Intermediary Balance Sheet Constraints, Bond Mutual Funds' Strategies, and Bond Returns*

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Abstract

We show that after the introduction of the leverage ratio constraint on bank-affiliated dealers, bond mutual funds have engaged in more liquidity provision in investment-grade corporate bonds, and their performance has benefited. However, the liquidity and returns of investment-grade corporate bonds have become more exposed to aggregate outflows from bond mutual funds with liquidity-supplying strategies. Thus, the occasional inability of bond funds to purchase bonds exposed to leverage constraints impacts market functioning. We show that mutual funds' missing liquidity provision helps explain which bonds experienced more severe deterioration in liquidity and returns at the onset of the COVID-19 pandemic.

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1 Introduction

Due to prudential regulations implemented in response to the global financial crisis, banks have become reluctant to intermediate low-margin, balance-sheet-intensive trades in safe asset markets (Duffie 2018). The same regulations have also significantly decreased the propensity of bank-affiliated dealers to provide liquidity for corporate bonds (Bessembinder et al. 2018; Choi et al. 2024; Rapp and Waibel 2023). However, less is known about how unregulated market participants respond and how their performance is affected. Not only have the regulations changed the trading frictions and opportunities for unregulated intermediaries, but how the unregulated intermediaries respond to these changes may affect the functioning of the corporate bond market. To address these important questions, this paper explores the strategies and performance of bond mutual funds and the consequences of their behavior on bond returns and liquidity.

Mutual funds have become prominent players in the corporate bond market in the decade following the 2008 global financial crisis. Unlike other market participants, such as insurance companies, which typically buy bonds at issuance and hold them until maturity, mutual funds frequently trade both in response to changes in their assets under management and to create alpha for their investors. Consequently, regulatory constraints on bank-affiliated dealers that affect liquidity conditions could significantly impact mutual funds' strategies and performance. The sign of this impact, however, is ambiguous. On the one hand, lower liquidity in the bond market could decrease the returns of mutual funds if they demand liquidity. On the other hand, the constraints on bank-affiliated dealers could provide trading opportunities if mutual funds engage in liquidity provision. In this case, liquidity-supplying mutual funds could partially substitute regulated financial institutions in liquidity provision and possibly earn an alpha on their trades.

This paper shows that mutual funds that engage in liquidity provision have benefited from tighter regulatory constraints on bank-affiliated dealers. Although these funds contribute to improving liquidity in the bond market, we show that their significant role in liquidity provision has increased the extent to which bond returns and liquidity are exposed to fund redemptions, suggesting that tighter regulations may have made liquidity conditions in the bond market more fragile.

To explore how constraints on regulated financial institutions spill over to mutual funds, we study the consequences of Basel III leverage ratio requirements for mutual funds' strategies, trading behavior, and performance. While various regulations that were introduced in the aftermath of the global financial crisis could have similar effects, the design of the Basel III leverage ratio is unique because it increases the intermediation costs for investment-grade bonds rather than high-yield bonds and induces within-quarter variation in the intensity of the constraints. These features facilitate the empirical identification of the effects of the leverage ratio requirements compared to other regulations.

Specifically, as part of Basel III, the leverage ratio requirements mandate that banks maintain a minimum amount of capital against all on- and off-balance sheet exposures, irrespective of their risk. Because the leverage ratio constrains the size of bank-affiliated dealers' balance sheets, extensive bond inventories become costly, irrespective of bond credit ratings. Since bank-affiliated dealers were already subject to risk-based capital requirements, which disproportionately increase the cost of holding high-yield bonds, the leverage ratio requirements primarily create regulatory pressure on dealers' investment-grade holdings. The leverage ratio should, therefore, constrain dealers' willingness to hold and provide liquidity in investment-grade bonds.

Furthermore, the leverage ratio requirements become most binding at quarter ends (Du et al. 2018), when international bank-affiliated dealers sharply contract their corporate bond inventories, and US banks are unwilling to expand their balance sheets (Correa et al. 2022; Rapp and Waibel 2023). Exploiting the intra-quarter timing of mutual funds' trades in bonds that we expect to be more or less affected by bank-affiliated dealers' leverage ratio constraints, we can identify the effects of the regulation on mutual funds' trading strategies. Along the same lines, we can explore how the intra-quarter performance of funds with different trading strategies varies to isolate the mechanism through which the leverage ratio requirements affect mutual funds' performance.

Since mutual funds' strategies differ significantly and only a subset of funds engage in liquidity provision, we start by constructing a proxy for mutual funds' strategies inspired by Anand et al. (2021). Trading strategies are strategic decisions that depend on investment objectives, legal restrictions, and investor clientele and consequently change little over time (Cella et al. 2013). Accordingly, we classify the extent to which a fund has a liquidity-demanding or supplying trading style based on the correlation of the fund's trades with dealers' inventory cycles in the past. From the dealers' point of view, a positive inventory cycle in a bond is a scenario in which the market sells and the dealers accumulate inventories. Thus, a mutual fund would demand liquidity if it tends to sell like the rest of the market, exerting additional pressure on the dealers' balance sheets.

We find that the leverage ratio constraint affects mutual funds' trading: Following the introduction of the leverage ratio requirements, at quarter ends, liquidity-supplying (LS) funds purchase bonds that are predominantly intermediated by dealers subject to the leverage ratio constraints (henceforth "constrained" bonds) and that have been experiencing selling pressure. Thus, LS funds purchase bonds that are in need of liquidity provision. We do not detect any changes in the strategies of liquidity-demanding funds. Consistent with the idea that market-making in high-yield bonds was already constrained by risk-weighted capital requirements, we observe that LS funds' trading behavior changes only for investment-grade bonds. LS funds appear to provide liquidity in high-yield bonds throughout the sample period. Notably, the quarter-end purchases of constrained investment-grade bonds subsequently outperform other purchases of LS funds.

Thanks to their liquidity provision in constrained bonds, LS funds appear to outperform other funds after the introduction of the leverage ratio requirements. This outperformance is driven by investment-grade bond funds, that is, funds that invest to a larger extent in the bonds in which market making was negatively affected by the leverage ratio constraint. In addition, we show that the alpha of LS funds, after the introduction of the leverage ratio constraint, is entirely realized in the first month of each quarter. This is consistent with our finding that LS funds purchase undervalued bonds in the last month of each quarter when the constraints are most binding for bank-affiliated dealers. Importantly, while all LS funds appear to provide liquidity in investment-grade bonds, the performance of those affiliated with dealers subject to the leverage ratio constraint benefits significantly more. This suggests that mutual funds have partially substituted bank-affiliated dealers in their liquidity provision and complement banks that may transfer profits to their affiliated funds.

We also evaluate the aggregate implications of mutual funds' behavioral changes for the bond market. While adopting an LS trading style is a mutual fund's strategic decision, which changes little over time (Cella et al. 2013; Anand et al. 2021), the extent to which mutual funds can actually engage in liquidity provision depends on their previous performance and flows. Poorly performing mutual funds are more likely to face redemptions and, hence, less likely to buy bonds that require liquidity supply. As a result, in periods in which LS mutual funds experience poor performance and outflows, their ability to engage in liquidity provision drops. We show that because of bond funds' missing liquidity provision during periods of widespread redemptions, after the adoption of the leverage ratio constraint, the liquidity and returns of constrained investment-grade bonds have become more exposed to aggregate outflows from LS mutual funds. Importantly, this effect is distinct from that of fire sales (see, for example, Falato et al. (2021) and Giannetti and Jotikasthira (2024)) not only because we control for bonds' fire sales and aggregate outflows from the bond mutual fund industry but also because conceptually the increased exposure of bonds to redemptions arises from LS funds' missing purchases (not sales).

We validate our conclusions regarding the effects of mutual funds' missing liquidity provision by considering cross-sectional differences in bond liquidity and returns during the onset of the COVID-19 pandemic. We show that when the shock hit the corporate bond market and bond mutual funds experienced unprecedented redemptions (Falato et al. 2021), liquidity conditions and bond returns deteriorated, especially for investment-grade bonds that, through dealers' inventories, were more exposed to the leverage ratio constraint. Since we control for flow-induced fire sales, this result confirms that bond mutual funds' missing liquidity provision indeed impacted bond market conditions.

Overall, our results indicate that recent banking regulations have shifted profits from liquidity provision in the bond market, at least in part, to unregulated institutions. While mutual funds help alleviate dealers' regulatory pressures at quarter ends by providing liquidity, relying on open-ended investment funds makes the corporate bond market more vulnerable to investor redemptions, as LS funds cannot buy bonds in need of liquidity during such events.

We contribute to a growing body of literature that documents the effects of prudential regulations introduced after the global financial crisis on the functioning of bond markets. Existing studies on the corporate bond market highlight how increased capital requirements and other related regulatory provisions, such as the Volcker Rule, decreased the affected dealers' market-making activities and ultimately bond liquidity, especially in periods of market stress (Adrian et al. 2017; Bessembinder et al. 2018; Bao et al. 2018; Dick-Nielsen and Rossi

2019; Allahrakha et al. 2019; Haselmann et al. 2022; Choi et al. 2024). While most studies focus on the effects of capital requirements and other "risk-based" regulations, Breckenfelder and Ivashina (2021) and Rapp and Waibel (2023) explore the impact of leverage ratio constraints on dealers' inventories and bond liquidity.

So far, the existing literature has focused on dealers' behavior and provides little evidence on whether unregulated market participants substitute for bank-affiliated dealers who are encumbered by regulations.[1] Specifically, insurance companies and hedge funds provide liquidity during periods of market stress, primarily supporting the dealers with prior trading relationships in anticipation of future benefits (O'Hara et al. 2022; Kruttli et al. 2024). However, during normal times, life insurance companies, the main actors in the corporate bond market, do not engage in liquidity provision, and their behavior has not changed after the post-global financial crisis regulations. While contemporaneous work by Rapp and Waibel (2023) shows that Property and Casualty (P&C) insurance companies supply liquidity following the retraction of bank-affiliated dealers due to regulations, P&C insurance companies are relatively small players in the corporate bond market (representing less than 5% of the market at the end of 2019). Life insurance companies with their long-term liabilities are typically considered the natural liquidity providers (Chodorow-Reich et al. 2021; Coppola 2025; Huang et al. 2021), while bond mutual funds, with their open-end funding structures, are liquidity-demanders. Given the mixed evidence on insurance companies, it is unclear whether mutual funds, with more fragile funding, have incentives to provide liquidity to dealers subject to regulatory constraints, even when they follow liquidity-supplying trading strategies (Anand et al. 2021).

To the best of our knowledge, we are the first to uncover mutual funds' incentives to substitute regulatory-constrained dealers in liquidity provision by considering the effects of the leverage ratio constraint on mutual funds' trading and performance. This differs from existing literature that emphasizes that insurers provide liquidity to their own dealers to reap future benefits in execution costs from repeated business (see, for example, Hendershott et al. (2020)). We abstract from dealer network relationships and show that LS mutual funds can take advantage of the new trading opportunities arising from the positive effect of the

[1] O'Hara and Zhou (2021b) show that during our sample period, electronic trading never exceeds 14% of market volume, is almost entirely constrained to small trade sizes, and decreases in importance during periods with high liquidity demand. Thus, electronic trading remains unlikely to substitute bank-affiliated dealers.

leverage ratio regulation on the returns from liquidity provision. This finding is important because the growing bond market is transitioning from a relationship-based market structure to a more transaction-based one, and concerns have been raised about whether participants have incentives to provide liquidity when relationships weaken (O'Hara and Zhou 2025).

Our findings also contribute to an emerging literature documenting the interlinkages between banks and non-bank financial intermediaries in other domains (Acharya et al. 2024). Last but not least, we are also the first to highlight the limits of liquidity provision by mutual funds and the consequences of their "missing" liquidity provision for bond returns and liquidity. Our results contribute to the understanding of the effects of post-global financial crisis regulations on the macrostructure of financial markets (Haddad and Muir 2025), an emerging field that studies how the organization of financial markets influences asset prices, going above and beyond the microstructure effects on which most of the literature focuses.

