.386)	(0.000)
ln(100×Amihud+1)	0.0049***	0.0017	0.0072***
orthoganolized	(0.002)	(0.500)	(0.000)
ln(100×(1-Resiliency)+1)	0.0090***	0.0018	0.0061***
orthoganolized	(0.000)	(0.553)	(0.000)
ln(100×Market Spread+1)	32.034***	23.927***	17.245***
	(0.000)	(0.000)	(0.000)
ln(100×Market Amihud+1)	0.1950**	0.1162	0.0896***
	(0.015)	(0.181)	(0.004)
ln(100×(1-Market Resiliency)+1)	-0.0016	-0.0017	-0.0014
	(0.381)	(0.537)	(0.303)
Coupon	0.0144**	0.0342**	-0.0055
	(0.046)	(0.031)	(0.157)
Adj. R2	0.621	0.773	0.120
Bonds	65	64	64
Days	904	256	648
Obs.	9,601	3,882	5,719
Sample	Full	Crisis	Post-Crisis
Fixed Effects	None	None	None

Table 6: Changes Specification

This table displays results for robustness tests intended to show that the pricing of liquidity dimensions remains statistically significant when controlling for the possible non-stationarity in the non-default spreads (NDS). Since the NDS is close to a non-stationary variable, we include the lagged level of the NDS. Following Dick-Nielsen, et al. (2012) and others, we control for the differential in liquidity pricing during crisis periods by splitting the sample into crisis (2008-09) and post-crisis (2010-12) subsamples in Models 4 and 5, respectively.

The sample for this unbalanced panel regression consists of bonds guaranteed by the FDIC under the DGP. Standard errors are clustered by bond and date. Two-tailed *p*-values are in parenthesis. ***, **, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Variable	**(1) ΔNDS**	**(2) ΔNDS**	**(3) ΔNDS**	**(4) ΔNDS**	**(5) ΔNDS**
Lagged NDS	-0.1845***	-0.1943***	-0.2074***	-0.0775***	-0.7726***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(Bid-Ask Spread)	0.0162***	0.0179***	0.0166***	-0.0002	0.0167***
orthoganolized	(0.000)	(0.000)	(0.000)	(0.910)	(0.000)
ln(Amihud)	0.0014	0.0033***	0.0031***	-0.0008	0.0058***
orthoganolized	(0.143)	(0.004)	(0.004)	(0.366)	(0.000)
-ln(Resiliency)	0.0093***	0.0101***	0.0086***	-0.0007	0.0076***
orthoganolized	(0.000)	(0.000)	(0.000)	(0.697)	(0.000)
ln(Market Spread)			0.0013***	0.0006	0.0010***
			(0.000)	(0.221)	(0.001)
ln(Market Amihud)			0.0051***	-0.0014	0.0080***
			(0.005)	(0.539)	(0.000)
-ln(Market Resiliency)			0.0428**	0.0215	0.0413***
			(0.014)	(0.451)	(0.004)
Coupon	0.0103***	*Subsumed by Fixed Effects*			
	(0.007)				
Constant	0.0112	*Subsumed by Fixed Effects*			
	(0.273)				
Adj. R2	0.130	0.141	0.150	0.051	0.565
Bonds	64	64	64	63	64
Days	957	957	886	253	633
Obs.	10,110	10,110	9,408	3,833	5,575
Sample	Full	Full	Full	Crisis	Post-Crisis
Fixed Effects	None	Bond	Bond	Bond	Bond

Table 7: Vector Autoregressions

This table displays results for one-lag vector autoregression testing of the impact of the lagged three dimensions of liquidity (orthogonalized to each other) on the non-default spreads (NDS) and the dimensions themselves. The contemporaneous VIX level is included in the VAR to control for market volatility. Panel A contains the crisis subsample while panel B contains the post-crisis subsample.

