Funding Liquidity and Market Liquidity: the Broker-Dealer Perspective*

Marco Macchiavelli† Xing (Alex) Zhou ‡

June 17, 2019

Abstract

We provide the first direct analysis of how dealers' funding liquidity affects their liquidity provision in securities markets. Dealers' repo trading terms, including both haircuts and repo spreads, and their ability to finance their bond inventories through repos affect their bid-ask spreads and transaction costs in corporate bonds. Using dealers' exposure to the SEC 2016 money market fund reform as an instrument, we show that funding liquidity indeed has a causal effect on market liquidity. Dealers with lower funding liquidity tend to have smaller market shares and they execute more trades on an agency basis.

JEL classification: G12, G23, G24.

Keywords: Funding liquidity, market liquidity, repos, broker-dealers, corporate bonds.

*For their comments, we are grateful to George Aragon, Jack Bao, Hendrik Bessembinder, Sergey Chernenko (discussant), Edith Hotchkiss, Davide Tomio (discussant), Heather Tookes, and participants at the Federal Reserve Board, 2019 FIRS Annual Conference, and 2^{nd} Short Term Funding Market Conference. We thank Thomas Flanagan for excellent research assistance. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Board of Governors or the Federal Reserve System.

†Federal Reserve Board, email: marco.macchiavelli@frb.gov

‡Federal Reserve Board, email: xing.zhou@frb.gov

1 Introduction

Dealers play an important role in the proper functioning of the corporate bond markets. With orders arriving in large lots at irregular times, liquidity of the bond markets is essentially determined by dealers' ability to absorb temporary order imbalances and fund the resulting inventory changes for short periods of time, until they identify a willing buyer. Theoretical studies by Brunnermeier and Pedersen (2008), and Andersen et al. (2019) argue that the funding conditions of financial intermediaries affect the liquidity of the assets they trade. The connection between the market liquidity of an asset and the funding conditions of dealers is rather direct in practice: dealers indeed finance a significant portion of their bond inventories in the repo markets. In a survey conducted by the European Systemic Risk Board (ESRB) to the thirteen largest market makers operating in Europe, scarcity of repo financing is considered to be one of the main drivers of illiquidity in the bond markets.[1]

This paper provides the most direct tests to date of the theoretically-implied relation between funding liquidity and market liquidity. Specifically, we study individual dealers' financing activities and empirically test how various aspects of a dealer's funding conditions in the repo markets–including its repo haircuts and spreads, and its reliance on repos to finance bond inventories–affect its liquidity provision in corporate bonds. We address the possible endogeneity of dealers' funding conditions by employing bond-time fixed effects and using the dealer-specific exposure to the SEC 2016 money market fund reform as an instrument. Our findings strongly support the view that greater funding liquidity leads to higher market liquidity.

Repos provide an important vehicle to dealers to fund their bond inventories. When a dealer uses the purchased bond as collateral and borrows against it in the repo market, the interest rate imposed by the repo lender directly captures the cost of funding for the dealer. In addition, as repo haircuts (the difference between the cash loan and

[1]The aggregate market share of the survey respondents is about 73% for investment-grade and 64% for high-yield corporate bonds. See "Market liquidity and market-making", European Systemic Risk Board, European System of Financial Supervision, October 2016.

the collateral value) have to be financed with the dealer's own capital, they affect the dealer's ability to fund bond inventories and intermediate bond trading (Brunnermeier and Pedersen (2008)). Using information on dealers' trades and outstanding positions in triparty repos provided daily by the two clearing banks (BNY Mellon and JP Morgan) to the Federal Reserve Bank of New York (FRBNY) for the period from July 2011 to December 2017, we estimate the terms that each dealer receives in its repo borrowing backed by corporate collateral. The median dealer in our sample faces a 7% haircut and pays a 29 basis points spread in its corporate repo transactions.

In the model by Brunnermeier and Pedersen (2008), funding liquidity and market liquidity can reinforce each other through a feedback loop. While market liquidity can affect traders' funding liquidity, documenting such effects is challenging without meaningful measures of funding liquidity at the asset level. Furthermore, the triparty repo market is designed to attenuate such feedback loop, since it relies on general collateral: the liquidity of an individual security in the collateral pool is therefore unlikely to affect the terms of the repo contract. In this paper, we focus on exploring the effect of dealers' funding liquidity on asset market liquidity.

Taking advantage of information on dealer identities included in a regulatory version of corporate bond transaction data from the Trade Reporting and Compliance Engine (TRACE), we study the impact of a dealer's funding liquidity on its liquidity provision in corporate bonds. We estimate two alternative measures of bond liquidity at the dealer-bond-month level: effective bid-ask spreads, and transaction costs as in Hendershott and Madhavan (2015). Dealers' liquidity provision in corporate bonds is significantly affected by the terms they receive on their repo borrowings. Dealers facing lower haircuts and paying smaller spreads on their triparty corporate repos tend to provide more liquidity in their corporate bond trading. Our results are unlikely to stem from selection bias or reverse causality. Indeed, controlling for bond-time fixed effects a la' Khwaja and Mian (2008), we look within a specific bond-month pair and compare the liquidity provided by different dealers with various degrees of funding liquidity: dealers with greater funding liquidity provide more liquidity in the same bond and at the same time relative to dealers with worse funding liquidity. Comparing the liquidity provided by multiple dealers within each bond-month pair, we can rule out the possibility that dealers with less funding liquidity select into trading solely in less liquid bonds.

We also more explicitly account for the possible endogeneity of funding liquidity and market liquidity by using an instrumental variable approach. The SEC 2016 Money Market Fund (MMF) reform led to a reallocation of about $1 trillion from prime funds to government funds. Since prime funds can supply non-government (including corporate) repos to dealers while government funds cannot, the MMF reform results in a sharp decline in the supply of corporate repos from MMFs to dealers. Counterparty relationships in money markets tend to be associated with better repo pricing terms (Anderson and Kandrac (2017), Li (2017), Han and Nikolaou (2016)). As a result, the shift in non-government repo supply from prime funds to other institutions increased dealers' cost of corporate repo funding, and serves as an exogenous shock to dealers' funding liquidity. Indeed, dealers that rely more heavily on prime funds for their repo borrowings in 2014 face higher repo haircuts and spreads in the post-reform period (once these borrowing relationships with prime funds are impaired). Using the share of a dealer's triparty repo funding from prime funds in 2014 as an instrument for its post-reform repo pricing terms, we find strong evidence that funding liquidity has a significant causal effect on corporate bond liquidity.

If dealers with greater funding liquidity are able to provide higher liquidity to their customers, will they attract customers from dealers with lower funding liquidity? How do dealers facing less favorable funding conditions change their behavior in order to compete with better funded dealers? We find that dealers with worse funding conditions (higher haircuts and repo spreads) are indeed less likely to take on inventory risk. Instead, they tend to serve more as brokers and execute more customer orders on an agency basis. We also find some evidence that, on net, the market share of corporate bond trading is smaller for dealers with less favorable repo pricing terms. It is unclear whether dealers facing less favorable funding conditions will be ultimately driven out of business, in part due to the existing relationship-based trading networks and relatively high costs in searching for better counterparties in over-the-counter (OTC) markets (Duffie et al. (2005); Li and Schürhoff (2014); Di Maggio et al. (2017)).

As an alternative aspect of funding liquidity, we also examine a dealer's ability to fund their bond inventories through the repo markets. Repos are attractive to dealers as an inventory funding vehicle mainly because of their flexility and low cost. To finance the purchase of a bond, a dealer often raises cash by pledging the same bond as collateral in the repo markets. When the dealer manages to find an interested buyer, it can simply stop rolling over the overnight repo (or terminate open ones) so as to obtain the collateral (bond) back when the sale settles, and deliver the bond to the buyer.[2] Therefore, repos generally allow dealers to finance a bond only for the time needed. Moreover, due to collateralization, the cost of repo funding is typically lower than that of equity capital and unsecured external funding. Altogether, a dealer's ability to tap the repo markets to finance bond inventories is expected to play an important role in supporting its market making activities.

Specifically, we examine dealers' repo funding for their bond inventories by linking each dealer's financing activities in the repo markets with its corporate bond inventory changes estimated from the TRACE data. Since the vast majority of a dealer's repo borrowing is backed by Treasury and Agency collateral and hence is unlikely to be used to fund corporate bond inventories, we focus on dealers' repos with corporate collateral. Further, given that a substantial proportion of corporate repos are used to fund associated reverse repos, namely to provide secured cash loans to clients, the share of corporate debt inventories that are funded on the repo markets has to be estimated (Iyer and Macchiavelli (2018)). In addition to dealers' positions in triparty repo, we also obtain data on the overall corporate repo activities for each of the Primary Dealers from the

[2] Alternatively, if longer-term repos are used, the dealer can usually substitute the bonds pledged as collateral, delivering the purchased bond to the client while pledging a new conforming bond in the collateral pool.

FR2004 Primary Dealer Report. Althought the FR2004 data do not provide information on the terms of repo transactions, they have more coverage compared to the triparty repo data as they include dealers' financing through triparty repos as well as bilateral repos and securities lending, and span a longer time period (2002-2017). We find that repos indeed provide an important funding vehicle to support dealers' market making activities: the median dealer in our sample funds about 39% of its weekly changes in corporate bond inventories through the repo markets, with the share of its inventories funded by triparty repos being 12%.

Consitent with repos being an attractive vehicle for funding inventories, dealers that fund more of their inventories through the repo markets are able to provide tighter bid-ask spreads and lower transaction costs. Not surprisingly, the effect of repo terms on bond liquidity is stronger for dealers that rely more heavily on repos to fund their inventories. We also find that the effect of dealer funding liquidity on bond liquidity changes over time, with the link being substantially weakened during the financial crisis. Although funding liquidity might have a larger impact on market liquidity during a crisis, as dealers on average are more constrained (Brunnermeier and Pedersen (2008)), the crisis is also a period of generalized market illiquidity. Potentially attributed to the instability of repo funding during the crisis period (Duffie (2010); Gorton and Metrick (2012); Iyer and Macchiavelli (2018)), dealers that rely more heavily on repos to fund inventories back away from providing market liquidity, leading to an impaired transmission of liquidity from the liability side of broker-dealers into their market making activities in the cross-section.