By focusing on the leverage ratio regulations, we also contribute to the growing literature that studies the distortions created by the leverage ratio constraint on fixed income and short-term money markets (Duffie 2018). Existing studies focus on parity deviations (Du et al. 2018; Cenedese et al. 2021), money market dislocations (d'Avernas and Vandeweyer 2022; Correa et al. 2022; He et al. 2022), changes in the swap and treasury yield curves (Du et al. 2023; Jermann 2020; Klingler and Sundaresan 2023), and changes in the repo market structure and bank risk-taking (Allahrakha et al. 2018; Choi et al. 2020; Klingler and Syrstad 2021). To the best of our knowledge, we are the first to highlight that some unregulated market participants benefit from the dislocation caused by constraints on regulated financial intermediaries and that LS funds' missing liquidity provision during periods of large aggregate outflows may increase fragility in the corporate bond market.

2 Changes in Regulatory Environment

Since the global financial crisis of 2007-2008, banks have been required to comply with various regulations that impact their capital and liquidity requirements (Greenwood et al. 2017). These regulations have increased balance sheet costs for banks' market-making activities, potentially affecting clients, including bond mutual funds. While the main thrust of our analysis should extend to any regulations affecting bank-affiliated dealers' costs of liquidity provision, we focus our investigation on the leverage ratio constraint because, as we explain below, its design allows sharper identification of its effects on bank-affiliated dealers and, by extension, bond mutual funds. In addition, a better understanding of the effects of the leverage ratio regulation is particularly relevant as some argue that it causes a distortionary reduction in banks' incentives to intermediate safe assets without financial stability benefits (Duffie 2018).

Specifically, the implementation of Basel III and the subsequent introduction of non-risk-weighted capital requirements have raised the cost of balance sheet expansion for banks and their affiliated dealers. Because of these regulations, commonly referred to as the leverage ratio (supplementary leverage ratio in the United States), banks began reporting their leverage ratios to regulators in January 2013. The effects on financial markets have been found to coincide with the first public disclosure of the leverage ratios in January 2015 (Du et al. 2018; Jermann 2020). Thus, even though compliance with the leverage ratio requirements became mandatory only in 2018, consistent with the literature, we consider 2015 to be the starting point for the regulation. We show that the dynamic effects we uncover are consistent with this assumption. The leverage ratio requirements mandate that banks maintain a minimum amount of capital against all on-balance-sheet assets and off-balance-sheet exposures, regardless of the risk associated with them. Hence, for the leverage ratio requirements, the size of the balance sheet matters rather than its riskiness.

In contrast, banks and their affiliated dealers have always been subject to risk-weighted capital requirements. Because the capital that a regulated institution must set aside depends on the risk of its assets, risk-weighted capital regulations increase banks' inventory costs for riskier bonds, thereby constraining bank-affiliated dealers' liquidity provision in these bonds. Since the risk-weighted capital requirements were already in place, the newly introduced leverage ratio regulations have prompted intermediaries to primarily divest their holdings of safe assets (Duffie 2018), such as repo and government securities, and have reduced bank-affiliated dealers' propensity to hold inventories of investment-grade corporate bonds relative to high-yield bonds (Rapp and Waibel 2023). Thus, we expect the leverage ratio to change mutual funds' trading behavior and performance in investment-grade bonds but not in high-yield bonds.

Moreover, although leverage ratio requirements vary across jurisdictions due to preexisting regulatory frameworks, the incremental regulatory burden at quarter ends, compared to prior regulations, has intensified for all impacted financial institutions. Historically, U.S. banks operated under non-risk-weighted capital requirements, which appeared to exert limited influence before Basel III (Du et al. 2018). The regulatory landscape shifted for systemically important financial institutions with the inception of the supplementary leverage ratio, which rendered the leverage ratio constraint more stringent. Although the leverage ratio of U.S. systemically important financial institutions is calculated as the average over the quarter, the average metrics are reported at the end of each quarter. Conversely, for international banks, non-risk-weighted capital requirements were introduced after the global financial crisis and are calculated based on the leverage ratio as of the end of each quarter. This implementation of the regulation changed in 2017 for U.K. banks, for which the leverage ratio began to be averaged over the quarter, as it was for U.S. banks.

Importantly, following the introduction of the leverage ratio constraint, irrespective of whether regulators consider the average over the quarter or just the quarter-end value, all bank-affiliated dealers subject to the Basel III regulations appear to contract their investment-grade bond inventories at quarter ends (Rapp and Waibel 2023). The fact that the leverage constraint becomes binding at quarter ends even for institutions reporting the quarterly average metrics is intuitive because bank-affiliated dealers are unable to expand their balance sheets and accumulate inventories at the end of the quarter, unless they have saved their balance-sheet space during the quarter.[2] The leverage ratio constraint thus appears to be binding for all bank-affiliated dealers at quarter ends. Because the dealers subject to the leverage ratio regulation constitute a significant part of the market, changes in their intermediation behavior can significantly affect bond market conditions.

As we explain below, in our empirical analysis, we exploit the fact that the regulation becomes more stringent at quarter ends to identify the effects of the leverage ratio constraint on mutual funds' strategies and performance. Specifically, our identification relies on the within-quarter timing of mutual funds' trades and portfolio performance, combined with the cross-sectional variation in the extent to which recent bond market makers are affected by the leverage ratio constraint. Besides using within-quarter variation, in supplementary

[2] This view is consistent with Correa et al. (2022)'s findings on the repo market. First, dealers affiliated with regulated U.S. banks engage in reserve-draining intermediation at quarter ends to extend lending without expanding their balance sheets. Second, there are quarter-end spikes in the repo interest rate, indicating that binding constraints prevent US-regulated dealers from taking advantage of investment opportunities.

tests, we also consider that bank-affiliated dealers have different capitalization levels, and their leverage ratio constraints may be more or less binding. Finally, we expect any effects of the leverage ratio to emerge only for investment-grade bonds, not high-yield bonds.

While several overlapping regulations were introduced after the global financial crisis, other banking regulations do not produce the same within-quarter variation and are unlikely to affect investment-grade bonds more than high-yield bonds. For instance, risk-weighted capital requirements were already in place before 2015, and more importantly, are expected to disproportionately affect inventories of riskier, high-yield bonds, rather than investment-grade bonds. The additional capital requirements for globally systemically important banks (G-SIBs), known as G-SIB surcharges, the Volcker Rule, and the liquidity directives partly overlap with the introduction of the leverage ratio. However, the G-SIB surcharges, which also increase the cost of balance sheet space for institutions whose holding companies have been identified as G-SIB, are binding only at year ends. As we will show, our results are invariant to the exclusion of the last quarter of the year and become even stronger at year-end, when the G-SIB surcharges further increase the cost of balance sheet space. The Volcker Rule restricts banking entities from engaging in proprietary trading, which impacts dealers' cost of intermediation because higher values of bond inventories may indicate proprietary trading activities. However, the Volcker Rule does not become more binding at quarter ends, and there is no reason to believe it should have a stronger impact on investment-grade bonds. Finally, the liquidity coverage ratio (LCR) aims to ensure that a bank has enough liquid assets, and the net stable funding ratio (NSFR) ensures that banks have reliable funding sources in a stressed environment. Thus, the NSFR addresses the liability side of the balance sheet and should be irrelevant for market making. The LCR addresses the asset side of the balance sheet and impacts intraday liquidity. However, unlike the leverage ratio, the LCR is enhanced by holdings of liquid investment-grade bonds and should, therefore, incentivize banks to retain more liquid investment-grade bonds over high-yield bonds.

3 Data and Main Variables

We obtain data on bond mutual fund holdings from Morningstar, data on mutual fund characteristics from Morningstar Direct and the CRSP Mutual Funds database, data on bond characteristics from Mergent's Fixed Income Securities Database (FISD), and data on corporate bond transactions with dealers' identities from the regulatory version of FINRA's Trade Reporting and Compliance Engine (TRACE) database.[3] Our primary sample spans from 1/2010 to 12/2019, but we complement these analyses with an investigation of the period surrounding the onset of the COVID-19 pandemic. Detailed variable definitions can be found in the Appendix.

3.1 The Mutual Fund Sample

We focus on open-end mutual funds classified by Morningstar as taxable bond funds. There are a total of 2,310 unique funds, but given our focus on the corporate bond market, our main analysis includes only 1,167 funds, for which corporate bonds are at least 20% of the portfolio holdings (of these, 61% invest mostly in investment-grade bonds while 39% invest mostly in high-yield bonds). Using Morningstar along with Morningstar Direct and CRSP, we construct a survivorship-bias-free dataset that includes information on various fund characteristics, such as TNA, returns, flows, and fund-level bond holdings. The frequency of TNA, returns, and flows is monthly, and so are our estimated alphas. While the SEC requires mutual funds to report holdings on a quarterly basis, funds tend to voluntarily report their holdings more frequently. Approximately 83% of our sample's fund reporting-period observations are monthly, while the remaining are quarterly. We condition on the available frequency in measuring trading styles, while our tests on mutual funds' trading rely only on funds that report monthly.

3.2 Classifying Funds' Strategies

Funds' trading styles, including the decision to supply or demand liquidity, reflect long-term strategic decisions, which involve the choice of investment objectives as well as legal restrictions, funding conditions, and investor clientele (Cella et al. 2013).

Theoretically, a fund can be considered liquidity-supplying if it buys bonds in which dealers' cumulative inventories are larger than desired. Similarly, a liquidity-supplying fund would sell when the aggregate dealer sector's inventories fall below the desired level. To

[3] TRACE does not include identifiers for customers and therefore does not allow to identify mutual funds' trades.

implement this intuition empirically, we follow Anand et al. (2021). Specifically, using transaction data from the regulatory version of TRACE, we compute, on each trading day, the inventory change in a given bond for an individual dealer and then aggregate the inventory changes across all dealers to obtain a measure of the change in the dealer sector's inventory in the bond.[4]

The aggregate inventory of the dealer sector may be considered above (below) the desired level if the change in inventory in a given bond is positive (negative) when cumulated over several trading days. We assume that the cycle starts when the cumulative inventory crosses zero and ends when it crosses zero again from the opposite direction. Like Anand et al. (2021), we restrict our attention to significant trading cycles by imposing a minimum peak inventory of $10 million and a minimum inventory cycle length of 5 calendar days. In addition, to minimize errors, when the cumulative inventory in a given bond does not cross zero for a period longer than 3 months (63 trading days), we drop older inventories and instead define the dealer sector's aggregate inventories in the bond over a rolling window of three months. Our inventory cycles last about 62 days on average, with 59% being positive and 41% being negative. The average peak inventory is $29 million.

These inventory cycles are likely to capture customers' buying and selling imbalances. By considering the trading behavior of mutual funds over the cycles, we can gauge their trading strategies. A fund supplies liquidity by purchasing bonds that are experiencing a positive inventory cycle and selling bonds in a negative inventory cycle. Similarly, a fund demands liquidity if it sells bonds experiencing a positive inventory cycle and buys bonds in a negative inventory cycle. To the extent that not all bonds are in a cycle, each fund will also have unclassified trades.

The fund's trading style is summarized by the fund's liquidity score, *LS score*, which is computed for fund i and period t as:

$$LS\,score = \frac{Liquidity\,supplied\,(\$) - Liquidity\,demanded\,(\$)}{Liquidity\,supplied\,(\$) + Liquidity\,demanded\,(\$) + Unclassified\,(\$)}. \tag{1}$$

We infer the transactions of a bond mutual fund by comparing the fund's holdings in a bond over consecutive reporting periods. Because in our sample, 83% of the funds' positions are reported monthly and the remaining quarterly, the period can be either a month or a

[4]We consider only principal trades (not agency trades) to compute dealer inventory changes.

quarter.