The sample for this unbalanced panel regression consists of bonds guaranteed by the FDIC under the DGP. Two-tailed *p*-values are in parenthesis. ***, **, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Panel A: Crisis Subsample

Variable	(1) NDS_{id}	(2) ln(Bid-Ask Spread)$_{id}$	(3) ln(Amihud)$_{id}$	(4) ln(Resiliency)$_{id}$
$NDS_{i,d-1}$	0.8025***	-0.0197	0.5886*	0.2824**
	(0.000)	(0.903)	(0.076)	(0.038)
ln(Bid-Ask Spread)$_{i,d-1}$	0.0049***	0.0946***	0.2440***	-0.0066
orthogonalized	(0.003)	(0.000)	(0.000)	(0.726)
ln(Amihud)$_{i,d-1}$	0.0020***	0.0067	0.3733***	0.0104
orthogonalized	(0.008)	(0.522)	(0.000)	(0.238)
ln(Resiliency)$_{i,d-1}$	0.0053***	0.0147	0.2373***	0.0239
orthogonalized	(0.006)	(0.579)	(0.000)	(0.279)
Constant	-0.0582***	-0.1294	0.9394***	-0.0301
	(0.000)	(0.163)	(0.000)	(0.697)
VIX_{id}	0.0042***	0.0176***	-0.0394***	0.0018
	(0.000)	(0.000)	(0.000)	(0.622)
Adj. R^2	0.926	0.042	0.142	0.012
Bonds	53	53	53	53
Days	274	274	274	274
Obs.	2094	2094	2094	2094
Sample	Crisis	Crisis	Crisis	Crisis
Fixed Effects	None	None	None	None

Panel B: Post-Crisis Subsample				
Variable	**(1)** **NDS_{id}**	**(2)** **ln(Bid-Ask Spread)$_{id}$**	**(3)** **ln(Amihud)$_{id}$**	**(4)** **ln(Resiliency)$_{id}$**
$NDS_{i,d-1}$	0.4963***	1.3543***	-0.5500	0.1757
	(0.000)	(0.000)	(0.313)	(0.343)
ln(Bid-Ask Spread)$_{i,d-1}$	0.0019	0.1010***	0.1799***	0.0190
orthogonalized	(0.105)	(0.000)	(0.000)	(0.132)
ln(Amihud)$_{i,d-1}$	0.0008	0.0098	0.2559***	0.0226***
orthogonalized	(0.187)	(0.416)	(0.000)	(0.001)
ln(Resiliency)$_{i,d-1}$	0.0005	0.0135	0.2200***	0.0644***
orthogonalized	(0.796)	(0.708)	(0.000)	(0.002)
Constant	0.0166***	-0.6024***	0.9338***	-0.0260
	(0.001)	(0.000)	(0.000)	(0.638)
VIX_{id}	0.0025***	0.0053	-0.0080	0.0006
	(0.000)	(0.198)	(0.255)	(0.808)
Adj. R^2	0.357	0.022	0.061	0.006
Bonds	50	50	50	50
Days	570	570	570	570
Obs.	2461	2461	2461	2461
Sample	Post-Crisis	Post-Crisis	Post-Crisis	Post-Crisis
Fixed Effects	None	None	None	None

Figure 1: Residual Non-Default Yield Spread by Issuer Credit Rating

This figure displays the average residual non-default yield spread for bonds grouped by issuer credit ratings at the time of observation. The residual non-default yield spreads are calculated by including rating fixed-effects in the regressions modelled in Table 5, thus these residual non-default yield spreads assume the mean level of the VIX in each respective regression: 26.22 (Full Sample), 31.84 (Crisis subsample), and 22.40 (Post-crisis subsample).