Our paper fits into a large body of literature that studies the effect of traders' funding costs and capital constraints on various financial market outcomes. Capital losses suffered by convergence traders can affect the prices of the the assets they trade (Xiong (2001)), and create contagion in asset markets (Kyle and Xiong (2001)). Gromb and Vayanos (2002) study the implications of arbitrageures' financial constraints for asset prices. More recently, Duffie (2010) illustrates how vanished funding liquidity led to the failure of dealer banks during the recent financial crisis. He and Krishnamurthy (2013) explore the asset pricing implications of the capital constraints faced by financial intermediaries in a theorectial framework. Adrian et al. (2014) and He et al. (2017) provide consistent empirical evidence and show that shocks to proxies for funding conditions of financial intermediaries possess explanatory power for asset returns in the cross-section. Bai et al. (2018) shows that the mismatch between the market liquidity of banks' assets and the funding liquidity of their liabilities is informative about the liquidity risk of the entire banking system.

More closely related to our paper are several recent studies that relate dealers' funding liquidity to the market liquidity of the assets they trade.[3] Brunnermeier and Pedersen (2008) argue that traders' ability to provide market liquidity depends on their availability of funding. The model in Andersen et al. (2019) also contends that funding costs are an important determinant of dealers' bid and ask quotes. In addition, Huh and Infante (2018) model the role of repos and dealers' leverage in affecting bid-ask spreads of the assets they trade.

The view that funding costs affect dealer intermediation in these theoretical studies has been indirectly supported by some empirical evidence. For example, Wang et al. (2016) show that the introduction of upfront payments during the CDS "Big Bang" in 2009 increased the costs of market making for all dealers and reduced market liquidity. Relatedly, Aragon and Strahan (2012) take the perspective of a different group of traders, hedge funds, and find that stocks held by hedge funds using Lehman as prime broker experienced greater declines in liquidity following Lehman's bankrupcy relative to other stocks. Kahraman and Tookes (2017) find that liquidity improves after stocks become eligible for margin trading. Pelizzon et al. (2016) find that ECB liquidity injections attenuate the link between the credit risk and market liquidity of sovereign bonds. On

[3]Also related to this literature are papers that study dealers' liquidity provision and inventory risks, which are largely affected by price movements of assets in inventories and can have little to do with dealers' funding liquidity. For example, Comerton-Forde et al. (2010) find that the average liquidity in an NYSE specialist's assigned stocks is related to its inventories and revenues. In the bond market, how dealers manage their inventories has been studied by Goldstein and Hotchkiss (2018) and Schultz (2017).

a related topic, Chen et al. (2018) show that the ability to pledge a bond as collateral leads to lower bond yields–a collateral premium.

The paper that is the closest to ours is Rapp (2016), which studies how dealers' CDS spreads affect their bid-ask spreads in corporate bond trading. While CDS spreads capture the credit risk of the bank holding company and its overall cost of long-term debt, it is unclear how relevant they are with respect to the dealer's cost of short-term funding for its inventories. Indeed, Hu et al. (2015) show that dealers' CDS spreads are not significantly related to their repo trading terms such as haircuts and interest rate spreads. By linking a dealer's trading in the corporate bond market to its repo borrowing, our paper for the first time provides direct evidence of the effect of dealers' short-term funding liquidity on liquidity provision in the corporate bond market.

Our work is also related to a recent strand of literature that studies how various post-crisis regulations affect corporate bond liquidity. Several papers document that the Volcker Rule has reduced corporate bond liquidity (Bao et al. (2018), Schultz (2017), and Dick-Nielsen and Rossi (2017)), while others cite more stringent capital regulations as a contributing factor for the decreased liquidity provision by dealers (Bessembinder et al. (2018) and Choi and Huh (2017)).[4] Adrian et al. (2017) study the effect of bank regulations on dealers' balance sheets and link individual bond liquidity to the balance sheet constraints faced by dealers trading the bond.[5] Differing from Adrian et al. (2017), we focus on the role played by dealers' funding conditions in determining corporate bond liquidity. As pointed out by Duffie (2018), dealers' funding costs are at least as important as regulatory constraints (chiefly the leverage ratio) in determining dealers' total intermediation costs.

[4]Recent papers that also study corporate bond liquidity after the financial crisis include Anderson and Stulz (2017), Trebbi and Xiao (2017), and Goldstein and Hotchkiss (2018).

[5]Adrian et al. (2017) also examine dealers' total repo borrowing as a share of total assets as one aspect of their balance sheet constraints. However, total repo borrowing speaks little to how dealers fund their corporate bond inventories. As discussed earlier, the vast majority of dealers' repo borrowings are in Treasury and Agency collaterals, and even for those backed by corporate debt collateral, a substantial proportion is used to provide funding to dealers' clients, not to finance their own corporate inventories. Our measures of funding liquidity, by directly capturing dealers' cost and flexibility of inventory financing, are meant to address these issues.

The rest of the paper is organized as follows. Section 2 introduces our measures of dealers' funding liquidity and describes the data used for estimating these measures. Section 3 estimates several measures of bond liquidity and dealer behavior, linking them to dealer funding liquidity. Section 4 examines an alternative aspect of dealers' funding liquidity. Finally, Section 5 concludes.

2 Funding Liquidity for Corporate Bond Dealers

Repos are collateralized loans which allow a firm to raise cash against the pledge of securities as collateral. For corporate bond dealers, repos constitute a major funding vehicle to finance bond inventories, and are therefore essential in supporting their market making activities. In raising cash through repos, dealers pay the repo rate for the amount borrowed and at the same time, finance the haircut with their own capital. Therefore, dealers' repo trading terms directly capture the funding conditions that they face when making markets in corporate bonds.

2.1 Triparty Repo Data

Information on dealers' trading terms in triparty repos is provided daily by the two triparty clearing banks (BNY Mellon and JP Morgan) to the Federal Reserve Bank of New York (FRBNY) starting in July 2011. Triparty repos are particularly useful to dealers for the purpose of financing inventories for a couple of reasons. They are standardized, in the sense that a broad pool of securities within a certain group qualify as collateral, and do not require back-office capabilities to settle and value collateral, as these services are provided by the clearing bank (BNY Mellon or JP Morgan). These features are also appealing to cash lenders, including money market mutual funds, since they help reducing overall costs.[6]

The triparty repo data include both a daily position file and a transaction-level trade

[6] For a comparison with bilateral repos and securities lending, see Adrian et al. (2013).

file. For each day and each repo borrower (including both dealers and non-dealers), the position file provides outstanding triparty repo volumes and collateral values broken down by residual maturity in days, and collateral type. The transaction file provides the interest rate for each repo transaction. For the purpose of our study, we focus on repos with corporate debt securities as collateral.

2.2 Repo Trading Terms: Haircut and Repo Spread

To calculate the haircut that a dealer faces in its repo borrowing, we use the daily position file. For each dealer on any given day, we first divide the difference between the collateral value and the repo volume by the repo volume to calculate daily haircuts for each dealer. We then compute monthly estimates of haircuts for corporate collateral at the dealer level as a volume-weighted monthly average of the dealer's daily haircuts. The median haircut in our sample is about 7%, with the bottom and the top quartiles being 5% and 9%, respectively. To compute repo spreads, we first use the transaction file to estimate the daily volume-weighted average repo rate that each dealer pays in its corporate triparty repo trades. To control for the influence of movements in risk-free interest rates on dealers' repo costs, we subtract the effective federal funds rate from repo rates on each day, and obtain a daily repo spread for each dealer. We then average the daily repo spreads over the month for each dealer to obtain dealer-month level estimates of repo spreads. The median dealer in our sample pays a 29 basis points spread on its corporate repo transactions, with the dealers at the bottom (top) quartile paying a spread of 18 (42) basis points. In general, the distributions of haircuts and repo spreads in our sample are consistent with those for corporate repos in Hu et al. (2015), whose triparty repo data are extracted from the N-MFP reports filed by U.S. money market funds.

3 The Link between Funding Liquidity and Bond Liquidity

In this section, we study the link between the funding liquidity of the dealers and their provision of corporate bond liquidity. In particular, we first estimate two alternative measures to capture an individual dealer's liquidity provision in each bond, and then study how various aspects of a dealer's funding liquidity, as discussed in the previous section, affect these bond-dealer level liquidity measures. We end the section with an analysis of how funding liquidity affects dealer behavior and market shares.

3.1 Corporate Bond Liquidity at the Bond-Dealer Level

We use two alternative measures to capture the liquidity of a bond: the realized bid-ask spread and the transaction cost measure as in Hendershott and Madhavan (2015). To estimate these measures, we obtain from the Financial Industry Regulatory Authority (FINRA) the TRACE corporate bond transaction data from July 2011 to December 2017, the period for which we also have triparty repo data. TRACE data provide detailed information on secondary market transactions in corporate bonds, including bond CUSIP, trade execution date and time, trade price and quantity, an indicator for inter-dealer trades, an indicator for agency or principal trades, and an indicator for whether the reporting dealer buys or sells the bond. Unlike the publicly disseminated TRACE data in which the actual size of a transaction over a certain par value is not displayed, our regulatory version provides the uncapped size for each trade. In addition, our data include the identity of the dealer involved in each trade. Together with the actual trade sizes, dealer identities allow us to come up with reliable measures of bond liquidity at the dealer-bond level.

For each bond in TRACE, we require it to have valid information about bond characteristics, including total amount outstanding, issuance and maturity dates, all of which are from the Mergent Fixed Income Securities Database (FISD). To closely match the set of bonds in TRACE with the corporate collateral pool underlying secured financing transactions, we keep those issued in US dollars by US firms in the following three broad FISD industry group: industrial, financial and utility. Each bond has to be rated by Moody's or S&P. If a bond is rated differently by the two rating agencies, we use the lower of the two ratings for the bond. After applying these filters, we end up with a comprehensive sample of 41,008 corporate bonds.

To prepare the sample for estimating bond liquidity, we impose a number of additional filters. Our first set of filters rely on bond characteristics. To avoid the potential impact of special bond features on the liquidity estimation, we focus on fixed-coupon corporate bonds with semi annual coupon payments, $1,000 par amount, and fixed maturity. We exclude from our sample the following bonds: convertible or putable bonds, private placements, asset-backed issues, and issues that are part of a unit deal. In addition, a significant amount of corporate bonds are issued by financial firms, including the dealers studied in our sample. To avoid capturing a mechanical correlation between dealers' funding liquidity and the liquidity of bonds issued by dealers themselves, we exclude bonds issued by financial firms. We also impose a set of filters using trade information from TRACE. Specifically, we exclude the following transactions: when issued, canceled, subsequently corrected, and reversed trades. In the calculation of bid-ask spreads and transaction costs, we remove trades that do not require capital commitments by the dealer, namely riskless principal trades. Since these trades do not require financing from the dealer, they are irrelevant for the purpose of studying the effects of funding liquidity on the cost of trading when dealers commit capital.[7] Similar to Harris (2015), we classify a trade as being a riskless principal trade if it is offset by another trade that occurs within one minute with the same trade size but with opposite trade direction. Since our regulatory version of the TRACE data includes dealer identities, we also require that the trade has to be reversed by the same dealer in order to be classified as a riskless principal

[7] However, as discussed later, in response to adverse funding liquidity, dealers might change their behavior and shift from committing their own capital in market making to serving as a broker and executing trades on an agency basis. Therefore, we bring back these riskless principal trades when studying the effects of funding liquidity on dealer behavior.

trade.