Since fund strategies should not vary significantly over time, yet we also want to capture the effects of regulations on funds' strategies, we define funds' strategies over a rolling 24-month window. In most of the empirical analysis, we classify funds with a positive rolling average *LS score* during the previous 24 months as liquidity-supplying (LS) and all remaining funds as liquidity-demanding (non-LS).[5] With this classification, about a quarter of the sample funds are characterized as LS, with a small increase from 24% in 2010 to 27% in 2019.

3.3 Mutual Funds' Characteristics

Table 1, Panel A reports descriptive statistics for various fund attributes, with the first five columns highlighting the full sample (58,040 fund-reporting period observations) and the last two columns comparing the means for LS and non-LS funds. The distribution of fund TNA is positively skewed, with a mean of about \$2.52 billion and a median of only \$0.54 billion. Consistent with the growth in bond mutual funds documented by Goldstein et al. (2017), our sample funds experience significant inflows. The average monthly fund flow is 0.7% of TNA, with the 10th and 90th percentiles at -3.1% and 5.1%, respectively, indicating significant variation across funds and over time.

During our sample period, LS funds appear to be significantly larger than other funds and experience 0.71% higher net flows and 2 basis points higher alpha, suggesting that they might have benefited from the change in the regulatory environment.[6]

The average fund in our sample holds 8% in cash and cash equivalents, with LS funds holding significantly more cash (9% of their portfolio) than other funds. However, other characteristics of LS funds' portfolios regarding bond issue size, rating, age, or duration are similar to those of other funds. Also, on average, both LS and non-LS funds invest about 55% of their portfolios in corporate bonds, 15% in government bonds, and 22% in other

[5] Our results do not depend on the particular cutoff we use to define LS funds. Tables A6, A7, and A8 show that our results are invariant if we use the definition of Anand et al. (2021) based on the top 20% of the LS score. Our definition is preferable in our context because it allows mutual funds' strategies to vary in response to the regulation.

[6] The LS funds in our sample have somewhat different characteristics from those in Anand et al. (2021) because we focus on the period around the introduction of the leverage-ratio regulation. We thus start our sample in 2010 (not in 2003). Furthermore, we define funds with a positive past *LS score* (rather than the top-20%) as LS funds.

securities.

Bond mutual funds have relatively high turnover. In our sample, the turnover in corporate bonds within a fund's portfolio is 16.32% per month, equivalent to almost 200% over a year for funds that report their positions monthly. The summary statistics of the fund-position level variables in Table 1, Panel B show that each bond's trade accounts for just about 0.33 basis points of a fund's TNA, on average. However, LS funds' trades are more concentrated, with an average transaction equal to 0.41 basis points relative to the fund's TNA.

3.4 Bonds and Dealers

As is common in the literature (see, for example, Bessembinder et al. (2018)), we consider only bonds in the FISD database that are classified as non-puttable U.S. corporate debentures and U.S. corporate bank notes (bond types CDEB or USBN) with a reported maturity date. We clean bond transactions in the regulatory version of TRACE for same-day corrections, cancellations, and reversals as described by Dick-Nielsen and Rossi (2019), and further exclude i) bonds with less than five trades over the sample period; ii) bonds with a reported trade size that exceeds the bond's issue size; iii) transactions reported after the bond's amount outstanding is recorded by FISD as zero; and iv) primary market transactions. Our sample includes a total of 20,436 distinct bond issues (CUSIPs).

We aim to test whether LS funds strategically supply liquidity in bonds that are relatively more affected by the leverage ratio regulation. Such a test requires that we quantify the exposure of each bond to the regulation. Therefore, similar to Adrian et al. (2017), we construct a measure of past intermediation activity in a bond by bank-affiliated dealers that are subject to the leverage ratio constraint. We use the regulatory version of TRACE, which includes unmasked dealer identities. In line with the literature, we define European and Japanese bank-affiliated dealers and U.S. bank-affiliated dealers subject to the supplementary leverage ratio requirements as constrained (Correa et al. 2022). We then define the degree to which bond j is constrained in month m as the share of positive inventory holdings that constrained dealers built up in bond j during the first twenty days of the month relative to bond j's issue size:

$$\text{Constr. Dealers' Inventory Holdings}_{j,m} = \frac{\sum_{d=1}^{N} \max\left\{\sum_{t_m=1}^{20} Inventory_{d,j,t_m}, 0\right\} \cdot \mathbb{1}_{d \in C}}{Offering\,Amount_j}, \quad (2)$$

where d indexes dealers active in bond j during month m. C denotes the subset of dealers that are defined as constrained, t_m indexes the calendar day in a given month, and $Inventory_{d,j,t_m}$ is the incremental inventory that dealer d takes on in bond j during day t_m.[7] Positive $Inventory_{d,j,t_m}$ reflects a dealer' net purchases of bond j on a given day, while negative $Inventory_{d,j,t_m}$ reflects the dealer's net sales of the bond. We only aggregate dealers' cumulative inventory changes that are positive, as bank-affiliated dealers' purchases and not their sales generate balance sheet pressure under the leverage ratio rules.[8] A limitation of this approach is that we disregard dealers' short positions, which are, however, negligible in the corporate bond market, especially after the global financial crisis (Hendershott et al. 2020).

Using data over the entire sample period and ignoring bonds that have not been traded in the first 20 days of a month and have zero cumulative inventory changes, we sort bonds into quintiles based on their cumulative inventory changes of constrained dealers relative to the bond's issue size (Constr. Dealers' Inventory Holdings$_{j,m}$ in Equation 2). Then, we define bonds in the top quintile as constrained bonds; the indicator variable constrained bond is set to zero for all the other bond observations in the sample (including the bonds with zero inventory changes).[9]

Our proxy captures that bank-affiliated dealers are the primary handlers of a security and that market participants are selling. In principle, constrained dealers can sell any securities on their balance sheets to meet the leverage ratio requirements, and we do not aim to capture the tendency of regulated dealers to shrink their balance sheets. Rather, the need for liquidity provision arises when the rest of the market is selling a security that is typically intermediated by bank-affiliated dealers that are now unable to further expand their balance

[7]Due the to lack of information on the stock of bond holdings in a dealer's inventory, we focus on daily inventory changes and cumulate them over a number of trading days to infer the inventory level (Bessembinder et al. 2018).

[8]We verify that our trading results are similar if we also include the negative inventory changes.

[9]While the dichotomic variable is easy to interpret, we show that our results are invariant to alternative definitions of bond constraints, which exploit the continuous Constr. Dealers' Inventory Holdings$_{j,m}$ and take into account dealers' distance from the regulatory minimum capital.

sheets and accumulate more inventories. Market making in a particular bond tends to be provided by the same dealers over time (Breckenfelder and Ivashina 2021), and, therefore, unregulated dealers are unlikely to easily step in and intermediate the bonds that we define as constrained. As a result, when regulated dealers have recently accumulated large inventories in a bond and face binding regulatory constraints, the liquidity provision of mutual funds may become critical for that bond.

Table 1, Panel C summarizes the characteristics of the bonds in our sample. The first five columns highlight the whole sample (908,354 bond-month observations). On average, the bond maturity is ten years, the issue size is $687 million, and the bond's age is 5.4 years. Approximately 71% of the bond-month observations are for investment-grade bonds, and the average credit rating is about BBB-. Together, all taxable mutual funds own about 10% of our sample's average bond issue.

The last two columns of Table 1, Panel C distinguish between constrained and unconstrained bonds. Throughout our sample period, constrained dealers' shares of inventory holdings relative to the bond issue size are around 2.21% for constrained bonds but just 0.28% for unconstrained bonds. While dealers' inventory holdings may depend on exogenous shocks to the demand for different bonds, they are also an endogenous choice of the dealers, who could otherwise arrange customer trades. For this reason, it is important to compare the characteristics of constrained and unconstrained bonds, which tend to be similar, with a few exceptions. Constrained bonds are larger in issue size, younger, and have slightly worse credit ratings. In addition, constrained bonds are slightly more liquid than unconstrained bonds, as measured by most of the several proxies for liquidity we use. Overall, this evidence suggests that dealers are willing to hold larger inventories of bonds that are easier to sell. This should make it harder to find any positive effects of liquidity provision on funds' performance. Nevertheless, to alleviate concerns that dealers choose in which bonds they hold high inventories at quarter ends in a way that may affect the interpretation of our findings, we show that our main results are robust when we match constrained bonds to similar but unconstrained counterparts.

Specifically, we estimate the propensity of a bond to be defined as constrained as a function of its age, maturity, illiquidity, issue size, and rating. Table A1 in the Internet Appendix shows how these bond characteristics are related to the probability that a bond is constrained. Then, for each constrained bond in each month, we select (with replacement) an unconstrained bond with the smallest absolute distance in terms of the estimated propensity score. We exclude from the pool of unconstrained bonds any securities in the fourth quintile of $Constr.\,Dealers'\,Inventory\,Holdings$ because they may be almost as constrained as our constrained bonds. Table A2 provides the covariate balance, showing that the characteristics of constrained and unconstrained bonds are not statistically different in this matched sample.

4 Leverage Constraints and Funds' Trading

4.1 Main Results

We begin by examining the impact of the leverage ratio regulations on mutual funds' trading behavior, focusing on distinct subsets of mutual funds and corporate bonds. Specifically, we concentrate on mutual funds specializing in liquidity provision, as they are most apt to take advantage of the constraints on bank-affiliated dealers arising from the leverage ratio regulation. In addition, we focus on investment-grade bonds because inventories of high-yield bonds were already subject to Basel II risk-weighted capital regulations, which are more stringent. Consequently, we study how LS funds' trading in investment-grade bonds changed following the introduction of the leverage ratio requirements.

Since the effects of the leverage ratio requirements should be particularly strong for regulated dealers at quarter ends—that is, close to reporting dates when the constraints are verified—we test whether the trading of LS funds changes in the last month of each quarter following the introduction of the leverage ratio requirements. We estimate the following fund-bond-month level regression:

$$
\begin{aligned}
Fund\,Position\,Change_{i,j,t} = {} & \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[QE] \times \mathbb{1}[LR\ Period] \\
& + \theta_{\mathbf{1}}'\,\mathbf{M_{j,t}} + \theta_{\mathbf{2}}'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t},
\end{aligned}
$$

where the dependent variable is

$$
Fund\,Position\,Change_{i,j,t} = \frac{Par\,Change_{i,j,t} \times p_{j,t-1}}{TNA_{i,t-1}} \times 10,000,
$$

and $Par\,Change_{i,j,t}$ refers to the change in par amount of bond j by fund i in period t, and $p_{j,t-1}$ is the price of bond j at the end of period $t-1$. $TNA_{i,t-1}$ refers to fund i's total net assets at the end of period $t-1$. $\mathbb{1}[LR\ Period]$ is an indicator variable that equals one during the leverage ratio period, that is, from 2015 onwards, and $\mathbb{1}[QE]$ is an indicator variable capturing the last month of each quarter. We control for bond and fund characteristics, $\mathbf{M_{j,t}}$ and $\mathbf{M_{i,t}}$, respectively, and also include the interactions of bond and year fixed effects, $\eta_j \times \lambda_y$, to account for the fact that bond and fund level shocks could drive different trading behavior. We test whether fund i disproportionately increases its position in bond j during month t if month t is the last month of the quarter and whether this behavior emerges during the leverage ratio period.

Table 2 shows that LS funds purchase more investment-grade bonds at quarter ends following the implementation of the leverage ratio (column 1), whereas this pattern is not observed before the introduction of the regulation (column 2). In columns 3 and 4, we show that the difference between the coefficients in the first two columns is not only statistically significant but also economically meaningful and particularly large when we do not allow the coefficients on the control variables to differ between the leverage-ratio and the pre-leverage-ratio periods. Specifically in column 3, the 0.15 increase in quarter-end purchases amounts to almost 58% of the average position change in an investment-grade bond made by an LS fund (that is, 0.15 divided by 0.26). Figure 1 illustrates the year-by-year dynamics of the effect documented in Table 2. The figure reveals that LS funds' propensity to purchase investment-grade bonds at quarter ends becomes apparent only after the introduction of the leverage ratio constraint. It also supports our assumption that the regulation became binding in 2015, with the public disclosure of the leverage ratio.