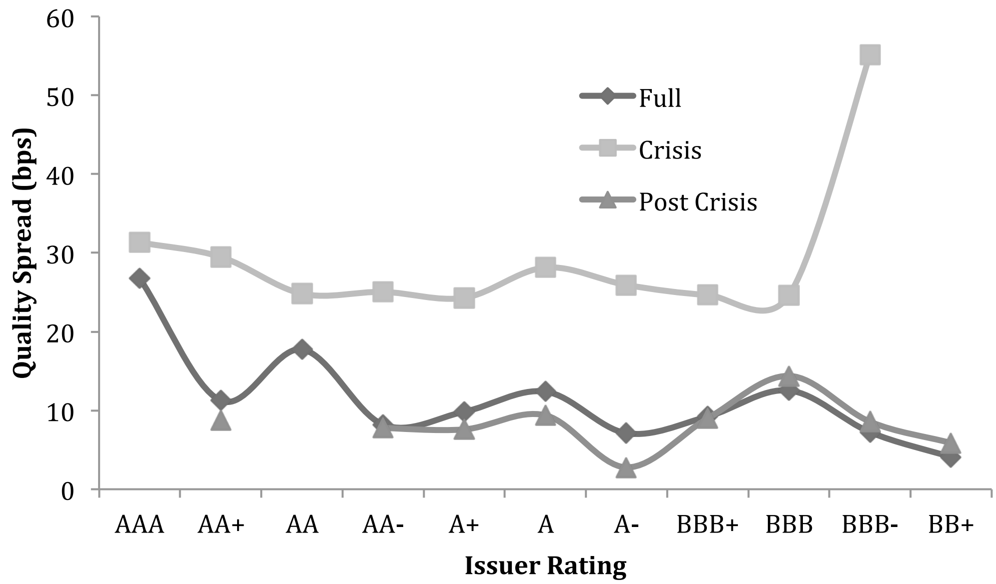
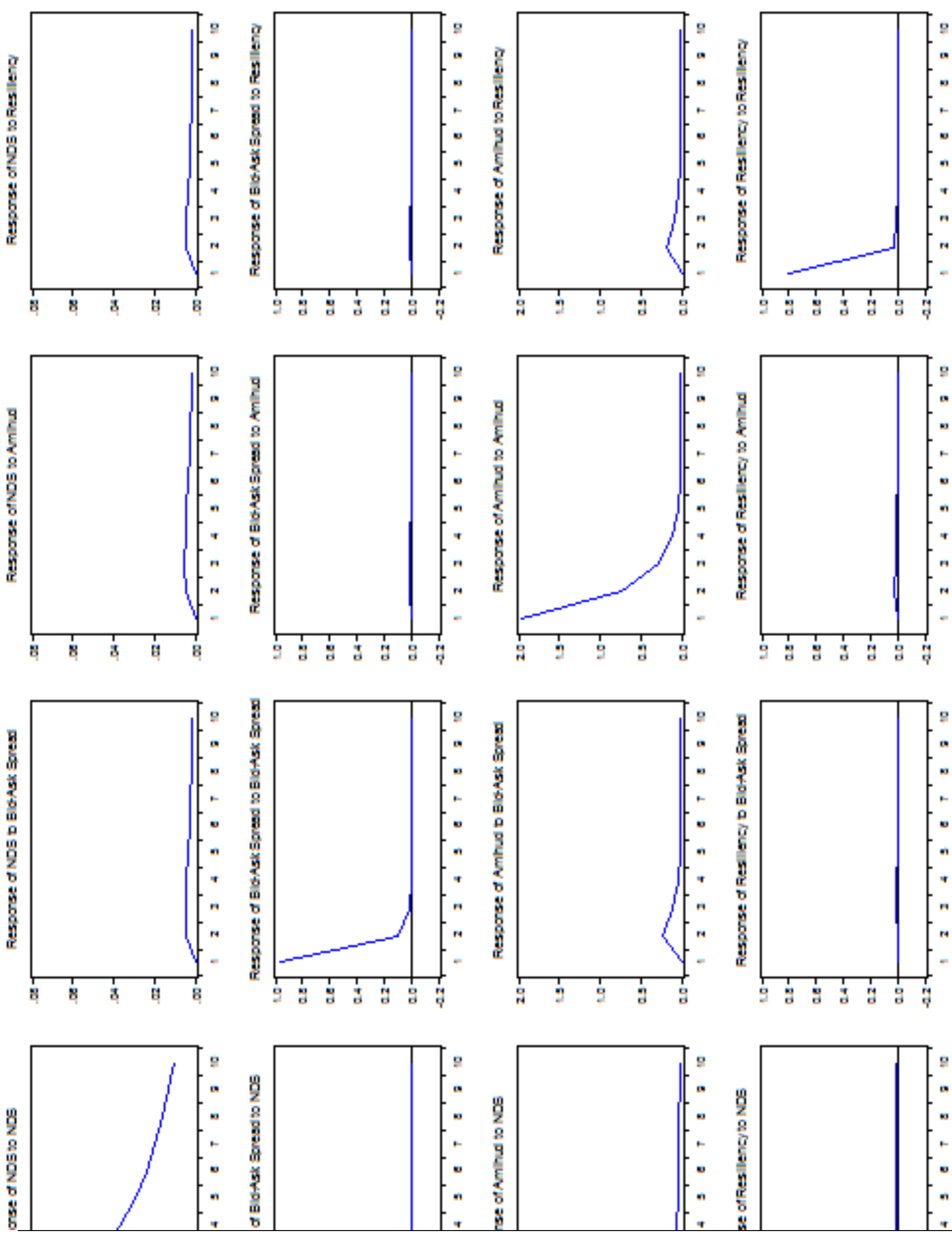