Since our focus is on studying the link between funding liquidity and market liquidity at the dealer level, we estimate both liquidity measures for each bond-dealer pair using all trades between a dealer and a customer (i.e., excluding inter-dealer trades). To compute the realized bid-ask spread, we use all trades and calculate, for each dealer-bond pair, the average daily difference between the dealer's volume-weighted average customer buy prices (Ask) and its volume-weighted average customer sell prices (Bid). This calculation requires at least one buy and one sell by the same dealer in the same bond on the same day. The daily measure of a dealer's bid-ask spread in a bond is then averaged within each month to get a bond-dealer-month level estimate.

We construct our sample by matching the bond-dealer-month level bid-ask spread estimates with the dealer-month level funding liquidity measures discussed above. Although there are only 26 distinct dealers in the sample, they represent the largest dealers in the corporate bond markets and together account for close to 90% of corporate bond trading in our comprehensive TRACE sample. Panel A of Table (1) shows that monthly realized spreads at the bond-dealer level have a mean of 0.44%, with the median being lower at 0.22%. Although matching bond-dealer level liquidity estimates with dealer level funding liquidity estimates can potentially lead to a sample overweighting dealers trading more bonds, we find that the distribution of funding liquidity measures obtained by weighting each dealer equally (previously discussed) is similar to their distribution in the bond-dealer sample (shown in Table (1)). This symmetry is possibly due to the fact that our sample includes only the largest dealers in the corporate bond market, all of which are trading a variety of bonds. The median bond has a rating of BBB+, with bonds at the bottom and the top quartiles of the sample carrying an A and a BBB- rating, respectively.[8] Finally, the median issue in our sample has an issue size of $1 billion with 1,860 days (about 5 years) to maturity.

To alleviate concerns about the restrictions imposed in the calculation of bid-ask

[8]For bond credit rating, we assign a numeric value to each notch of S&P (Moodys) credit rating, with 1, 2, 3, 4, ..., 21 denoting AAA (Aaa), AA+ (Aa1), AA (Aa2), AA- (Aa3), ..., C(C), respectively.

spreads (at least one buy and one sell by the same dealer in the same bond on the same day), we estimate an alternative measure of bond liquidity, namely the transaction cost measure in Hendershott and Madhavan (2015):

$$Cost_{i,j,r} = ln\left(\frac{P_{i,j,r}}{P^B_{i,j,r}}\right) \cdot Sign_{i,j,r}. \tag{1}$$

$P_{i,j,r}$ refers to the price for trade r by dealer i in bond j. $P^B_{i,j,r}$ is the benchmark price for trade r, which refers to the last trade price in the inter-dealer markets. $Sign_{i,j,r}$ represents the sign of the trade r, which takes the value of +1 for customer buy and -1 for customer sell. As in the estimation of effective bid-ask spreads, we first calculate a daily average transaction cost for dealer i in bond j, and then average it across days within a month to get a transaction cost measure for dealer i in bond j, during month t ($Cost_{i,j,t}$); we then divide the cost measure by 100 to facilitate our interpretation of the magnitude. The estimated monthly transaction costs are finally merged with dealer funding liquidity proxies and bond characteristics. Panel B of Table (1) shows that the mean transaction cost is 0.27%, and the median is lower at 0.22%. Since the estimation of the transaction cost for a dealer-to-customer trade only requires the price from the most recent inter-dealer trade, it imposes less stringent data requirements relative to the estimation of realized bid-ask spreads. Therefore, the sample constructed based on the availability of transaction costs estimates is much larger than the sample based on realized spreads. However, both dealers' funding liquidity estimates and bond characteristics exhibit similar distributions in these two samples (see Table (1)).

3.2 The Effects of Repo Trading Terms on Bond Liquidity

We start with an analysis of how the terms received by a dealer on its repo borrowings affect its liquidity provision. We first examine how a dealer's repo haircut affects its bond liquidity measures by estimating the following panel regression:

$$BondLiquidity_{i,j,t} = \beta Haircut_{i,t} + \gamma X_{j,t} + \mu_t + \mu_i + \varepsilon_{i,j,t}, \tag{2}$$

where $BondLiquidity_{i,j,t}$ is the liquidity provided by dealer i in bond j during month t (captured by either realized bid-ask spreads or transaction costs). $Haircut_{i,t}$ is the weighted average haircut on triparty repos backed by corporate debt collateral incurred by dealer i in month t. $X_{j,t}$ refers to a set of bond-level controls including the log of the total par amount outstanding, the residual time to maturity of the bond, and a set of dummy variables for the 21 fine credit ratings in month t. We include month fixed effects (μ_t) to control for changes in macroeconomic conditions (e.g., market volatility, interest rate term structures, credit conditions, etc.) that may affect funding conditions and asset market liquidity for all dealers at the same time. We also include dealer fixed effects (μ_i) to control for unobservable dealer characteristics that could also affect dealers' liquidity provision in corporate bonds. Standard errors are two-way clustered at the bond and dealer-month levels (as haircuts vary at the dealer-month level).

Table (2) provides strong evidence that better funding liquidity is associated with greater bond liquidity. In Panel A, Column (1) shows that the coefficient of $Haircut$ is positive and highly significant, suggesting that after controlling for bond characteristics (credit rating, time to maturity and total par amount outstanding), and both dealer and month fixed effects, dealers tend to offer lower bid-ask spreads if they face lower haircut in their repo borrowing. The effect of repo haircut on bond liquidity is also economically meaningful. The coefficient of 0.021 suggests that a decrease in $Haircut$ from the top quartile to the bottom quarter is associated with about 7 basis points decrease in the bid-ask spreads, which is over 31% of the median spread in our sample. Bond charateristics exhibit expected signs, with smaller bond issues and those with longer time to maturity being associated with lower liquidity. The relationship between funding liquidity and market liquidity is robust to an alternative measure of bond liquidity. Column (3) shows that higher $Haircut$ is associated with lower transaction costs. The effect on transaction costs is also economically significant, with a decrease in $Haircut$ from the top quartile to the bottom quartile being associated with a reduction in transaction costs equivalent to about 24% of its median value.

The relationship between bond liquidity and funding liquidity could however suffer from selection bias. It could be the case that dealers with better repo funding terms are also those that make markets and trade in the most liquid bonds. It could even be the case that the reason why certain dealers have better access to the repo market is exactly because they trade the most liquid bonds. To account for possible selection bias, we include bond-month fixed effects a la' Khwaja and Mian (2008). This approach allows us to examine whether a dealer with lower haircuts provides more liquidity in the same bond and at the same time, relative to a dealer with higher haircuts. It also allows us to control for both macro factors and bond-specific time-varying characteristics, such as firm leverage, equity volatility, or any firm-specific sensitivity to monetary policy cycles. Column (2) shows that, even after the inclusion of bond-month fixed effects, the results continue to hold. The coefficient of $Haircut$ declines somewhat in magnitude, but remains positive and highly significant. Therefore, among dealers that trade the same bond at the same time, those with lower haircuts in their repo borrowings provide tighter bid-ask spreads. This finding refutes the argument that the relationship between funding liquidity and bond liquidity is caused by selection bias. Our result is robust to using the alternative transaction cost measure (Column (4)).

Examining repo spread as an alternative measure of funding liquidity yields a similar picture. *RepoSpread* is defined as the repo rate in excess of the effective federal funds rate. We replace $Haircut_{i,t}$ with $RepoSpread_{i,t}$ in Equation (2) and re-estimate the panel regressions. Column (1) of Panel B shows that the coefficient of *RepoSpread* is positive and highly significant, suggesting that bid-ask spreads are tighter for dealers paying lower repo spreads. The 0.341 coefficient for *RepoSpread* suggests that moving from the bottom quarter to the top quartile of *RepoSpread* is associated with about 10 basis points increase in transaction costs, which is about 45% of the median transaction cost in our sample. Results change little when we control for bond-month fixed effects (Column (2)). This finding again is robust to using transaction costs as an alternative measure of bond liquidity (Columns (3) and (4)).

3.3 Causal Evidence: Dealers' Exposure to the 2016 Money Market Fund Reform

One potential concern on the estimated relationship between a dealer's funding liquidity and its liquidity provision in corporate bonds is that both of them can be driven by some omitted factors, such as the risk appetite of the dealer. To directly address endogeneity concerns, we identify exogenous changes to the funding liquidity of each dealer, and use an instrumental variable approach to re-examine the effect of funding liquidity on market liquidity. Changes in the funding conditions of a dealer that originate from changes in its creditworthiness do not satisfy exclusion restriction, as they are likely affecting the riskiness of its market making activities directly. We identify changes in funding conditions that are orthogonal to the dealer's creditworthiness. Exogenous variation comes instead from a structural change in the money market fund industry–money market funds are major supplier of cash to the dealers.

In 2014, the SEC approved a reform of the 2a-7 rule that regulates the operations of money market funds (MMFs). The key regulatory changes include imposing floating net asset values (NAVs) and liquidity fees and gates for prime MMFs, which are key suppliers of non-government repos to securities dealers. These changes reduced the attractiveness of prime MMFs to investors and led to heavy outflows. As shown in Figure (1), starting in late 2015, and continuing until late 2016, a total of about $1 trillion moved from prime to government MMFs, which are not affected by the reform (Cipriani and La Spada (2017)). The latter, while experiencing a dramatic increase in assets under management, are only able to supply government repos–those backed by Treasury and agency collateral–

to dealers. Due to such moves caused by the reform, dealers lost significant ability to raise non-government repos from MMFs. Using the N-MFP reports which provide security level holdings of MMFs at the monthly level, we find that the average dealer was raising 13% of its total triparty repo funding from prime MMFs in the second half of 2014; as a result of the reform, that percentage dropped to 3% in the first half of 2017.