Importantly, these findings indicate that window-dressing behavior at reporting dates to conceal holdings of losing stocks and overstate holdings of winning stocks (Lakonishok et al. 1991; He et al. 2004; Agarwal et al. 2014) cannot explain the patterns we document for bond mutual funds' quarter-end trading because the effects emerge after the adoption of Basel III, while incentives to window-dress should be unchanged over the sample period. [10]

Table 3 examines whether alternative factors could have similarly affected mutual funds' trading patterns. If all funds, regardless of their liquidity strategies, had begun to increase their purchases of investment-grade bonds at quarter ends following the implementation of

[10] In addition, as we show below, there is no reason to believe that incentives to window-dress should exist for investment-grade bonds but not high-yield bonds.

leverage ratio constraint, this could suggest that the finding in Table 2 is not directly linked to the introduction of the leverage ratio because non-LS funds are unlikely to engage in liquidity provision. Thus, in columns 1 to 3, we consider non-LS funds as a placebo group and test whether they also began to purchase more investment-grade bonds at quarter ends once the leverage ratio regulations were introduced.[11] For non-LS funds, we observe neither quarter-end effects nor changes in trading behavior following the introduction of the leverage ratio regulations. This finding indicates that the strategies of liquidity-demanding funds have not been affected by the leverage ratio and supports our claim that the increase in quarter-end purchases of investment-grade bonds by LS funds is associated with their liquidity provision in months when bank-affiliated dealers encounter higher regulatory costs in expanding their balance sheets.

Columns 4 to 6 of Table 3 examine LS funds' trading in high-yield bonds as a second placebo test. Bank-affiliated dealers' high-yield bond inventories have been subject to Basel II risk-weighted capital ratio regulations throughout the entire sample period. Thus, we anticipate no shifts in LS funds' propensity to provide liquidity in high-yield bonds. We find that LS funds consistently increase their purchases of high-yield bonds in quarter-end months throughout the entire sample period and do not observe any statistically significant changes in their behavior following the introduction of the leverage ratio regulations. This evidence is consistent with Basel II risk-weighted capital ratios becoming more binding at quarter ends, thus providing trading opportunities for LS funds throughout the whole sample period. Furthermore, the fact that LS funds do not provide more liquidity in high-yield bonds after 2015 indicates that the quarter-end effects we estimate do not capture the effects of the Volcker Rule. By prohibiting proprietary trading for banks, the Volcker Rule should have created trading opportunities in high-yield bonds that have longer holding periods for dealers and hence are more likely to alert regulators of potential violations.

To sharpen our analysis, we consider that mutual funds' liquidity provision at quarter ends should be particularly necessary for investment-grade bonds handled by dealers affected by the regulation when the market is selling. We do so using our proxy for constrained bonds. Since regulated dealers have accumulated inventories during the first 20 days of the month, market participants must have been selling these bonds. At the same time,

[11] Figure A1 in the Internet Appendix shows the year-by-year dynamics of this effect.

the large inventories accumulated by regulated dealers suggest that they are the natural market makers of these securities and that unregulated dealers are unlikely to handle these bonds and provide liquidity. Therefore, at quarter ends when the leverage ratio is binding, constrained bonds are the most likely to lack natural liquidity providers.

We test whether LS funds purchase relatively more of the constrained investment-grade bonds, as captured by the dummy $\mathbb{1}[Constr.\ Bond]$. To do so, we augment our fund-bond-month level regression with a triple-interaction term, as follows:

$$
\begin{aligned}
Fund\,Position\,Change_{i,j,t} = \ & \beta_0 + \beta_1\,\mathbb{1}[Constr.\,Bond_{j,t}] + \beta_2\,\mathbb{1}[LS\,Fund_{i,t}] + \beta_3\,\mathbb{1}[QE] \\
& + \beta_4\,\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_5\,\mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr.\,Bond_{j,t}] \\
& + \beta_6\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] + \beta_7\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr.\,Bond_{j,t}] \\
& + \theta_1'\,\mathbf{M_{j,t}} + \theta_2'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t},
\end{aligned}
$$

where $\mathbb{1}[LS\ Fund]$ is an indicator that is one if the fund has a liquidity-supplying trading style. We focus on the post-leverage-ratio period and test whether LS funds indeed provide more liquidity in quarter-end months. We also use non-LS funds, which appear not to have changed their behavior after the introduction of the regulations in Table 3, as a control group to address the concern that *constrained* investment-grade bonds may differ along unobserved dimensions.

Table 4 reports the estimates. During quarter-end months, LS funds indeed appear to purchase larger volumes of constrained investment-grade bonds (column 1)—that is, the bonds handled by bank-affiliated dealers that have been recently sold by the market. The estimates in column 2 show that liquidity-demanding funds do not purchase constrained investment-grade bonds at quarter ends. In column 3, the difference between LS and non-LS funds is both statistically and economically significant, as LS funds' increased purchases of constrained bonds at quarter ends are equivalent to around 40% of the average change in a fund's position size (that is, 0.085 divided by 0.23).

Importantly, the dynamics of the effects are fully consistent with our interpretation of the empirical evidence, thereby assuaging the concern that constrained bonds may differ along unobserved dimensions and that these differences may affect the propensity of LS funds to purchase the bonds. Figure A2 in the Internet Appendix shows that LS funds start purchasing more constrained bonds only after the introduction of the leverage ratio (Panel

C) and that there are no changes in their trading of unconstrained bonds during the sample period (Panel A). Non-LS funds' trading behavior is unchanged in both constrained and unconstrained bonds.

In column 4 of Table 4, we also consider that the leverage ratio constraint is more binding for bank-affiliated dealers with scarce capital. These dealers should be even more reluctant to accumulate inventories than other regulated dealers at the end of the quarter. The bonds handled by these more constrained dealers should, in turn, need more liquidity provision when the rest of the market is selling. To account for this, we retrieve banks' reported leverage ratio data from S&P Global SNL Financials,[12] and construct new proxies for constrained bonds, distinguishing whether bank-affiliated dealers closer to or further from the leverage ratio constraint have accumulated inventories in a given bond. Specifically, $\mathbf{1}[Constr.\,Bond\,|\,\Delta\,LR\,Min. \leq 50\%]$ is a dummy that equals one if the cumulative inventories of bank-affiliated dealers with below-median distance from the regulatory minimum capital in a bond, relative to the bond's issue size, are in the top quintile; $\mathbf{1}[Constr.\,Bond\,|\,\Delta\,LR\,Min. > 50\%]$ is defined analogously, considering the inventories of bank-affiliated dealers whose distance from the regulatory minimum capital is above the median. Consistent with our hypothesis that LS funds purchase bonds that require liquidity provision at quarter ends, we find that the effect is entirely driven by the purchases of bonds in which dealers closer to the regulatory minimum capital have accumulated larger inventories. Importantly, the coefficient on $\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,|\,\Delta\,LR\,Min. \leq 50\%] \times \mathbf{1}[LS-Fund]$ in column 4 is around 35% higher than the one on $\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS-Fund]]$ in column 3, where we do not consider regulated dealers' distance from the regulatory minimum capital.

4.2 Robustness

The above findings are robust to several robustness checks. First, in Table A3 of the Internet Appendix, we substitute the constrained bond dummies that facilitate the interpretation of the results for their continuous counterparts and show that our findings are unchanged.

[12] S&P Global SNL Financials includes information on U.S. banks' supplementary leverage ratio from the FRY-9C filings. We hand-collect information from publicly available balance sheets for bank-affiliated intermediaries not covered in S&P Global SNL Financials.

Second, we assess the impact of differences in the implementation of the leverage ratio regulations across jurisdictions on our findings. In Table A4 of the Internet Appendix, we consider separately dealers affiliated with banks that report leverage ratios at quarter ends and those affiliated with banks that report leverage ratios as quarterly averages when defining the constrained investment-grade bond dummy. Our results are invariant and similar for the two definitions of constrained bonds, supporting our empirical choice not to distinguish between the two categories of bank-affiliated dealers.

Third, to further address the lingering concern that bonds in which bank-affiliated dealers accumulated inventories before quarter ends differ from other bonds in dimensions that may drive our findings, we implement a matching methodology that pairs constrained bonds with comparable unconstrained bonds based on a set of observables. Then, we re-estimate the regressions in Table 4 using our matched bond sample. The results in Table A5 of the Internet Appendix are qualitatively and quantitatively unchanged.

4.3 Effects of Other Regulations on Fund Trading

So far, we have attributed LS funds' propensity to purchase more investment-grade bonds at quarter ends to the leverage ratio constraint, which reduces bank-affiliated dealers' willingness to intermediate investment-grade bonds. However, other regulations introduced after the global financial crisis may have had similar effects. This section explores how different regulations interact with the leverage ratio.

We begin by considering the G-SIB surcharges, which were also introduced during our sample period. Because G-SIB surcharges are calculated based on year-end balance sheet values (Behn et al. 2022), it is unclear whether we are capturing an increase in the propensity of LS funds to provide liquidity at the end of the year due to the G-SIB surcharges or at the end of each quarter due to the leverage ratio requirements. In the former case, the economic mechanism would be similar, because a temporary withdrawal of bank-affiliated dealers from liquidity provision due to higher regulatory costs would drive LS funds' behavior. However, we should not attribute the observed effect solely to the leverage ratio. To address this concern, we re-estimate the regressions in Tables 2 and 4 separately for quarters 1 to 3 and quarter 4. Tables A9 and A10 in the Internet Appendix show that our results are unchanged when we consider LS funds' trading in investment-grade bonds only during the first three quarters of a year. Interestingly, the estimated effects are particularly large in the fourth quarter, suggesting that bank-affiliated dealers' propensity to withdraw from liquidity provision is stronger at year ends, when the additional costs of G-SIB capital surcharges magnify the effects of the leverage ratio regulations.[13]

We also account for the fact that bank-affiliated dealers were required to be fully compliant with the Volcker Rule by July 2015. The Volcker Rule prohibits banking entities from engaging in proprietary trading. To ensure compliance, bank-affiliated dealers must report, during the first ten days of each month, several metrics whose values may be indicative of proprietary trading (Bao et al. 2018).

Although the findings of our tests, which aim to capture quarter-end effects, cannot be attributed to the regulatory reporting cycle of the Volcker Rule, we nonetheless evaluate whether the Volcker Rule might interact with the leverage ratio and influence mutual funds' trading. We examine whether the Volcker Rule may constrain a dealer's propensity to provide liquidity using three relevant metrics: (1) Inventory turnover, defined as the absolute value of the ratio of total trading volume divided by cumulative net purchases of a given dealer in a given month;[14] (2) the customer-dealer trade share, defined as customer-dealer trading volume divided by total trading volume; and, (3) the agency trade share, defined as agency trading volume divided by total trading volume.[15] A low value of any of these metrics may be considered indicative of proprietary trading.

Each month, we rank dealers according to these metrics. Specifically, we consider a dealer's liquidity provision more likely to be negatively affected by the Volcker Rule if the dealer ranks below the median based on the average of its ranks across the three metrics. At the bond level, liquidity provision is likely to be constrained by the Volcker Rule if dealers with below-median ranking on these metrics have accumulated relatively larger inventories.

In Table A11 in the Internet Appendix, we show that LS funds do not appear to provide more liquidity by purchasing bonds that are constrained by the Volcker Rule during the quarter or at quarter ends. One possible explanation is that LS funds have weaker incentives

[13]This evidence that LS funds' propensity to provide liquidity is stronger in the last month of each quarter indicates that seasonality in mutual fund trading is unlikely to drive our findings (Kamstra et al. 2017).

[14]Our proxy for dealer inventories based on monthly cumulative net purchases follows Bessembinder et al. (2018).