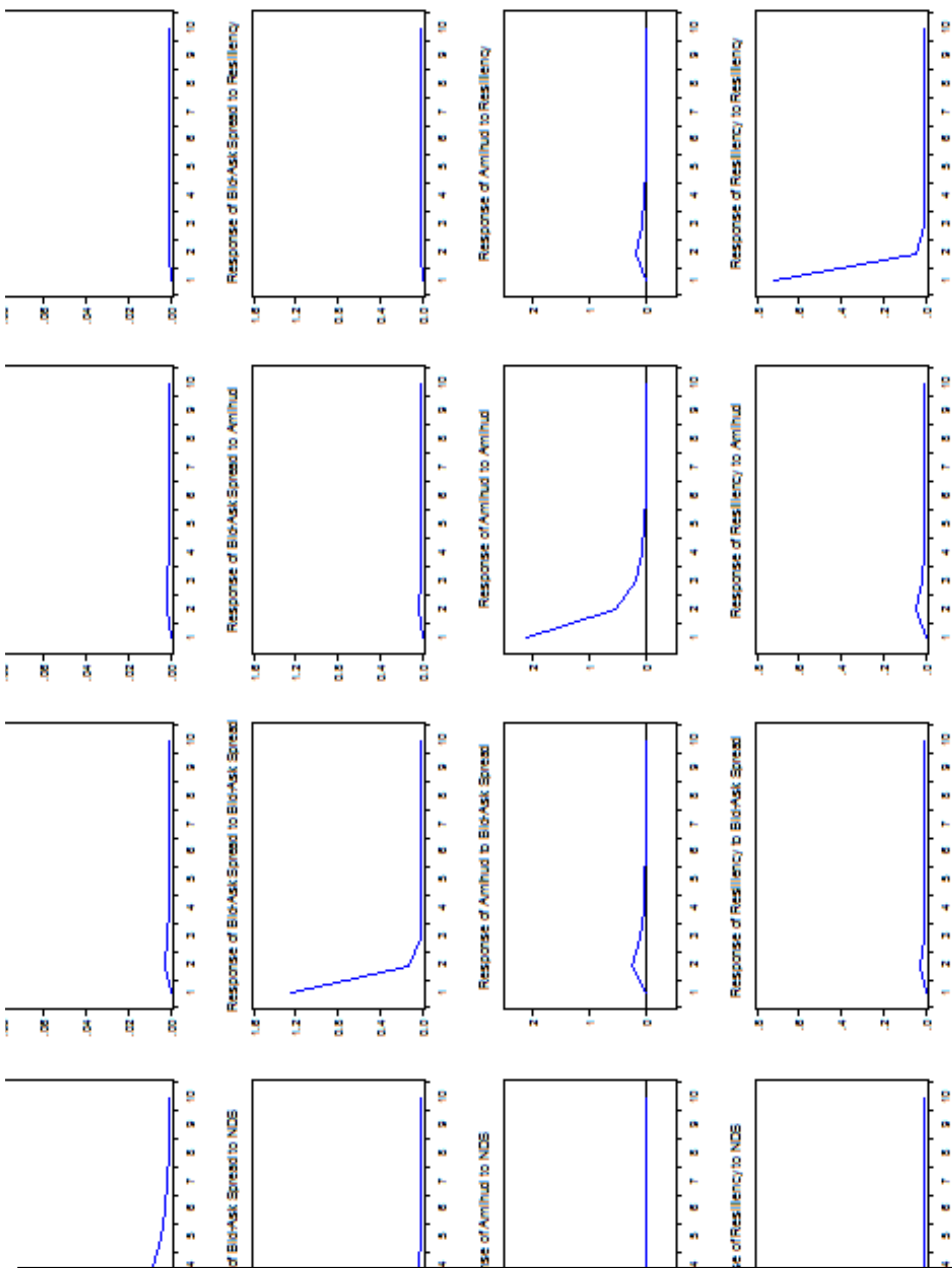
Figure 2: Impulse Response Functions

This figure displays the response of the non-default spread (NDS), ln(Bid-Ask Spread), ln(Amihud measure), and ln(Resiliency) to a one standard deviation shock to each of the variables while controlling for contemporaneous market volatility using the VIX level. The three liquidity variables are orthogonalized to each other. Panel A contains responses during the financial crisis (2008-2009) while Panel B contains responses during the post-crisis period (2010-2012).

Panel A: Crisis Subsample



Panel B: Post-Crisis Subsample



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