We find that the MMF reform did not drastically change dealers' total repo borrowing backed by lower-quality collateral, as they substituted the loss in prime MMFs' repos with more repos supplied by other triparty repo lenders, including sec lending agents (that reinvest cash collateral) and sovereign wealth funds. However, this substitution came at the expense of dealers having to face worse pricing terms from the new repo suppliers. Indeeed, several recent papers (Anderson and Kandrac (2017), Li (2017), Han and Nikolaou (2016)) have shown that relationships between MMFs and dealers play an important role in the repo markets, and are usually associated with better pricing terms. Therefore, dealers that used to raise significant repo funding from prime MMFs prior to the 2016 reform had to give up benefitial relationships and create new ones at relatively less attractive pricing terms. Consequently, a greater reliance on prime MMFs for repo funding by a dealer in late 2014 constitutes a negative shock to the dealer's ability to raise cheap triparty repos backed by lower-quality collateral (including corporate debt), after the 2016 MMF reform.

We use the N-MFP reports to compute the average total repo funding that each dealer raises from prime MMFs over the second half of 2014. We then use the position file in the triparty repo dataset to calculate each dealers' total triparty repo funding over the same time period. Our instrument, $MMFExposure_{i,'14}$, is defined as the ratio of a dealer's triparty repo funding from prime MMFs over its total triparty repo funding during the second half of 2014. We then estimate the following two stage regressions:

$$\begin{aligned} Haircut_{i,t} &= \gamma MMFExposure_{i,'14} \cdot \mathbb{1}(Year = 2017) + \delta_i + \delta_{j,t} + \eta_{i,j,t}, \\ BondLiquidity_{i,j,t} &= \beta_{IV} Haircut_{i,t} + \mu_i + \mu_{j,t} + \varepsilon_{i,j,t}, \end{aligned} \tag{3}$$

where *BondLiquidity* is either the bid-ask spread or transaction cost measured at the dealer-bond-month level. The regressions are estimated with observations from 2015 and 2017, excluding the transition year of the reform. We set our instrument to zero in 2015, and turn it on in 2017 ($\mathbb{1}(Year = 2017)$), when the funding shock is realized. The use of dealer fixed effects then captures the average reliance on prime MMFs in 2015, allowing the instrument to capture the differential effect of relying on prime MMFs after the 2016 reform. Standard errors are two-way clustered at the dealer-month and bond level.

Table (3) provides strong evidence to support the causal relationship between funding liquidity and market liquidity. Consistent with the role of counterparty relationships in the triparty repo market, the coefficient of $MMFExposure$ is positive and highly significant in the first stage regressions, suggesting that after the MMF reform, haircuts increase for dealers with high pre-reform repo exposure to prime MMFs (see Column (1)). We conduct F-tests on the strength of the instrument in the first stage. As reported, the Kleibergen-Paap F statistic is well above the conventional critical value of 10. More importantly, the second stage coefficients continue to be positive and highly significant: in Column (1), the effect of repo haircuts on bid-ask spreads is positive and significant. Our results hold when using transaction cost as proxy for bond liquidity (Column (2)). We also replace $Haircut$ with *RepoSpread* and re-estimate Equation (3). Column (3) shows that repo spreads increased more for dealers with higher reliance on prime funds for repo funding before the reform. Also, the instrumented *RepoSpread* continue to have a significant effect on bid-ask spreads. Our results are again robust to the alternative bond liquidity measure (Column (4)). In sum, these results lend strong support to the interpretation that the funding liquidity of a dealer affects its liquidity provision in the corporate bond market.

3.4 Funding Liquidity and Dealer Behavior

If dealers facing larger repo haircuts and spreads ultimately offer less attractive pricing to clients, how are they competing with better-funded dealers? In this section, we analyze whether higher funding costs lead some dealers to avoid taking bonds in inventory by prearranging trades. We also analyze the impact of funding liquidity on the dealer's market share.

For this purpose, we bring back dealers' riskless principal trades that we exclude when estimating realized bid-ask spreads and transaction costs. For each dealer-bond pair $i-j$, we calculate the percentage of the total par amount traded that is comprised of riskless principal trades during month t, and call it $RPTShare_{i,j,t}$. Accounting for the potential endogeneity between funding liquidity and dealer bahavior, we use the instrumental variable $MMFExposure$ developed earlier and re-estimate Equation (3) by using $RPTShare_{i,j,t}$ instead of $BondLiquidity_{i,j,t}$ as the dependent variable in the second stage. The results are presented in Table (4).

Since the calculation of $RPTShare$ imposes less data restrictions relative to the two measures of bond liquidity, the sample size in Table (4) is larger than in Table (3). Nevertheless, the coefficients of the first stage regressions are very similar. Further, Column (1) shows that the coefficient for the instrumented $Haircut$ is positive and highly significant in the second stage regression, suggesting that dealers with higher repo haircuts are more likely to prearrage trades. Using $RepoSpread$ as a measure of funding liquidity, we reach a similar conclusion: dealers paying higher repo spreads are also more likely to trade on an agency basis (Column (3)). These results indicate that dealers' funding conditions have a material impact on their willingness to commit capital in market making.

If some dealers shift from acting as principals to acting as agents in response to adverse funding conditions, are they still able to compete for customer orders against better-funded dealers? To shed light on this question, we estimate the market share of each dealer in each bond, by calculating the percentage of the dealer's trade volume out of the total trade volume in the bond on a monthly basis, and denote it as $MarketShare_{i,j,t}$. We then re-estimate Equation (3) by using $MarketShare_{i,j,t}$ instead of $BondLiquidity_{i,j,t}$ as the dependent variable in the second stage. Columns (2) and (4) show that the coefficients for both $Haircut$ and $RepoSpread$ in the second stage are negative and significant only at the 10% level. These results imply that while dealers facing higher haircuts and paying higher spreads in their repo borrowings tend to have smaller market shares in corporate bond trading, the effects are not as sharp as to drive the dealers with worse funding conditions out of the market. This is potentially due to the existence of relationship-based trading networks and relatively high searching costs in over the counter markets (Duffie et al. (2005); Li and Schürhoff (2014); Di Maggio et al. (2017)).

4 Repo Funding Beta

In this section, we analyze a different aspect of dealers' funding liquidity by examining how dealers use repos to fund their bond inventories. We start with an analysis of dealers' inventory financing through triparty repos. We then extend the coverage by including funding a dealer obtains from both repos (including both triparty and bilateral repos) and securities lending markets.

4.1 Bond Inventories Funded through Corporate Repos

Corporate bond dealers rely on a variety of external funds to finance their bond inventories. While each funding source has its own pros and cons, and dealers may diversify their funding sources, repo is in general considered to be the most desirable source of external funding. First, unlike many types of term funding, such as corporate bonds and notes, repo funding (especially overnight and open) provides a flexible and efficient funding vehicle as it allows a dealer to finance a bond only for the time that the bond remains in its inventory. Once a bond is sold to an interested buyer, funding for the bond can be terminated, since the dealer can stop rolling over the repo so as to obtain the bond back for delivery to the buyer.[9] Second, compared with short-term unsecured funding vehicles such as commercial paper (CP), the collateralized nature of the repo transaction reduces

[9]As for term repos (with maturities longer than overnight), collateral substitution usually allows a dealer to remove a bond that is sold to a client from the collateral pool, substituting it with another bond with similar or better ratings.

risks to the lender and hence appeals to many institutional investors, such as money market funds, which drastically reduced their appetite for financial CP after a well-known fund "broke the buck" due to its exposure to Lehman's CP (Kacperczyk and Schnabl (2013)).[10] The collateralization of repo transactions increases market depth and lowers dealers' cost for funding their inventories. Lastly, the popular use of repos for inventory funding is also related to its operational efficiency. Both market making and collateral financing are usually executed within the broker-dealer unit, whereas CP is usually issued at the bank holding company level. The importance of repo funding for security dealers is reflected in the size of the repo markets where security dealers are major participants. Although repo volumes have declined since the crisis, they still far exceed the financing that dealers can raise in unsecured markets (Baklanova et al. (2015); Ruane (2015)).

As repos are also used by dealers to finance reverse repos (or economically similar trades), the size of a dealer's corporate repo books per se does not allow us to capture the extent to which a dealer funds its inventories on the repo markets. Table (5) provides two stylized examples of how dealers use repos: namely, to finance part of their own inventories (Panel A), and to fund secured loans to their clients, for instance in the form of reverse repos (Panel B). In each panel, dealers' assets and liabilities are listed in the top and bottom sections, respectively. In the left panel, the dealer starts with \$600 in cash obtained via a combination of \$400 in unsecured debt (Other Debt), and \$200 of retained earnings (Equity). In the first transaction (T1), the dealer buys a security worth \$1,000. Being short \$400, the dealer pledges part of the security as collateral (repoing it out) in an overnight repo transaction, thus raising the needed amount of cash in the second transaction (T2). After these two transactions, the dealer ends up with \$1000 worth of securities on inventory, 40% of which is funded by repos. The right panel provides an example of a matched book trade, where a dealer uses its repos to fund a secured loan (reverse repo) to a client. Suppose that client A wants to pledge a certain security to

[10] Another possible source of short-term unsecured funding is certificates of deposit (CDs). However, CDs are issued by commercial banks, and under Section 23A (Reg W) there are strict limits on the funding that a commercial bank can provide to the affiliated dealer.

raise \$1,000 from the dealer. What the dealer can do is to provide \$1,000 in cash to client A in exchange for collateral in one transaction (T1), while raising the same amount of cash by repoing out the same security pledged by client A to a cash lender, in a separate transaction (T2).[11] In this example, the dealer's repo transaction has nothing to do with financing its own inventories.

4.2 Triparty Repo Funding

To capture dealers' use of repos to fund corporate bond inventories, we first focus on dealers' triparty repo funding and combine the triparty repo position data with the TRACE corporate bond transaction data using dealer identities. Similary to Iyer and Macchiavelli (2018), we estimate each dealer's use of triparty corporate repos to fund its bond inventories by running the following regression for each dealer on an annual basis:

$$\Delta TripartyRepo_{i,t} = \beta_{i,Y} \Delta Inventories_{i,t} + \varepsilon_{i,t}, \tag{4}$$

where $\Delta TripartyRepo_{i,t}$ is the weekly (Wednesday to Wednesday) change in dealer i's triparty corporate repos outstanding, and $\Delta Inventories_{i,t}$ is the weekly (Wednesday to Wednesday) change in dealer i's corporate bond inventories during the same week.[12] The weekly change in corporate bond inventories is estimated by subtracting the dealer's cumulative sales from its cumulative buys in our comprehensive TRACE sample of 41,008 corporate bonds within the week. Since corporate bonds had a t+3 settement (which became t+2 starting September 2017), to ensure that a dealer's bond inventory changes are measured over the same week as for the dealer's financing transactions, we use the settlement date instead of the execution date for each bond trade. Specifically, we use all trades settled between each Thursday and the following Wednesday and subtract a

[11] This matched book trade assumes the same haircut on both repo and reverse repo. If instead the haircut on the reverse repo is higher than that on the repo, the dealer raises additional cash, called net financing.