[15]We define agency trades using the agency–principal flag in TRACE and, following Bao et al. (2018), recode a principal trade as an agency trade if it is offset within one minute by another trade of the same size and opposite direction by the same dealer.

to provide liquidity when asymmetric information is high, as may be the case when dealer behavior appears driven by proprietary trading. More importantly, controlling for a bond's exposure to the Volcker Rule does not alter our main finding: LS funds continue to purchase bonds primarily intermediated by institutions that are subject to the leverage ratio constraint at quarter ends.

5 Leverage Constraints and Funds' Performance

5.1 Performance of Quarter-end Trades

Because the changes in LS funds' trading patterns appear economically relevant, we explore whether their quarter-end trades in constrained bonds are particularly profitable. We follow Kacperczyk et al. (2014) and consider as a proxy for a trade return the change in a fund's position in a bond from periods $t-1$ to t (scaled by the fund's TNA at $t-1$) multiplied by the bond's abnormal return in the next period (from t to $t+1$). We consider two different estimates of a bond's abnormal returns. The first follows Dickerson et al. (2023) and is based on a bond market model, in which we use the credit-rating-matched bond index return as the return of the relevant market portfolio. This allows for segmentation by credit rating within the corporate bond market. The second relies on the duration-adjusted bond market CAPM, a two-factor model proposed by van Binsbergen et al. (2025). The model considers as separate factors the duration-matched Treasury return and the duration-adjusted return components of the corporate bond market return.[16] In both cases, we estimate factor exposures over a 36-month rolling window.

Naturally, our proxy for trading returns is higher if a fund purchases relatively more of a security that yields high returns over the following month. If liquidity provision benefits a fund's performance, we expect end-of-quarter purchases to have become particularly profitable during the leverage ratio period. This is precisely what we find in Table 5. In column 1, LS funds' purchases of investment-grade bonds during quarter-end months appear to outperform similar purchases during other months by 0.02 basis points. This is equivalent to about 20% of the standard deviation of the dependent variable. The economic magnitude is even larger in column 3, where we compare the profitability of the trade before and after

[16] We obtain the factors from van Binsbergen et al. (2025)'s replication package.

the implementation of the leverage ratio. On average, LS funds' trades in investment-grade bonds appear to outperform similar trades by about 0.07 basis points more after than before the introduction of the leverage ratio. This represents an increase of around 80% relative to the standard deviation of the dependent variable.

While columns 1 to 3 test for differences in performance of all quarter-end purchases relative to other purchases, column 4 considers the quarter-end purchases in constrained bonds. On average, after the introduction of the leverage ratio, the outperformance of LS funds' quarter-end purchases of constrained investment-grade bonds is 0.05 basis points larger than the outperformance of other quarter-end purchases during the same period. This finding further supports the conjecture that LS funds benefit from the constraints on bank-affiliated dealers.

Table A12 in the Internet Appendix presents the average next-month portfolio abnormal returns of all investment-grade bonds purchased by LS funds during quarter-end versus non-quarter-end months, distinguishing between pre- and post-leverage ratio periods and constrained and unconstrained bonds. The table presents the average abnormal returns, estimated using the one-factor bond market model for different subsamples, and shows that LS funds' purchases of constrained investment-grade bonds during the last month of a quarter outperform their other purchases after the introduction of the leverage ratio. This effect is economically meaningful, as the outperformance of the constrained bond purchases' portfolio over that of the other purchases' portfolio is 0.26% per month (or 3.12% on an annualized basis) higher at quarter ends than non-quarter ends. Moreover, we find no statistically significant outperformance for quarter-end purchases of constrained investment-grade bonds before the introduction of the leverage ratio constraint.

5.2 Funds' Alpha

Overall, LS funds appear to take advantage of bank-affiliated dealers' leverage ratio requirements and provide liquidity when the constraints become particularly tight. In this section, we examine how this behavior impacts the overall performance of LS funds.

We measure performance using a fund's monthly alpha, estimated with the factor model of Chen and Qin (2017). Specifically, we estimate the model parameters over a rolling window of 24 months before month t and calculate the benchmark return using the estimated parameters and the factor values in month t. We test whether the alpha of LS funds changes relative to other funds after the introduction of the leverage ratio constraint, controlling for funds' strategic focus with interactions of fund category and time fixed effects and fund time-varying characteristics (including lagged flows, lagged alpha, broker affiliation dummy, age, size, family size, average maximum rear load, % cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, average bond issue size, and average bond age).

Since in Table 3 non-LS funds appear not to have changed their trading behavior after the introduction of the leverage ratio regulation, we use non-LS funds as a control sample and estimate the following difference-in-differences regression at the fund-month level:

$$\begin{aligned} Fund\,Alpha_{i,t} = {} & \beta_0 + \beta_1\,\mathbb{1}[LS\ Fund_{i,t}] + \beta_2\,\mathbb{1}[LR\,Period] \times \mathbb{1}[LS\ Fund_{i,t}] \\ & + \theta'\,\mathbf{M_{i,t}} + \eta_c \times \lambda_t + \varepsilon_{i,t}. \end{aligned}$$

The dependent variable, $Fund\,Alpha_{i,t}$, refers to the monthly fund alpha. The remaining variables are defined as in the earlier tests. Specifically, $\mathbb{1}[LR\,Period]$ is an indicator variable that equals one during the leverage ratio period. $\mathbb{1}[LS\ Fund]$ equals one for LS funds. $\mathbf{M_{i,t}}$ refers to a vector of time-varying fund controls, η_c denotes fund-category fixed effects, and λ_t denotes month fixed effects (which absorb the direct effect of $\mathbb{1}[LR\,Period]$). Our coefficient of interest is β_2, which measures the change in performance from before to after the introduction of the leverage ratio constraint for LS funds relative to non-LS funds.

Table 6 reports the results. In column 1, we consider funds that focus on investment-grade bonds. Consistent with our earlier results, we find that LS funds outperform non-LS funds during the leverage ratio period. Following the introduction of the leverage ratio constraint, the outperformance of investment-grade LS funds, relative to non-LS funds, appears statistically and economically significant at approximately 2.2 basis points per month or 0.26% per annum.

Figure 2 provides dynamic estimates of the relative performance of LS funds that focus on investment-grade bonds. Not only does it confirm that their alpha becomes statistically different from zero after the introduction of the leverage ratio constraint, but also that the effect emerges in all years after 2015.

Column 2 of Table 6 considers a placebo based on funds focusing on high-yield bonds.

Interestingly, high-yield-focused LS funds exhibit an alpha over the entire sample period, possibly due to the opportunities created by the risk-weighted capital regulations. More importantly and consistent with our prior, we find no evidence that high-yield-focused LS funds' performance, relative to that of other high-yield-focused funds, changes in the leverage ratio period. These findings suggest that constraints on the leverage ratio of bank-affiliated dealers make liquidity provision in investment-grade bonds by mutual funds more profitable and consequently enhance their performance. The introduction of the leverage ratio disproportionately increased the cost of holding inventories in the safe investment-grade bonds because the capital that bank-affiliated dealers have to set aside depends on the size of the bank's balance sheet but not on the risk of the bank's assets. It is, therefore, unsurprising that only the performance of investment-grade-focused LS funds benefits from the leverage ratio regulations.[17]

To provide additional evidence that the newly introduced regulations affect mutual funds' performance, we consider the months of a quarter during which LS funds obtain a higher alpha. The leverage constraint regulation is expected to create more significant distortions at the end of each quarter when European and Japanese bank-affiliated dealers and U.S. dealers subject to the supplementary leverage ratio requirements must satisfy their leverage ratio constraints. If the outperformance of LS funds indeed derives from the fact that the profitability of supplying liquidity increases when bank-affiliated dealers are constrained, we should observe that the positive alpha is realized during the first month of each quarter, that is, the month following each quarter-end month. This is precisely what we observe in columns 3-4 of Table 6. Consistent with our results on trade returns in Table 5, we observe that following the introduction of the leverage ratio constraint, LS investment-grade-focused funds significantly outperform other investment-grade-focused funds during the first month of each quarter, when presumably the prices of the bonds most negatively affected by dealers' constraints converge back to their fundamental value. We do not observe such outperformance in the second or third months of each quarter.

[17] High-yield bonds are more opaque and less liquid than investment-grade bonds. Hence, bank-affiliated dealers' trading in high-yield bonds is more likely to raise suspicions of proprietary trading. The finding that the alpha of high-yield bond funds did not increase suggests that LS funds did not significantly take advantage of trading opportunities arising from the Volcker Rule.

6 Which Funds Take Advantage of Liquidity Provision?

Our results demonstrate that the Basel III leverage ratio requirements have created profitable trading opportunities in investment-grade bonds for bond mutual funds. Banks could favor their affiliated funds to retain potential profits from liquidity provision by selling them undervalued bonds. However, since engaging in liquidity provision for investment-grade bonds is profitable and involves limited risk, all LS mutual fund managers should have incentives to compete for these trades, irrespective of their affiliation with a dealer. Moreover, LS mutual funds do not necessarily trade with bank-affiliated dealers but are likely to purchase from other market participants who are unable to sell to the regulated dealers that typically handle these bonds. It is thus an empirical question whether all funds, or exclusively bank-affiliated mutual funds, engage in liquidity provision to benefit from the opportunities created by the regulation.

We identify funds affiliated with a given dealer by matching fund management companies and fund advisors from CRSP to bank-affiliated dealers, subject to the leverage ratio, by name.[18] We then define a fund as bank-affiliated if either the fund management company or the fund advisor is affiliated with a dealer subject to the leverage ratio. Columns 1-4 of Table 7 examine the extent to which bank-affiliated mutual funds are more likely to provide liquidity in investment-grade bonds. As in the earlier tests, we compare the leverage ratio and pre-leverage ratio periods, and LS and non-LS funds trading in investment-grade bonds. The estimates confirm our earlier results, showing that only LS funds provide liquidity in constrained investment-grade bonds at quarter ends during the leverage ratio period. In column 1, the statistically insignificant coefficient estimate on the triple interaction $\mathbb{1}[QE] \times \mathbb{1}[Constr.\, Bond] \times \mathbb{1}[Bank-aff.]$ indicates that bank-affiliated mutual funds are not more inclined to engage in liquidity provision than other LS funds. This finding is consistent with the conjecture that all mutual funds with liquidity-supplying strategies should have incentives to undertake profitable trades that involve limited risk.

It is no surprise that this finding contrasts with evidence showing that when liquidity dried

[18] This definition partially overlaps with, but is more comprehensive than that of *Broker affiliation*, which we include in our standard set of controls following Anand et al. (2021). For this reason, in Table 7 we exclude *Broker affiliation* from the controls.

up at the onset of the COVID-19 pandemic, insurance companies with stable funding—rather than open-ended bond mutual funds—provided liquidity, particularly to those dealers with whom they had stronger prior trading relationships (O'Hara et al. 2022). March 2020 marked a period of significant turmoil for the corporate bond market, during which even investment-grade bonds carried substantial risks of future downgrades and further price declines. The expected risk-adjusted payoff of liquidity provision was, therefore, likely to be low. Even among institutions with stable funding conditions, such as insurance companies, primarily those with close relationships to dealers—who could expect to be compensated through better execution quality and primary market allocations in the future—had incentives to supply liquidity. By contrast, mutual funds' liquidity provision in regular times, when fund managers have no reason to expect large redemptions, involves limited risks. Thus, most funds with LS strategies are willing to engage in these types of trading opportunities.

While both bank-affiliated and unaffiliated LS funds provide liquidity, it appears plausible that constrained bank dealers favor affiliated funds by directing more profitable trades to them. Although our data do not allow us to observe actual trading relationships, we examine whether bank-affiliated funds outperform when engaging in liquidity provision. We consider investment-grade-focused funds and test whether bank-affiliated LS funds outperform other LS funds during the leverage ratio period. This is precisely what we observe in column 5 of Table 7. While all investment-grade-focused funds generate an alpha from LS strategies after the introduction of the leverage ratio requirements, the alpha of those that are bank-affiliated is almost three times larger than that of other investment-grade-focused LS funds. Column 6 considers the possibility that bank-affiliated funds may have characteristics—such as better access to funding and more stable liabilities (Franzoni and Giannetti 2019)—that favor their liquidity provision. If this were the case, we would expect bank-affiliated LS funds to outperform other LS funds also before the introduction of the leverage ratio. We find no evidence to support this claim, suggesting that bank-affiliated funds are better equipped to capitalize on the trading opportunities created by the leverage ratio. One possible explanation is that constrained bank dealers direct relatively more attractive trades to their affiliated funds. Thus, mutual funds may not only substitute for bank-affiliated dealers in providing liquidity but also complement them, with affiliated funds potentially capturing some of the profits that would have otherwise accrued to the regulated dealers before the introduction of the regulation.