[12] We aggregate the triparty data to the weekly level so that our estimates can be better compared with the repo funding beta estimated later with weekly (Wednesday to Wednesday) data on dealers' overall funding secured by corporate collateral.

dealer's aggregate sales from its aggregate buys to calculate its weekly bond inventory change. The estimated $\hat{\beta}_{i,Y}$, referred to as $TripartyFundingBeta$, captures the share of dealer i's corporate bond inventories funded by triparty repos on average during year Y.

The use of of triparty repos to fund inventories exhibits substantial variation across dealers. Some dealers are able to fund more of their inventories in the triparty repo markets than others. We find that the median $\hat{\beta}_{i,Y}$ estimated using the triparty repo data is 12%, meaning that the median dealer in our sample funds 12% of its corporate bond inventories with triparty corporate repos. For the dealer at the top (bottom) quartile of the distribution, 15% (3%) of its corporate inventories are funded in the triparty repo market.

Given the attractivenss and flexibility of repos as a funding vehicle, we then estimate the following empirical model to understand how the use of repos to fund bond inventories affects a dealer's liquidity provision in corporate bonds:

$$BondLiquidity_{i,j,t} = \beta TripartyFundingBeta_{i,t} + \gamma X_{j,t} + \mu_t + \mu_i + \varepsilon_{i,j,t} \tag{5}$$

where $BondLiquidity_{i,j,t}$ is the liquidity provided by dealer i in bond j during month t (either realized bid-ask spreads or transaction costs), and $TripartyFundingBeta_{i,t}$ is the estimated dealer i's average usage of triparty repos to fund its corporate debt inventories during month t (estimated at the dealer-year level). As in Equation (2), $X_{j,t}$, μ_t, and μ_i represent a set of bond-level controls, month fixed effects, and dealer fixed effects, respectively. Standard errors are two-way clustered at the bond and the dealer-year level (as the main regressor varies at the dealer-year level).

Consistent with triparty repos being a flexible and low cost source of funding, Table (6) shows that funding inventories through triparty repos affects the dealer's liquidity provision in corporate bonds. Dealers with greater $TripartyFundingBeta$ tend to offer tighter bid-ask spreads in the corporate bond markets (Column (1)). This finding is robust to controlling for bond-month fixed effects (Column (2)) and using the alternative corporate bond liquidity measure (Columns (3) and (4)).

As shown earlier, dealers' haircuts and spreads in their repo transactions have significant effects on bond liquidity. Since repo trading terms matter more for dealers that fund more inventories on the repo market, we explore the additional effect of repo terms for dealers with greater use of triparty repos for inventory financing. Specifically, we create a dummy variable *HighBeta* that equals one for dealers with an above-the-median reliance on triparty repos to finance corporate inventories during month t, and estimate the following panel regression:

$$\begin{aligned} BondLiquidity_{i,j,t} = \beta_0 Haircut_{i,t} + \beta_1 HighBeta_{i,t} + \beta_2 HighBeta_{i,t} \cdot Haircut_{i,t} \\ + \gamma X_{j,t} + \mu_t + \mu_i + \varepsilon_{i,j,t}, \end{aligned} \tag{6}$$

where, as before, *BondLiquidity* is the liquidity provided by dealer i in bond j during month t (captured by either realized bid-ask spreads or transaction costs) and *Haircut* is the weighted average haircut on triparty repos backed by corporate debt collateral incurred by dealer i in month t. Also, as in Equation (2), $X_{j,t}$, μ_t, and μ_i represent bond-level controls, month and dealer fixed effects, respectively. The regression is estimated with standard errors two-way clustered at the bond and dealer-month level (repo haircuts and spreads vary at the dealer-month level).

Consistent with previous tests, dealers facing lower haircuts and those with greater use of triparty repo to fund their bond inventories offer tighter bid-ask spreads. More importantly, the coefficient of the interaction term of *HighBeta* and *Haircut* is positive and highly significant, suggesting that for dealers with greater reliance on triparty repos to fund their inventories, smaller repo haircuts are associated with even tighter bid-ask spreads (Column (1)). Although the coefficient for *Haircut* declines notably when we control for bond-month fixed effects, the coefficient for the interaction term changes little and remains positive and highly significant (Column (2)). Our finding is robust to using the alternative transaction cost measure (Columns (3) and (4)). Studying the additional effect of repo spreads on bond liquidity for dealers with greater reliance on triparty repos to fund inventories reaches a similar conclusion. Bid-ask spreads are tighter for dealers who make greater use of repos to fund their bond inventories as the coefficient of $HighBeta$ remains negative and highly significant. More importantly, the coefficient of the interaction term $HighBeta \cdot RepoSpread$ is positive and highly significant, suggesting that the effect of repo spreads on bond bid-ask spreads is more pronounced for dealers with greater use of repos to fund their bond inventories (Panel B).

4.3 Overall Secured Funding

In addition to the triparty repo market, dealers raise funding through the bilateral repo and securities lending markets. To better understand the importance of the secured funding markets for dealers' market making activites, we study dealers' overall financing activities in corporate bonds by using information provided by Form C of the FR2004 Primary Government Securities Dealers Reports from 2002 to 2017. Form C collects each dealer's financing transactions, divided in "Securities In" and "Securities Out", for each asset class at weekly frequency (each Wednesday at close of business). "Securities In" refers to agreements where securities are received, including reverse repos (dealer lends cash and receives a security as collateral) and securities borrowed (dealer borrows a security and provides cash or non-cash collateral). "Securities Out" similarly refers to agreements to deliver securities to counterparties, including repos (dealer borrows cash and delivers securities as collateral) and securities lent (dealer lends securities and receives either cash or non-cash collateral). Dealers report the cash delivered (in the case of "Securities In") or received (in the case of "Securities Out"), or the fair value of securities if securities are exchanged or pledged as collateral.

The economic effect of a repo transaction is similar to a securities lending transaction collateralized by cash, although their transaction forms are different. The choice of the legal agreement usually reflects a client's preference. For instance, pension funds usually transact under securities lending agreements while security dealers and hedge funds mainly use repos (Baklanova et al. (2015)). In this section, we use repos as a general term to represent the funding a dealer obtains from both repos and securities lending markets.

The granularity of this dataset evolves over time along few dimensions, two of which are of relevance for our analysis. First, starting in April 2013, repurchase agreements and securities lending transactions are separately reported. To keep the dataset comparable over time, after April 2013, we add repos and securities lending together into"Securities Out"; similarly, we add reverse repos and securities borrowing together into "Securities In". Second, in January 2015, the granularity of corporate debt collateral types reported improves. Originally, corporate debt securities were defined as dollar-denominated debt securities issued by companies incorporated in the U.S., including bonds, notes, commercial paper, privately placed securities and private-label mortgage based securities (MBS). Then, in January 2015, private-label MBS are removed from corporate debt collateral and added to a new category called Other Debt. At the same time, Other Debt also includes State and Municipal Securities, which were not reported before. In order to keep the corporate debt collateral reported in FR2004 as close as possible to the securities reported in TRACE, we effectively stop tracking private-label MBS in our definition of corporate debt collateral, starting in January 2015. This gap in private label MBS coverage is inconsequential due to its negligible post-crisis volumes.

We then combine the FR2004 data with the TRACE data using dealer identities. A total of 23 Primary Dealers that file the FR2004 reports are also covered in TRACE. As shown in Table (8), the Primary Dealers are also the largest bond dealers. They together account for almost 90% of the total trade volume in our comprehensive TRACE sample. We first estimate for each dealer the share of its inventory that, on average over a given year, is funded on repo markets. To control for the amount of repo funding that is used by dealers to finance reverse repos, we include "Securities In" as a control variable (as in Iyer and Macchiavelli (2018)).[13] Specifically, we run the following regression for each

[13] We also estimate the model without controlling for "Securities In" as in Equation (4) and obtain similar results.

dealer on an annual basis:

$$\Delta SecOut_{i,t} = \beta_{i,Y} \Delta Inventories_{i,t} + \gamma \Delta SecIn_{i,t} + \varepsilon_{i,t}, \tag{7}$$

where $\Delta SecOut_{i,t}$ and $\Delta SecIn_{i,t}$ are weekly (Wednesday to Wednesday) changes in dealer i's "Securities Out" and "Securities In", and $\Delta Inventories_{i,t}$ is the weekly (Wednesday to Wednesday) change in dealer i's corporate bond inventories during the same week, measured using TRACE as in Equation (4).[14] The estimated $\beta_{i,Y}$, referred to as $RepoFundingBeta$, captures the importance of dealer i's secured funding in financing its corporate bond inventories during year Y.

We then match the estimated $RepoFundingBeta$ with corporate bond liquidity measures to study the potential effects of dealers' overall repo financing activities on their corporate bond intermediation. For the sample created based on the availability of bid-ask spread measure, the median $RepoFundingBeta$ is 39%, meaning that the median dealer in our sample funds 39% of its corporate bond inventories with repos. For the dealer at the top (bottom) quartile of the distribution, 67% (4%) of its corporate inventories are funded in the repo market. The sample with transaction cost estimates exhibit a slightly lower of $RepoFundingBeta$ (Panel B).

As the FR2004 data cover a much longer time period than the triparty repo data, we also study how the link between dealers' funding liquidity and corporate bond liquidity evolves over time, especially during the financial crisis. Figure (2) shows the evolution of measures for bond liquidity and dealers' funding liquidity over the period 2002-2017. Both realized bid-ask spreads and transaction costs decline amid improved transparency following the phased-in implementation of TRACE. They climb at the onset of the finan-

[14] The choice of Wednesday as a reference point for weekly changes is dictated by the fact that the FR2004 report collects financing transactions that are outstanding as of close of business each Wednesday. Also, note that Form A in the FR2004 Primary Government Securities Dealers Reports collects dealers' long and short positions at fair (market) value in different asset classes, including corporate debt, each Wednesday. However, the reported positions are calculated using the execution date, instead of the settlement date of each trade, and hence are not perfectly lined up with the financing transactions in Form C. Our results are robust to using data from Form A to estimate dealers' bond inventory changes.

cial crisis, reach the peak and stay at high levels for a few months, and then decline as the financial crisis is resolved. Meanwhile, funding liquidity for dealers appears to be very procylical: the median $RepoFundingBeta$ across dealers peaks right before the crisis, only to plummet in the following years, and then slowly recovers during the post-crisis period.

To study the effect of dealers' repo funding on their liquidity provision and its potential changes over time, we divide our sample into three sub-periods: pre-Crisis (2002-2006), Crisis (2007-2010), and post-Crisis (2011-2017), and analyze the link between funding liquidity and bond liquidity during each of the sub-periods. Specifically, we create three sub-period dummies, Pre-Crisis, Crisis, and Post-Crisis, and interact them with $RepoFundingBeta$. We then re-estimate Equation (5) by replacing $TripartyFundingBeta$ with these three interaction terms. Table (10) displays the results.

When using bid-ask spreads as the measure for bond liquidity, the coefficient of $RepoFundingBeta$ is negative and highly significant in the pre-crisis period. It drops substantially during the crisis period, becoming insignificant both economically and statistically. After the financial crisis, the coefficient for $RepoFundingBeta$ turns negative and significant again, although the magnitude is still notably lower than in the pre-crisis period (Column (1)). Controlling for bond-month fixed effects does not materially change our results (Column (2)). Analyzing how the impact of funding liquidity on transaction costs changes over time yields a similar picture (Columns (3) and (4)).

The impaired transmission of liquidity from the liability side of broker-dealers into their market making activities can potentially be attributed to the hightened run risks in repos that dealers are exposed to during the crisis period. While repo financing of corporate inventories is cheap and flexible in normal times, it proved to be a source of fire-sale risk during the crisis as repos became subject to rollover risk (Duffie (2010); Gorton and Metrick (2012); Iyer and Macchiavelli (2018)). As repo lenders failed to roll over repos to dealer, the latter found it harder to finance the underlying corporate collateral. With both internal liquidity and access to repo funding drying up at the same time, dealers did not have the capacity to maintain large inventories of corporate securitites. In some cases, dealers may have been forced to sell the inventories that they were no longer able to finance at fire-sale prices. What used to be a cheap and flexible way of financing inventories during normal times, becomes a source of fire-sale risk during the crisis. As a result we witnessed a generalized cutback in funding liquidity, together with very elevated bond illiquidity (as shown in Figure (2)).

5 Conclusions

In this paper, we study individual dealers' financing activities in the repo markets and empirically show at the dealer-bond level how funding liquidity affects liquidity provision in the corporate bond market. Our findings strongly support the view that greater funding liquidity leads to higher market liquidity. Dealers facing better repo borrowing terms (smaller haircut and repo spreads) and those that are able to fund more of their inventories through repos are able to offer tighter bid-ask spreads and lower transaction costs in their corporate bond market making activities. Our identification strategy takes advantage of a bond-dealer-month panel and utilizes bond-month fixed effects a la' Khwaja and Mian (2008) to control for possible selection bias. Indeed, by comparing the differential liquidity provided to the same bond by multiple dealers with different funding liquidity, we make sure not to capture a correlation between funding and market liquidity that is due to the selection of less liquid dealers into ex-ante less liquid bonds. Our results are unlikely to be driven by endogeneity bias more generally: using individual dealers' exposure to the 2016 MMF reform as an instrument, we find strong evidence in support of the causal interpretation of our findings.

Dealers seem to change their behavior in response to adverse funding liquidity. We find that dealers facing less favorable funding conditions commit less capital in market making and tend to execute more trades on an agency basis. On net, better-funded dealers have higher market shares in corporate bond intermediation. Given the existing dealer-client relationships and high search costs in the bond market, it is unclear whether dealers facing less favorable funding conditions will eventually be driven out of the market.

Lastly, the link between dealers' funding liquidity and corporate bond liquidity seems to be very procyclical. Although repos provide a cheap and flexible funding vehicle for dealers during normal times, they become a source of fire-sale risk during times of stress. We find that during the crisis period, the link between funding liquidity and market liquidity weakens substantially, indicating that even the dealers with relatively greater reliance on repo financing refrain from providing market liquidity in times of severe stress.

References

Adrian, Tobias, Brian Begalle, Adam Copeland, and Antoine Martin, 2013, Repo and securities lending, in *Risk topography: Systemic risk and macro modeling*, 131–148 (University of Chicago Press).

Adrian, Tobias, Nina Boyarchenko, and Or Shachar, 2017, Dealer balance sheets and bond liquidity provision, *Journal of Monetary Economics* 89, 92–109.

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

Andersen, Leif, Darrell Duffie, and Yang Song, 2019, Funding value adjustments, *The Journal of Finance* .

Anderson, Alyssa G, and John Kandrac, 2017, Monetary policy implementation and financial vulnerability: Evidence from the overnight reverse repurchase facility, *The Review of Financial Studies* 31, 3643–3686.

Anderson, Mike, and René M Stulz, 2017, Is post-crisis bond liquidity lower? .

Aragon, George O, and Philip E Strahan, 2012, Hedge funds as liquidity providers: Evidence from the lehman bankruptcy, *Journal of Financial Economics* 103, 570–587.

Bai, Jennie, Arvind Krishnamurthy, and Charles-Henri Weymuller, 2018, Measuring liquidity mismatch in the banking sector, *The Journal of Finance* 73, 51–93.

Baklanova, Viktoria, Adam M Copeland, and Rebecca McCaughrin, 2015, Reference guide to us repo and securities lending markets .

Bao, Jack, Maureen O'Hara, and Xing Alex Zhou, 2018, The volcker rule and market-making in times of stress, *Journal of Financial Economics* .

Bessembinder, Hendrik, Stacey E Jacobsen, William F Maxwell, and Kumar Venkataraman, 2018, Capital commitment and illiquidity in corporate bonds, *The Journal of Finance* .

Brunnermeier, Markus K, and Lasse Heje Pedersen, 2008, Market liquidity and funding liquidity, *The review of financial studies* 22, 2201–2238.

Chen, Hui, Zhuo Chen, Zhiguo He, Jinyu Liu, and Rengming Xie, 2018, Pledgeability and asset prices: Evidence from the chinese corporate bond markets, *University of Chicago, Becker Friedman Institute for Economics Working Paper* .

Choi, Jaewon, and Yesol Huh, 2017, Customer liquidity provision: Implications for corporate bond transaction costs .

Cipriani, Marco, and Gabriele La Spada, 2017, Investors appetite for money-like assets: the money market fund industry after the 2014 regulatory reform .

Comerton-Forde, Carole, Terrence Hendershott, Charles M Jones, Pamela C Moulton, and Mark S Seasholes, 2010, Time variation in liquidity: The role of market-maker inventories and revenues, *The Journal of Finance* 65, 295–331.

Di Maggio, Marco, Amir Kermani, and Zhaogang Song, 2017, The value of trading relations in turbulent times, *Journal of Financial Economics* 124, 266–284.

Dick-Nielsen, Jens, and Marco Rossi, 2017, The cost of immediacy for corporate bonds .

Duffie, Darrell, 2010, *How big banks fail and what to do about it* (Princeton University Press).

Duffie, Darrell, 2018, Post-crisis bank regulations and financial market liquidity, *Baffi Lecture* .

Duffie, Darrell, Nicolae Gârleanu, and Lasse Heje Pedersen, 2005, Over-the-counter markets, *Econometrica* 73, 1815–1847.

Goldstein, Michael A, and Edith S Hotchkiss, 2018, Providing liquidity in an illiquid market: Dealer behavior in us corporate bonds .

Gorton, Gary, and Andrew Metrick, 2012, Securitized banking and the run on repo, *Journal of Financial Economics* 104, 425–451.

Gromb, Denis, and Dimitri Vayanos, 2002, Equilibrium and welfare in markets with financially constrained arbitrageurs, *Journal of financial Economics* 66, 361–407.

Han, Song, and Kleopatra Nikolaou, 2016, Trading relationships in the otc market for secured claims: Evidence from triparty repos .

Harris, Lawrence, 2015, Transaction costs, trade throughs, and riskless principal trading in corporate bond markets .

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

He, Zhiguo, and Arvind Krishnamurthy, 2013, Intermediary asset pricing, *American Economic Review* 103, 732–70.

Hendershott, Terrence, and Ananth Madhavan, 2015, Click or call? auction versus search in the over-the-counter market, *The Journal of Finance* 70, 419–447.

Hu, Grace Xing, Jun Pan, and Jiang Wang, 2015, Tri-party repo pricing, *National Bureau of Economic Research* .

Huh, Yesol, and Sebastian Infante, 2018, Bond market intermediation and the role of repo, *Available at SSRN 2773678* .

Iyer, Rajkamal, and Marco Macchiavelli, 2018, Primary dealers during the 2007-08 crisis: Assessing risks and vulnerabilities, *working paper* .

Kacperczyk, Marcin, and Philipp Schnabl, 2013, How safe are money market funds?, *The Quarterly Journal of Economics* 128, 1073–1122.

Kahraman, Bige, and Heather E Tookes, 2017, Trader leverage and liquidity, *The Journal of Finance* 72, 1567–1610.

Khwaja, Asim Ijaz, and Atif Mian, 2008, Tracing the impact of bank liquidity shocks: Evidence from an emerging market, *American Economic Review* 98, 1413–42.

Kyle, Albert S, and Wei Xiong, 2001, Contagion as a wealth effect, *The Journal of Finance* 56, 1401–1440.

Li, Dan, and Norman Schürhoff, 2014, Dealer networks .

Li, Yi, 2017, Reciprocal lending relationships in shadow banking .

Pelizzon, Loriana, Marti G Subrahmanyam, Davide Tomio, and Jun Uno, 2016, Sovereign credit risk, liquidity, and european central bank intervention: Deus ex machina?, *Journal of Financial Economics* 122, 86–115.

Rapp, Andreas C, 2016, Middlemen matter: Corporate bond market liquidity and dealer inventory funding, *Working Paper* .

Ruane, Brian, 2015, The future of wholesale funding markets, *BNY Mellon December 2015* .

Schultz, Paul, 2017, Inventory management by corporate bond dealers .