7 When Do Funds Engage in Liquidity Supply?

In what follows, we explore whether the profitability of liquidity provision after the introduction of the leverage ratio constraint has led more investment-grade-focused funds to adopt liquidity-supplying strategies. Although the trading style is a strategic choice that varies little over time and depends on funding conditions and managerial incentives (Cella et al. 2013; Anand et al. 2021), funds should be more likely to adopt LS strategies if they expect them to be profitable. Not only could the recent performance of LS funds be correlated with the expected profitability of LS strategies, but positive performance leads to higher flows, increasing funds' ability to engage in liquidity provision.

To test these conjectures, we consider a linear probability model with a dummy capturing whether a fund has a positive LS score during a month as the dependent variable. This enables us to identify short-term changes in a fund's strategy, which we relate to a rolling average of the performance of all LS funds over the preceding 12 months. We also consider whether an individual fund's flows (also defined as rolling averages over the past 12 months) affect its propensity to provide liquidity, controlling for the fund's strategic focus and other characteristics, by including Morningstar fund category dummies and time-varying fund and portfolio characteristics.

Table A13 shows that the probability that an investment-grade-focused fund has a positive LS score is positively related to the previous performance of LS strategies. The effect of performance is further reinforced by recent flows, which increase if funds experience better performance. Both the net individual flows and recent LS funds' performance only affect the propensity to provide liquidity for investment-grade-focused funds during the leverage ratio period, when the alpha of LS funds has increased significantly. We note that the standard deviation of the average alpha in the previous 12 months was 0.083 in the pre-leverage ratio period, while it was only 0.033 after the implementation of the leverage ratio. It is plausible that the significant increase in the Sharpe ratio of liquidity-supplying strategies (decrease in volatility of performance) may have made some funds more sensitive to changes in alpha.

In terms of economic magnitude, during the leverage ratio period, a one-standard-deviation increase in the past 12-month average alpha of LS strategies (0.033) raises the probability of a fund pursuing an LS strategy by about 0.017 (that is, 0.511 from column 1 times 0.033), which is highly significant from an economic point of view, given that the average fraction of LS funds is between 0.24 and 0.27 during our sample period. Notably, the statistically insignificant coefficient on the indicator for bank-affiliated funds confirms our previous conclusion that all funds have incentives to engage in liquidity provision, irrespective of their relationships with dealers.

While the finding that mutual funds' liquidity provision in investment-grade bonds responds to trading opportunities suggests that the regulations should have limited negative effects on market functioning, their liquidity provision appears to be conditional on prior performance. In addition, funds that experience outflows are less likely to continue pursuing LS strategies, indicating that funds face constraints related to their open-ended capital structure.[19] These findings raise concerns that liquidity provision in the bond market may have become more dependent on fund flows and performance, and the liquidity of investment-grade bonds may suddenly drop. Outflows during episodes of turmoil, as experienced in March 2020 at the onset of the COVID-19 pandemic (Falato et al. 2021), can consequently explain, at least in part, why liquidity conditions quickly deteriorated, especially for investment-grade bonds (Haddad et al. 2021; Kargar et al. 2021). In the following section, we test whether a partial shift in liquidity provision from bank-affiliated dealers to open-ended bond mutual funds has systematically affected bond liquidity and returns.

8 Effects of Leverage Constraints on Corporate Bonds

8.1 Extent of Mutual Funds' Liquidity Provision in Corporate Bonds

To evaluate whether mutual funds' liquidity provision in investment-grade bonds is large enough to affect bond liquidity and returns, we divide the sum of LS funds' monthly net purchases of an investment-grade corporate bond experiencing a positive inventory cycle by the dealer sector's average inventories in the same bond. Table 8 reports the weighted

[19] In an earlier sample period, Anand et al. (2021) find that in periods of turmoil, LS funds provide liquidity by selling bonds that the market demands but not by purchasing.

average of our measure of mutual funds' liquidity supply across all bonds traded by mutual funds in a given month, where the weight is the bond's trading volume.

The results in Panel A show how the liquidity provision of mutual funds has changed. After the introduction of the leverage ratio, LS funds' liquidity provision is concentrated in the last month of the quarter and involves only constrained bonds. By contrast, before the introduction of the leverage ratio, liquidity provision was more prevalent in the first two months of the quarter and only slightly more common in bonds in which regulated financial institutions had accumulated larger inventories. On average, LS funds purchase about 9% of dealers' mean inventories in constrained bonds at quarter ends during the leverage ratio period.

The results in Panel A could suggest that LS funds simply shifted liquidity provision from non-quarter-end to quarter-end months. Based on the net liquidity supply over mean inventories, it is unclear whether LS funds have become more important liquidity providers in the aggregate—an effect that may be obscured by the marked increase in the number of bonds outstanding during our sample period, which is evident from the number of observations. Therefore, in Panel B, we consider the dollar value of LS funds' liquidity provision to evaluate whether it has indeed increased. The results indicate that fund liquidity provision in constrained bonds has indeed increased at quarter ends. In the first two months of a quarter, LS funds appear to purchase as many bonds experiencing selling pressure and handled by bank-affiliated dealers in the pre-leverage ratio period as in the period following the introduction of the leverage ratio. However, LS funds more than double the amount of constrained bonds they purchase in the last month of the quarter compared to earlier months during the leverage ratio period. Interestingly, Table A14 in the Internet Appendix shows that LS funds finance these end-of-quarter purchases by decreasing the amount of cash and government bonds they hold.

Overall, it appears that LS funds help absorb a significant proportion of the selling pressure that occurs at quarter ends, when bank-affiliated dealers are unable to expand their balance sheets. Therefore, funding shocks affecting bond mutual funds can significantly impact the conditions of the corporate bond market. In what follows, we evaluate the extent to which this is the case.

8.2 Liquidity

Mutual funds are open-ended organizations subject to redemptions, and their ability to provide liquidity depends on investors' willingness to hold their shares. This implies that the liquidity conditions and returns of corporate bonds intermediated by regulated dealers may have become more sensitive to mutual fund flows.

To test the effect of bond mutual funds' funding conditions on bond liquidity, we estimate the following regression at the bond-month level:

$$
\begin{aligned}
Illiquidity_{j,t} = \beta_0 &+ \beta_1\, \mathbb{1}[Constr.\, Bond_{j,t}] + \beta_2\, \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \\
&+ \beta_3\, \mathbb{1}[Constr.\, Bond_{j,t}] \times \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \\
&+ \beta_4\, \mathbb{1}[Constr.\, Bond_{j,t}] \times \mathbb{1}[LR\, Period] + \beta_5\, \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \times \mathbb{1}[LR\, Period] \\
&+ \beta_6\, \mathbb{1}[Constr.\, Bond_{j,t}] \times \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \times \mathbb{1}[LR\, Period] \\
&+ \beta_7\, Agg.\, Flows_t + \beta_8\, Matched\, Ret_t + \gamma'\, \mathbf{M_{j,t}} + \eta_s + \lambda_q + \varepsilon_{j,t}.
\end{aligned}
$$

The dependent variable, $Illiquidity_{j,t}$, is a bond's monthly illiquidity. We consider four standard metrics of corporate bond illiquidity: the measure by Hendershott and Madhavan (2015), which compares the price of each trade to the most recent interdealer trade price; the effective bid-ask spread; the imputed round-trip cost; and the interquartile price range. Besides considering the individual metrics, following Adrian et al. (2017), we also extract the first principal component of the four individual measures and use it as an additional illiquidity proxy.[20] As in our earlier specifications, $\mathbb{1}[LR\, Period]$ is an indicator that takes the value of one after 2015; the indicator $\mathbb{1}[Constr.\, Bond_{j,t}]$ captures bonds in which bank-affiliated dealers have accumulated substantial inventories in the first 20 trading days of a given month; $\mathbb{1}[Flow \in [0\%, 20\%]]$ is an indicator that equals one if the aggregate flows to LS funds during month t are in the bottom 20 percent of the sample; $\mathbf{M_{j,t}}$ refers to our set of bond-month controls; η_s denotes issuer fixed effects, and, λ_q denotes quarter fixed effects.

Our objective is to test whether LS bond mutual funds' funding constraints impact liquidity conditions for investment-grade bonds to a larger extent after the introduction of the leverage ratio requirements. As in our previous tests, we anticipate that the effect will be driven by investment-grade bonds in which bank-affiliated dealers have accumulated

[20] During our sample period, the first principal component of the four illiquidity proxies explains around 58% of the variation.

inventories, which we hence define as *constrained*. Throughout the analysis, in addition to usual bond characteristics, we control for the selling pressure that a bond has experienced because the mutual fund owners faced large outflows (flows in the bottom decile) and sold the security, using the variable flow-induced fire sales or $FIFS$.[21] We also control for aggregate bond mutual fund flows. These controls capture the selling pressure and price dislocation caused by mutual funds' fire sales (Coval and Stafford 2007), allowing us to isolate the impact of the missing liquidity provision by LS funds in constrained investment-grade bonds, which also arises when these funds face large redemptions.

Columns 1-3 of Table 9 report the results using the first principal component of the four illiquidity measures as the dependent variable. The positive and significant coefficient on $\mathbb{1}[Constr.\, Bond_{j,t}] \times \mathbb{1}[LR\, Period]$ in column 3 suggests that following the introduction of the leverage ratio, constrained bonds have become more illiquid. This implies that LS funds do not completely substitute bank-affiliated dealers. More importantly, during the leverage ratio period, constrained bonds become even more illiquid when the net flows to LS mutual funds are in the bottom quintile. Since we control for the extent of flow-induced fire sales experienced by a security and for the aggregate outflows from the bond mutual fund industry, we interpret the indicator for constrained bonds, interacted with the net flows to LS funds being in the bottom quintile and the leverage ratio period indicator, as capturing the missing liquidity provision by bond mutual funds. This result thus suggests that mutual funds' retraction from liquidity provision affects liquidity conditions. The results are similar when considering each of the four different measures of liquidity individually, with the exception of the effective bid-ask spread, for which the coefficient on the triple interaction term of interest is not statistically significant at the conventional level. We note that the effective bid-ask spread is considered less suitable than, for instance, the Hendershott and Madhavan (2015) transaction cost measure, when a market is one-sided (O'Hara and Zhou 2021a), which is the situation we aim to capture.

The effects of the regulations on bond liquidity's sensitivity to LS fund flows are also economically significant. For example, after the introduction of the leverage ratio, the imputed round-trip costs increase by about 1.9 bps (column 6), or around 11.4% of its mean, more for

[21] We also include flow-induced fire purchases or $FIFP$, constructed in a symmetric way using inflows rather than outflows. Since our proxies for $FIFS$ and $FIFP$ do not use the fund's TNA and the bond price to value a position, we do not incur the criticism raised by Wardlaw (2020) that proxies for FIFSs can be mechanically related to returns.

constrained investment-grade bonds when LS mutual funds experience significant redemptions, as captured by the indicator for LS mutual funds' flows in the bottom quintile. For the interquartile range and Hendershott and Madhavan (2015) cost measures, the corresponding effects are 3.36 and 2.97 bps (columns 4-5), representing 7.1% and 20.3% of their means, respectively. Notably, the estimates remain qualitatively and quantitatively unchanged in the matched sample (Table A15 in the Internet Appendix), indicating that the leverage ratio regulations are likely to have increased the exposure of constrained bonds to liquidity risk arising from mutual fund redemptions. Importantly, in Table A17, we do not observe an analogous effect for high-yield bonds, further supporting the importance of LS funds' missing liquidity provision in driving the higher sensitivity of constrained investment-grade bonds to large outflows from LS funds during the leverage ratio period.

So far, we have considered the effects of LS funds' missing liquidity provision during the quarter and shown that the liquidity of constrained bonds has become more exposed to large outflows from LS funds. Since markets are forward-looking, we expect these effects to occur at any time during the quarter, as market participants anticipate LS funds' inability to provide liquidity at quarter ends and may be reluctant to purchase securities handled by bank-affiliated dealers, even in the early months of a quarter. The effects of LS funds' missing liquidity provision should, however, be more pronounced in quarter-end months. This is precisely what we find in columns 1-3 of Table A16 in the Internet Appendix, which shows that the effect of large outflows from LS funds on the illiquidity of constrained bonds is more than twice as large in quarter-end months than in other months of the quarter.

8.3 Returns

Since the liquidity of investment-grade corporate bonds has become more exposed to redemptions from LS funds, negative realizations of liquidity risk could affect bond returns (Bao et al. 2011). In this section, we adapt our methodology to test whether the leverage ratio constraint also changes the determinants of bond returns.

We focus on monthly returns, and as in Subsection 5.1, we use two alternative definitions of bond abnormal returns. Specifically, we test whether returns on corporate bonds that are intermediated to a larger extent by bank-affiliated dealers are more exposed to liquidity risk stemming from large outflows from LS mutual funds and underperform when these funds' liquidity provision is constrained because aggregate flows to LS mutual funds are in the bottom quintile. Importantly, our regression models control for a bond's FIFS and aggregate flows to bond mutual funds, in addition to the usual bond characteristics and issuer fixed effects.

Table 10 reports the results. Following the introduction of the leverage ratio, constrained investment-grade bonds experience significant losses when LS funds experience large redemptions. These effects are obtained after controlling for a bond's exposure to flow-induced fire sales and aggregate outflows from the bond mutual fund industry. The estimates thus suggest that the missing liquidity provision by LS mutual funds can have significant adverse effects on bond returns. The effects are not only statistically significant but also economically meaningful. Constrained investment-grade bonds' excess returns drop by an additional 18-21 basis points relative to unconstrained investment-grade bonds during periods of large outflows from LS funds (columns 3-4). This effect is present only after the introduction of the leverage ratio regulations. Estimates are similar in the matched bond sample (columns 4-6 of Table A15 in the Internet Appendix), suggesting that the effects are not driven by different characteristics of constrained vs. unconstrained bonds. Furthermore, Table A17 shows that large outflows from LS funds do not affect constrained high-yield bond returns, and their impact does not change during the leverage ratio period.

Table A16 in the Internet Appendix explores the effects of large redemptions from LS funds on the returns of constrained bonds in quarter-end months. We do not necessarily expect a larger quarter-end effect of outflows on bond returns because prices are forward-looking. We find a significantly negative effect of large redemptions from LS funds at quarter ends when using the two-factor model to calculate abnormal returns, but a significantly negative effect on average throughout the quarter when using the one-factor model. This inconclusive evidence suggests that the dynamic of the effect may ultimately depend on when market participants gain awareness of the outflows from LS mutual funds.

9 Leverage Constraints and the COVID-19 Shock

Our analysis over the years 2010-2019, a period without major financial turmoil, highlights that in response to the leverage ratio constraint faced by banks, the liquidity and returns of investment-grade corporate bonds have become particularly sensitive to the funding conditions of LS mutual funds. This section explores the extent to which the leverage ratio constraint can help explain why liquidity conditions and returns sharply deteriorated, especially for investment-grade corporate bonds, at the onset of the COVID-19 pandemic (Haddad et al. 2021; Kargar et al. 2021; O'Hara and Zhou 2021a).

In the first three weeks of March 2020, before the Federal Reserve's intervention, bond mutual funds experienced unprecedented redemptions, which depressed bond valuations (Falato et al. 2021). While the tendency of mutual funds to sell liquid assets to meet redemptions contributed to the price dislocations experienced by investment-grade bonds relative to high-yield bonds (Ma et al. 2022), we investigate whether investment-grade corporate bonds intermediated by dealers subject to the leverage ratio constraint experienced more significant price dislocations than other investment-grade bonds. Since we control for a bond's exposure to fire sales, evidence that constrained investment-grade bonds performed more poorly would indicate that the leverage ratio constraint amplified the shock as mutual funds experiencing large outflows had to retract from liquidity provision.

To begin our analysis, we examine whether illiquidity increased more and returns decreased more in March 2020 for bonds that we define as constrained. We lag our bond constraint measure, *Constr. Dealers' Inventory Holdings*$_{j,m-1}$, to avoid overlap with inventory changes due to the bond selloff in early March. That is, we consider bonds as constrained in March if they are in the top quintile of constrained dealers' inventory changes during the first 20 days of February.

The gravity of the COVID-19 pandemic became apparent during the first three weeks of March 2020, disrupting financial markets globally and ultimately leading to the Federal Reserve's intervention on March 23 to calm the U.S. corporate bond market and stabilize mutual fund flows. We thus consider a sample that includes the monthly illiquidity and returns of bond issues for January-February 2020 and the first 22 days of March 2020.[22] We test whether constrained bonds performed particularly poorly during March 2020.

Table 11 reports the results from the panel regressions of our bond illiquidity measure and bond returns. We control for aggregate bond mutual fund flows, a bond's exposure to flow-induced fire sales, bond characteristics, and issuer fixed effects. The positive sign on the

[22]The Fed further intervened, easing the leverage ratio requirements in April 2020, after the end of our sample period.

interaction term between the indicator variables capturing March 2020 and constrained bonds in column 1 suggests that illiquidity increased more for investment-grade bonds affected by the leverage ratio constraint.

The effect is not only statistically significant but also economically significant. Specifically, in March 2020, investment-grade bonds, in which dealers subject to leverage ratio constraint had built up inventory positions in February 2020, experienced a 14% (that is, 12.244 divided by 88.445) additional increase in illiquidity compared to unconstrained investment-grade bonds. Similarly, column 2 shows that the returns of constrained investment-grade bonds are about 1.3 percentage points lower than other investment-grade bonds during the first three weeks of March 2020. Overall, this evidence confirms that the leverage ratio constraint, by partially shifting liquidity provision from dealers to mutual funds with fragile funding, can amplify negative shocks in the corporate bond market.

10 Conclusion

We provide the first evidence that banking regulations, by reducing the willingness of bank-affiliated dealers to accumulate bond inventories, have spillover effects on unregulated financial institutions. Specifically, we show that when the leverage ratio constraints on bank-affiliated dealers are most binding, mutual funds provide more liquidity in the corporate bond market. Importantly, the regulation has benefited mutual funds' performance.

However, the liquidity supply of bond mutual funds depends on their performance and flows and drastically decreases when they experience significant redemptions. Consequently, liquidity in the corporate bond market has become increasingly dependent on the funding conditions of mutual funds. Not only does corporate bond liquidity deteriorate significantly when there are large redemptions from LS funds, but bond valuations also decline substantially.

Our findings show that unregulated institutions, which partially substitute bank-affiliated dealers, can mitigate regulatory costs under normal market conditions. However, smaller balance sheets for regulated institutions and lower prospective bailout costs for taxpayers entail a trade-off and come at a cost, as investment-grade corporate bonds have become more exposed to negative shocks. While we refrain from drawing normative conclusions from our analysis, policymakers will need to weigh these costs, along with those identified in the previous literature for government securities and repo markets (Duffie 2018), in their evaluation of the leverage ratio requirements.

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Figure 1: LS Funds' Liquidity Supply over Time

This figure displays the coefficients β_k for $k \in \{2010, \ldots, 2019\} \setminus \{2014\}$ from the regression:

$$Fund\,Position\,Change_{i,j,t} = \beta_0 + \beta_1\,\mathbb{1}[QE] + \sum_{k=2010\,\setminus\,\{2014\}}^{2019} \beta_k\,\mathbb{1}[Year = k] \times \mathbb{1}[QE] + \theta_1'\,\mathbf{M_{j,t}} + \theta_2'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,.$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[Year = k]$ is an indicator that is one in year k. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December), and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. Standard errors are double-clustered at the fund and year-quarter level. The gray shaded areas represent the 90% confidence intervals. The regression sample is restricted to LS funds and investment-grade bonds.

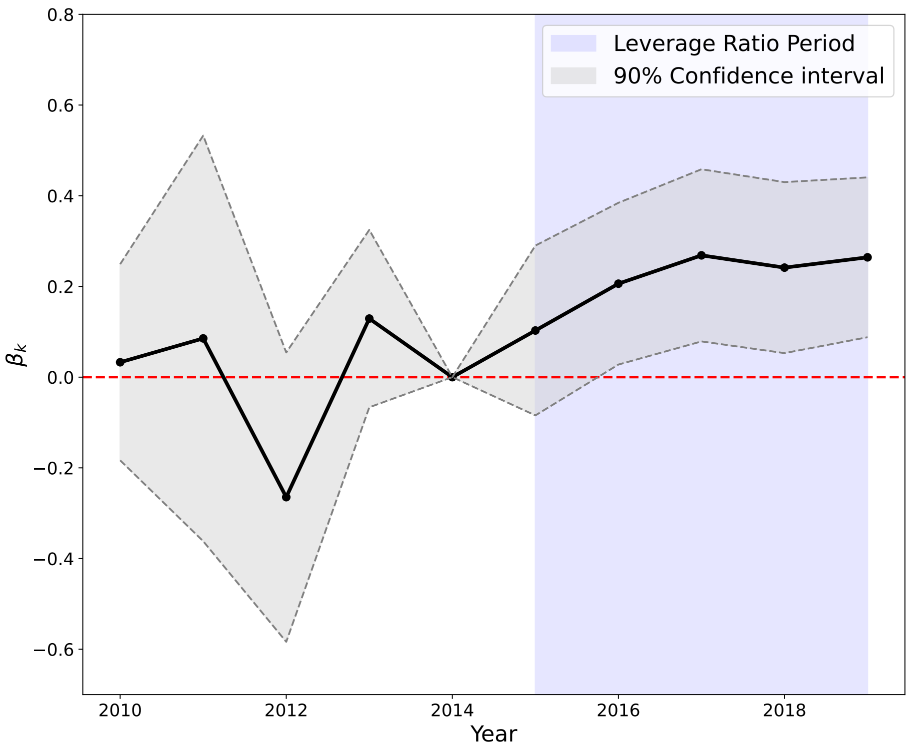

Figure 2: LS Funds' Performance over Time

This figure displays the coefficients β_k for $k \in \{2010, \ldots, 2019\} \setminus \{2014\}$ from the regression:

$$Fund\,Alpha_{i,t} = \beta_0 + \beta_1\,\mathbb{1}[LS\,Fund] + \sum_{k=2010\setminus\{2014\}}^{2019} \beta_k\,\mathbb{1}[Year = k] \times \mathbb{1}[LS\,Fund]$$
$$+ \gamma'\,\mathbf{M_{i,t}} + \eta_c \times \lambda_t + \epsilon_{i,t}\,.$$

The dependent variable, $Fund\,Alpha_{i,t}$, represents the alpha (in percent) of fund i in month t, and is calculated using Chen and Qin (2017)'s four-factor model. $\mathbb{1}[LS\,Fund]$ is an indicator that is one if the fund is defined as liquidity-supplying, and zero otherwise. $\mathbb{1}[Year = k]$ is an indicator that is one in year k. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). All controls are as of the end of period $t-1$. $\eta_c \times \lambda_t$ represents fund category-period fixed effects. Standard errors are double-clustered at the fund and year-quarter level. The gray shaded areas represent 90% confidence intervals. The regression sample is restricted to IG-focused funds.