Trebbi, Francesco, and Kairong Xiao, 2017, Regulation and market liquidity, *Management Science* .

Wang, Xingjie, Yangru Wu, Hongjun Yan, and Zhandong Zhong, 2016, Funding liquidity shocks in a natural experiment: Evidence from the cds big bang .

Xiong, Wei, 2001, Convergence trading with wealth effects: an amplification mechanism in financial markets, *Journal of Financial Economics* 62, 247–292.

6 Figures and Tables

Figure 1: Prime Money Market Funds around the 2016 Reform

The chart shows the evolution of total assets under management (solid black line) and total repo supply (dashed red line) by all prime MMFs, in $ billion. Measurement units for total assets under management are on the left axis, and for total repo supply on the right axis. The vertical black line represents the October 2016 MMF reform date.

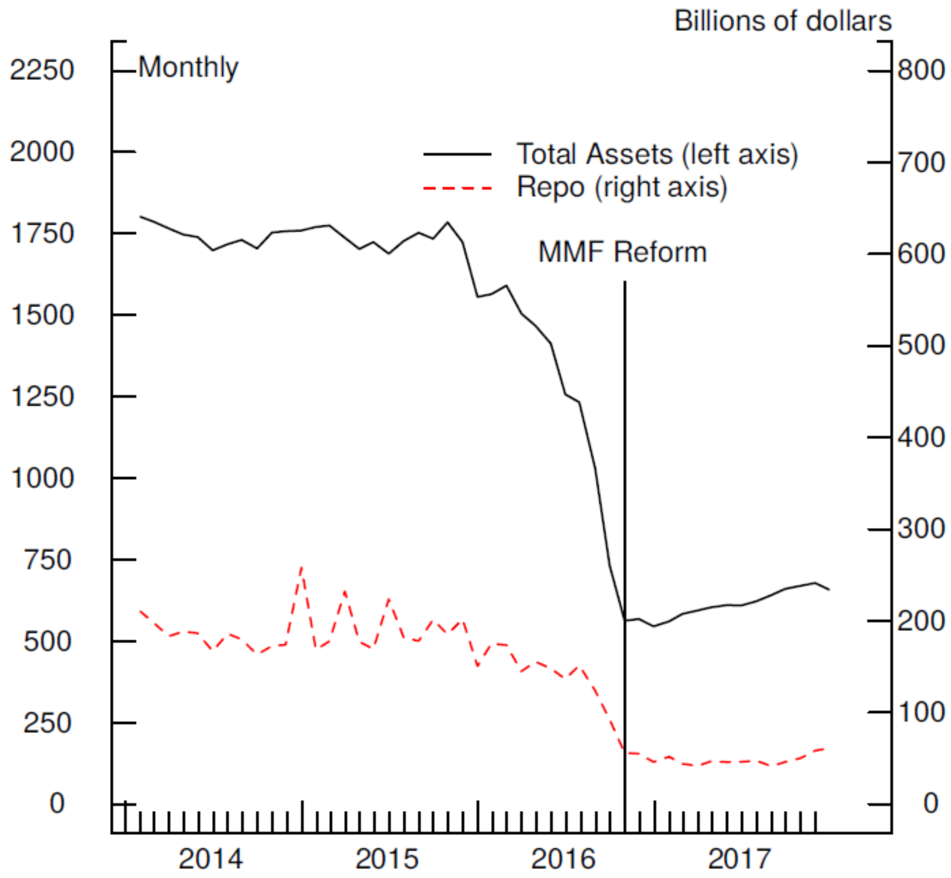

Figure 2: Funding Liquidity and Market Liquidity Over Time

The chart shows the evolution of three smoothed series: median dealer funding liquidity in solid black (called Repo Funding Beta in the regressions), median bid-ask spread in dashed blue (excluding riskless principal trades), and normalized median transaction costs in dashed red. The transaction cost series is rescaled so as to better fit the graph with the other two series.

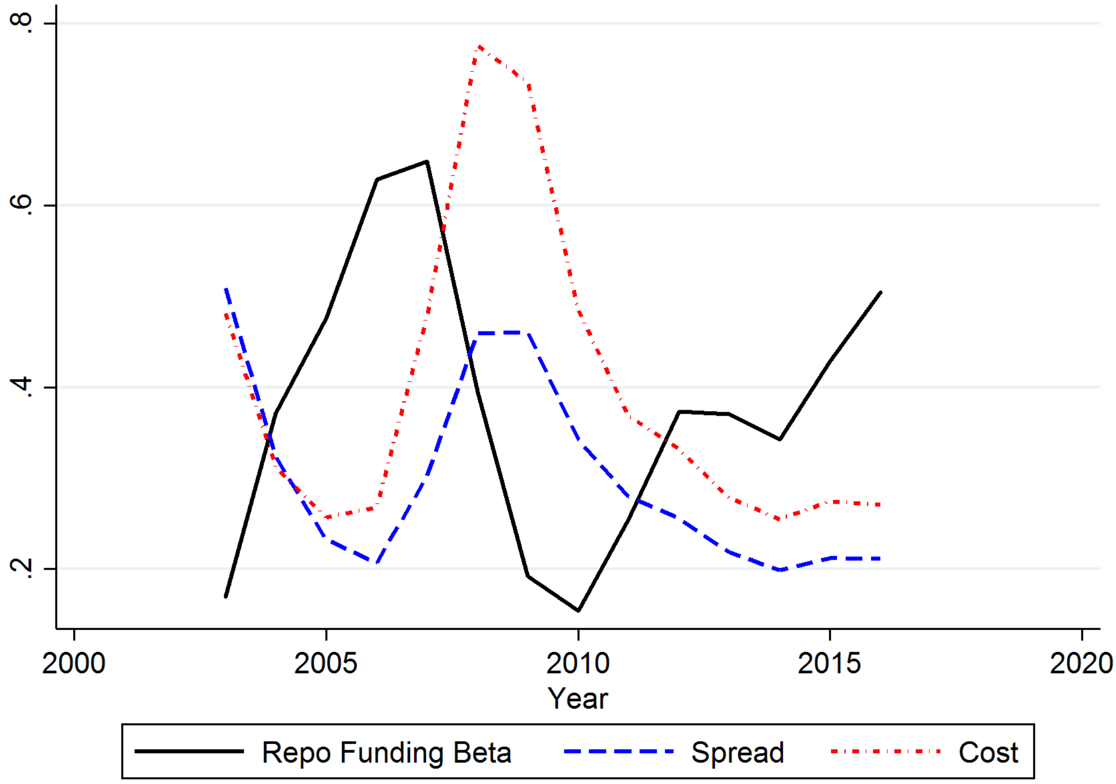

Table 1: Summary Statistics

Spread is the monthly-average bid-ask spread for each dealer-bond pair, excluding riskless principal trades (RPT). Cost is the monthly-average transaction cost (relative cost of customer trades to inter-dealer trades) divided by 100, for each dealer-bond pair, excluding RPT. Repo Spread is the monthly-average rate paid by each dealer on triparty corporate repos minus the current effective fed funds rate. Rating is the current bond rating on a scale of one to 21, with one being the highest rating. Finally, Outstanding Amount is the bond's total par amount outstanding in $ Millions, and Time to maturity is the residual time to the maturity of a bond, measured in 10,000 calendar days increments.

	Panel A: Bond-Dealer-Month, Spread regressions					
Variables	count	mean	st.dev.	p(25)	p(50)	p(75)
Spread	200,676	0.441	0.699	0.091	0.215	0.419
Haircut	200,676	7.155	2.465	5.460	7.384	8.661
Repo Spread	135,059	0.370	0.243	0.198	0.341	0.484
Rating	200,676	8.577	3.393	6	8	10
Outstanding Amount	200,676	1,288	917	540	1,000	2,000
Time to maturity	200,676	0.295	0.337	0.099	0.186	0.336
	Panel B: Bond-Dealer-Month, Cost regressions					
Variables	count	mean	st.dev.	p(25)	p(50)	p(75)
Cost	678,384	0.269	0.875	0.006	0.114	0.367
Haircut	678,384	7.216	2.583	5.362	7.541	8.768
Repo Spread	439,701	0.350	0.241	0.191	0.327	0.465
Rating	678,384	8.104	3.003	6	8	10
Outstanding Amount	678,384	1,242	882	500	1,000	1,750
Time to maturity	678,384	0.273	0.318	0.090	0.177	0.316

Table 2: Market Liquidity and Funding Liquidity – Repo Terms

The sample goes from 2011 to 2017. Spread and Cost are as defined in Table 1. Haircut (in Panel A) is the monthly-average haircut of outstanding triparty corporate repos for each dealer. Repo Spread (in Panel B) is the monthly-average rate paid by each dealer on triparty corporate repos minus the effective fed funds rate. Log(Outstanding), Time to maturity, and Ratings are defined in Table 1. Standard errors in parentheses are two-way clustered at the bond and dealer-month level; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Spread		Cost	
	Panel A: Haircut			
Haircut	0.021***	0.014***	0.008***	0.006***
	(0.003)	(0.002)	(0.001)	(0.001)
Log(Outstanding)	-0.123***		-0.100***	
	(0.009)		(0.005)	
Time to maturity	0.499***		0.300***	
	(0.024)		(0.015)	
N	200,676	138,495	678,384	629,064
	Panel B: Repo Spread			
Repo Spread	0.341***	0.261***	0.105***	0.101***
	(0.028)	(0.026)	(0.016)	(0.016)
Log(Outstanding)	-0.111***		-0.093***	
	(0.009)		(0.005)	
Time to maturity	0.478***		0.285***	
	(0.024)		(0.015)	
N	135,059	86,442	439,701	398,700
Dealer FE	Yes	Yes	Yes	Yes
Month FE	Yes	No	Yes	No
Rating FE	Yes	No	Yes	No
Bond-Month FE	No	Yes	No	Yes

Table 3: Market Liquidity and Funding Liquidity – Instrumental Variable Approach

The sample goes from 2015 to 2017, excluding the 2016 transition year. Spread and Cost are as defined in Table 1. Haircut is the monthly-average haircut of outstanding triparty corporate repos for each dealer. Repo Spread is the monthly-average rate paid by each dealer on triparty corporate repos minus the effective fed funds rate. Haircut and Repo Spread are instrumented for by MMF Exposure, which is zero in 2015 while in 2017 it equals the dealer's share of triparty repos obtained from prime Money Market Funds (MMF) in the second half of 2014. The MMF Reform was implemented in October 2016, and saw prime MMFs losing about $1 trillion in assets under management between late 2015 and October 2016. Standard errors in parentheses are two-way clustered at the bond and dealer-month level; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	First Stage			
	Haircut		Repo Spread	
MMF Exposure	7.150***	8.032***	1.148***	1.186***
	(1.208)	(1.538)	(0.144)	(0.175)
	Second Stage			
	Spread	Cost	Spread	Cost
Haircut	0.079***	0.062***		
	(0.015)	(0.012)		
Repo Spread			0.540***	0.520***
			(0.082)	(0.075)
N	40,855	186,260	35,084	163,560
Kleibergen-Paap F stat	35	27	63	46
Dealer FE	Yes	Yes	Yes	Yes
Bond-Month FE	Yes	Yes	Yes	Yes

Table 4: Riskless Principal Trades and Market Shares

The sample goes from 2015 to 2017, excluding the 2016 transition year. RPT Share is the percentage of riskless principal trades over total trades in a given bond by a dealer, in a given month. MKT Share is the percentage of trading in a given bond and month done by a dealer relative to the total trading in that bond-month pair. Haircut is the monthly-average haircut of outstanding triparty corporate repos for each dealer. Repo Spread is the monthly-average rate paid by each dealer on triparty corporate repos minus the effective fed funds rate. Haircut and Repo Spread are instrumented for by MMF Exposure, which is zero in 2015 while in 2017 it equals the dealer's share of triparty repos obtained from prime Money Market Funds (MMF) in the second half of 2014. The MMF Reform was implemented in October 2016, and saw prime MMFs losing about $1 trillion in assets under management between late 2015 and October 2016. Standard errors in parentheses are two-way clustered at the bond and dealer-month level; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	First Stage			
	Haircut		Repo Spread	
MMF Exposure	8.517***	8.517***	1.150***	1.150***
	(1.656)	(1.656)	(0.226)	(0.226)
	Second Stage			
	RPT Share	MKT Share	RPT Share	MKT Share
Haircut	2.400***	-0.318*		
	(0.671)	(0.179)		
Repo Spread			27.350***	-3.477*
			(6.679)	(1.753)
N	780,119	780,119	702,016	702,016
Kleibergen-Paap F stat	27	27	26	26
Dealer FE	Yes	Yes	Yes	Yes
Bond-Month FE	Yes	Yes	Yes	Yes

Table 5: Two Examples of Dealers' Use of Secured Financing

This table displays the two main uses of repos by dealers: inventory financing (Panel A) and matched book trades (Panel B).The top and the bottom rows represent the dealer's assets and liabilities, respectively. In each panel, we provide a snapshot of a dealer's balance sheets at both the Initial and the Final stages. T1 and T2 represents the two transactions that the dealer conducts in between. In the right panel, the matched book trade assumes the same haircut on both repo and reverse repo.

	Panel 1: Inventory Financing				Panel 2: Matched Book			
	Initial	T1	T2	Final	Initial	T1	T2	Final
Assets:								
Cash	600	-1,000	400	0	0	-1,000	1,000	0
Inventories	0	1,000	-	1,000	-	-	-	-
Reverse Repos	-	-	-	-	0	1,000	0	1,000
Liabilities:								
Repo	0	-	400	400	0	-	1,000	1,000
Other Debt	400	-	-	400	-	-	-	-
Equity	200	-	-	200	-	-	-	-

Table 6: Market Liquidity and Funding Liquidity – Triparty Funding Beta

The sample goes from 2011 to 2017. Spread and Cost are as defined in Table 1. Triparty Funding Beta is the estimated yearly average reliance of the dealer on triparty corporate repos to fund corporate inventories. Log(Outstanding) is the logarithm of the bond Outstanding Amount, and Time to maturity is the residual time to the maturity of a bond. Ratings are described in Table 1. Standard errors in parentheses are two-way clustered at the bond and dealer-year level; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Spread		Cost	
	Panel B			
Triparty Funding Beta	-0.179***	-0.181***	-0.159***	-0.122***
	(0.060)	(0.045)	(0.039)	(0.034)
Log(Outstanding)	-0.123***		-0.100***	
	(0.009)		(0.005)	
Time to maturity	0.501***		0.301***	
	(0.024)		(0.015)	
N	200,676	138,495	678,384	629,064
Dealer FE	Yes	Yes	Yes	Yes
Month FE	Yes	No	Yes	No
Rating FE	Yes	No	Yes	No
Bond-Month FE	No	Yes	No	Yes

Table 7: Market Liquidity and Funding Liquidity – Interaction Effects

The sample goes from 2011 to 2017. Spread and Cost are as defined in Table 1. High Beta equals one if the dealer's Triparty Funding Beta (defined in Table 6) is above the median in a given year. Haircut is the monthly-average haircut of outstanding triparty corporate repos for each dealer. Repo Spread is the monthly-average rate paid by each dealer on triparty corporate repos minus the effective fed funds rate. Log(Outstanding), Time to maturity, and Ratings are defined in Table 1. Standard errors in parentheses are two-way clustered at the bond and dealer-month level; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Spread		Cost	
	Panel A: Haircut			
Haircut	0.008**	0.001	0.002	0.002
	(0.003)	(0.002)	(0.001)	(0.001)
High Beta	-0.208***	-0.207***	-0.127***	-0.100***
	(0.038)	(0.030)	(0.020)	(0.018)
Haircut · High Beta	0.031***	0.030***	0.018***	0.014***
	(0.005)	(0.004)	(0.003)	(0.002)
Log(Outstanding)	-0.122***		-0.100***	
	(0.009)		(0.005)	
Time to maturity	0.498***		0.300***	
	(0.024)		(0.015)	
N	200,676	138,495	678,384	629,064
	Panel B: Repo Spread			
Repo Spread	0.242***	0.205***	0.006	-0.001
	(0.045)	(0.036)	(0.025)	(0.024)
High Beta	-0.072***	-0.057***	-0.080***	-0.076***
	(0.019)	(0.014)	(0.010)	(0.010)
Repo Spread · High Beta	0.129***	0.073**	0.125***	0.127***
	(0.045)	(0.035)	(0.027)	(0.024)
Log(Outstanding)	-0.110***		-0.093***	
	(0.009)		(0.005)	
Time to maturity	0.479***		0.285***	
	(0.024)		(0.015)	
N	135,059	86,442	439,701	398,700
Dealer FE	Yes	Yes	Yes	Yes
Month FE	Yes	No	Yes	No
Rating FE	Yes	No	Yes	No
Bond-Month FE	No	Yes	No	Yes

Table 8: List of Primary Dealers

The U.S. Primary Dealers in our sample usually operate through their New York branch, and are part of either domestic or foreign companies. The list of U.S. Primary Dealers can also be found on the New York Fed Website.

U.S. Primary Dealers		
ABN Amro	Bank of America	Barclays
Bear Stearns	BNP Paribas	Cantor Fitzgerald
Citigroup	Credit Suisse	Daiwa
Deutsche Bank	Goldman Sachs	HSBC
Jefferies	JP Morgan Chase	Lehman Brothers
Merrill Lynch	MF Global	Mizuho
Morgan Stanley	Nomura	Royal Bank of Canada
UBS	Wells Fargo	

Table 9: Summary Statistics – 2002-2017 Sample

This table presents statistics regarding the July 2002-Decenber 2017 bond-dealer-month sample. Spread is the monthly-average bid-ask spread for each dealer-bond pair, excluding riskless principal trades (RPT). Cost is the monthly-average transaction cost (relative cost of customer trades to inter-dealer trades) divided by 100, for each dealer-bond pair, excluding RPT. Repo Funding Beta is the estimated reliance on corporate repos to finance corporate inventories at the dealer-year level. Rating is the current bond rating on a scale of one to 21, with one being the highest rating. Finally, Outstanding Amount is the bond's total par amount outstanding in $ Millions, and Time to maturity is the residual time to the maturity of a bond, measured in 10,000 calendar days increments.

	Panel A: Spread regressions					
Variables	count	mean	st.dev.	p(25)	p(50)	p(75)
Spread	378,407	0.633	1.006	0.097	0.250	0.688
Repo Funding Beta	378,407	0.408	0.957	0.035	0.391	0.671
Rating	378,407	8.217	3.864	6	8	10
Outstanding Amount	378,407	1,239	972	500	1,000	1,750
Time to maturity	378,407	0.284	0.330	0.095	0.184	0.329
	Panel B: Cost regressions					
Variables	count	mean	st.dev.	p(25)	p(50)	p(75)
Cost	1,281,715	0.350	2.353	0	0.135	0.511
Repo Funding Beta	1,281,715	0.390	0.833	0.028	0.346	0.655
Rating	1,281,715	7.583	3.442	5	7	9
Outstanding Amount	1,281,715	1,185	909	500	1,000	1,500
Time to maturity	1,281,715	0.260	0.304	0.088	0.171	0.306

Table 10: Market Liquidity and Funding Liquidity – 2002-2017 Sample

The sample goes from July 2002 to December 2017. Spread is the bid-ask spread at the dealer-bond level, excluding riskless principal trades (RPT), and Cost is the transaction cost (relative cost of a customer trade to an inter-dealer trade) at the dealer-bond level, excluding RPT. Pre-Crisis, Crisis, and Post-Crisis refer to the 2002-2006, 2007-2010, and 2011-2017 periods, respectively. Repo Funding Beta is the estimated yearly average reliance of the dealer on secured financing to fund inventories. Log(Outstanding), Time to maturity, and Ratings are defined in Table 9. Standard errors in parentheses are two-way clustered at the bond and dealer-year level; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Spread		Cost	
Pre-Crisis · Repo Funding Beta	-0.163***	-0.158***	-0.082***	-0.082***
	(0.051)	(0.045)	(0.023)	(0.021)
Crisis · Repo Funding Beta	-0.009	-0.002	0.000	-0.002
	(0.013)	(0.012)	(0.013)	(0.012)
Post-Crisis · Repo Funding Beta	-0.073***	-0.062***	-0.061***	-0.053***
	(0.021)	(0.016)	(0.019)	(0.016)
Log(Outstanding)	-0.096***		-0.104***	
	(0.013)		(0.008)	
Time to maturity	0.478***		0.336***	
	(0.041)		(0.028)	
N	378,407	264,805	1,281,715	1,191,490
Dealer FE	Yes	Yes	Yes	Yes
Month FE	Yes	No	Yes	No
Rating FE	Yes	No	Yes	No
Bond-Month FE	No	Yes	No	Yes