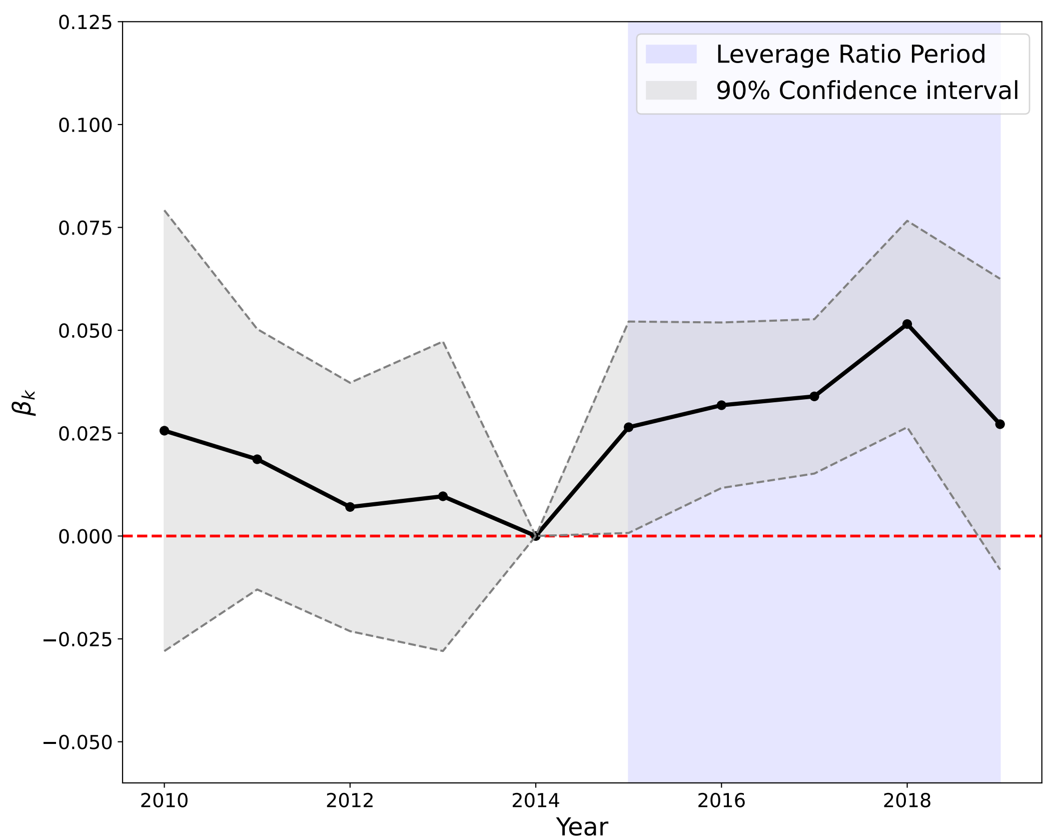

Table 1
Summary Statistics

This table presents summary statistics for fund-level (Panel A), position-level (Panel B), and bond-level (Panel C) variables. The data on fund holdings and characteristics are from Morningstar, Morningstar Direct, and CRSP. The data on bond characteristics are from Mergent FISD. The data on corporate bond transactions, which we use to calculate bond prices and returns, are from FINRA's Regulatory TRACE. The main sample covers the period from 1/2010 to 12/2019. The fund sample includes only open-ended taxable bond mutual funds that hold at least 20% of the total net assets under management (TNA) in corporate bonds. All share classes with the same master portfolio count as one fund, and the number of unique funds is 1,167. The bond sample includes only non-puttable U.S. Corporate Debentures and U.S. Corporate Bank Notes (bond type CDEB or USBN) held by at least one fund on the latest report date, and the number of unique bond CUSIPs is 20,436. The position sample includes only the positions of sample funds in sample bonds. Detailed variable definitions are in the Appendix.

Panel A: Fund-Level Variables

	Main Sample (58,040 Fund-Periods)					Mean by Fund Type (15,917 / 42,123 Fund-Periods)	
Variable	Mean	Std	10%	50%	90%	LS Funds	Non-LS Funds
Total net assets ($ Mil.)	2518.10	9698.27	42.20	542.90	5165.22	3261.82	2237.89
Portfolio avg. bond issue size	1059.64	291.76	710.38	1016.81	1467.30	1048.68	1063.72
Portfolio avg. bond age (year)	3.81	1.04	2.60	3.65	5.26	3.96	3.75
Portfolio avg. credit rating (1 = AAA)	10.11	3.95	5.00	9.00	16.00	9.76	10.24
Portfolio average duration (year)	5.46	2.46	2.59	4.90	8.94	5.09	5.60
Portfolio avg. coupon rate	5.35	1.63	3.39	5.19	7.60	5.14	5.43
Corporate bonds as % of portfolio	55.11	26.22	23.56	48.86	92.44	54.58	55.30
Government bonds as % of portfolio	14.89	17.13	0.00	8.67	42.10	15.17	14.79
Cash as % of portfolio	8.05	9.75	0.44	5.74	20.03	8.89	7.73
Flow (%)	0.70	4.36	-3.12	0.09	5.08	1.21	0.50
Alpha (%)	-0.04	0.55	-0.53	-0.02	0.44	-0.03	-0.05
Fund age	15.29	10.31	3.16	14.07	29.50	13.21	16.06
Broker affiliation	0.09	0.29	0.00	0.00	0.00	0.09	0.09
Bank affiliation	0.12	0.32	0.00	0.00	1.00	0.13	0.11
Turnover (%)	16.32	17.09	3.45	11.27	33.33	16.99	16.07
LS score	-0.05	0.26	-0.37	-0.04	0.26	0.05	-0.09

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Table 1 (continued)

Panel B: Position-Level Variables

	All Bonds (10,610,677 Fund-Bond-Periods)					Mean by Fund Type (3,302,574 LS Bond-Periods 7,308,103 Non-LS Bond-Periods)	
Variable	Mean	Std	10%	50%	90%	LS Funds	Non-LS Funds
Fund pos. change / TNA_{t-1} (bp)	0.33	4.79	0.00	0.00	0.28	0.41	0.29
IG Bonds:	0.23	4.02	0.00	0.00	0.00	0.26	0.21
HY bonds:	0.47	5.76	-1.14	0.00	2.97	0.76	0.39
Trade return	0.00	0.14	-0.07	0.00	0.07	0.00	0.00
IG Bonds:	0.00	0.09	-0.04	0.00	0.03	0.00	0.00
HY Bonds:	0.00	0.20	-0.16	0.00	0.17	0.00	0.00

Panel C: Bond-Level Variables

	Main Sample (908,354 Bond-Periods)					Mean by Bond Type (156,493 Constr. Bond-Periods 751,861 Unconstr. Bond-Periods)	
Variable	Mean	Std	10%	50%	90%	Constrained	Unconstrained
Bond rating	10.03	5.22	5.00	9.00	17.00	10.47	9.94
Bond age (year)	5.40	4.13	1.57	4.21	10.38	3.76	5.74
Bond maturity (year)	9.96	9.12	2.54	6.96	25.77	10.62	9.82
Bond issue size ($ Mil.)	687.30	524.77	249.36	499.40	1281.48	783.79	667.23
Investment grade	0.71	0.46	0.00	1.00	1.00	0.64	0.72
Upgrade	0.01	0.10	0.00	0.00	0.00	0.01	0.01
Downgrade	0.01	0.09	0.00	0.00	0.00	0.01	0.01
Mutual fund ownership	0.10	0.09	0.01	0.07	0.22	0.12	0.09
Flow-induced fire purchases	0.03	0.18	0.00	0.00	0.04	0.05	0.03
Flow-induced fire sales	0.04	0.22	0.00	0.00	0.04	0.06	0.03
Individual Bond Illiquidity Measures							
Interquartile range (bp)	47.50	50.89	7.51	30.14	110.74	49.66	47.02
Imputed roundtrip cost (bp)	16.82	25.98	0.36	7.94	41.12	14.71	17.18
Effective bid-ask spread (bp)	58.44	73.53	6.76	33.16	142.10	48.08	60.31
Madhavan & Hendershott (bp)	14.63	28.47	-1.77	7.81	41.94	12.77	14.93

Table 1 (continued)

Panel C: Bond-Level Variables

	Main Sample (908,354 Bond-Periods)					Mean by Bond Type (156,493 Constr. Bond-Periods 751,861 Unconstr. Bond-Periods)	
Variable	Mean	Std	10%	50%	90%	Constrained	Unconstrained
Bond illiquidity							
First principal component	-7.10	78.03	-69.20	-33.16	89.14	-13.87	-5.76
IG Bonds:	-10.10	77.38	-70.68	-35.80	83.74	-16.73	-8.97
HY Bonds:	1.76	79.25	-61.63	-25.84	103.24	-8.36	4.68
Bond return (%)	0.39	1.94	-1.31	0.27	2.34	0.30	0.42
Abnormal bond return (%)	-0.03	1.24	-1.39	-0.02	1.28	-0.11	-0.03
IG Bonds:	-0.04	1.02	-1.20	-0.03	1.11	-0.09	-0.04
HY Bonds:	-0.01	1.40	-1.83	0.01	1.89	-0.12	0.03
Constrained dealers' inventory holdings (%)							
All bonds	0.79	1.32	0.02	0.37	1.97	-	-
Constrained bonds	2.21	1.91	1.02	1.63	3.94	-	-
Unconstrained bonds	0.28	0.26	0.01	0.19	0.70	-	-

Table 2
LS Funds' Trading in Investment-Grade Bonds across Regulatory Periods

This table displays estimates for the regression:

$$Fund\,Position\,Change_{i,j,t} = \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[QE] \times \mathbb{1}[LR\ Period] + \theta_1'\,\mathbf{M_{j,t}} + \theta_2'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,.$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December), and zero otherwise. $\mathbf{1}[LR\ Period]$ is an indicator that equals one during the leverage ratio period (01/2015-12/2019), and zero otherwise. $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. The sample includes only positions of LS funds in investment-grade bonds. Column 1 considers only the leverage ratio period. Column 2 considers only the pre-leverage ratio period. Columns 3-4 consider all periods. Column 4 also includes the interactions of all bond and fund controls and $\mathbf{1}[LR\ Period]$. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Regulatory Period	Leverage Ratio	Pre-Leverage Ratio	All	
	(1)	(2)	(3)	(4)
$\mathbb{1}[QE]$	**0.058****	-0.039	-0.074	-0.039
	(0.025)	(0.053)	(0.048)	(0.052)
$\mathbb{1}[QE] \times \mathbb{1}[LR\ Period]$			**0.145*****	**0.098***
			(0.051)	**(0.056)**
Observations	1,410,791	491,412	1,902,203	1,902,203
R-squared	0.10	0.16	0.13	0.13
Bond x Year FE	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓
Controls interacted with $\mathbb{1}[LR\ Period]$	–	–	–	✓

Table 3
Fund Liquidity Provision across Regulatory Periods - Placebos

This table displays estimates for the regression:

$$\begin{aligned} Fund\,Position\,Change_{i,j,t} &= \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[QE] \times \mathbb{1}[LR\ Period] \\ &+ \theta_1'\,\mathbf{M_{j,t}} + \theta_2'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,. \end{aligned}$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December), and zero otherwise. $\mathbf{1}[LR\ Period]$ is an indicator that equals one for the leverage ratio period (01/2015-12/2019), and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. Columns 1-3 show the estimates for non-LS funds and investment-grade bonds, while columns 4-6 show the estimates for LS funds and high-yield bonds. Columns 3 and 6 also include the interactions of all bond and fund controls and $\mathbf{1}[LR\ Period]$. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Fund Type	Non-LS Funds			LS Funds		
Bond Type	Investment-Grade			High-Yield		
Regulatory Period	LR	Pre-LR	All	LR	Pre-LR	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[QE]$	0.045	0.085	0.085	0.172*	0.210*	0.210**
	(0.029)	(0.051)	(0.050)	(0.084)	(0.103)	(0.101)
$\mathbb{1}[QE] \times \mathbb{1}[LR\ Period]$			-0.040			-0.038
			(0.057)			(0.123)
Observations	1,895,858	1,362,662	3,258,520	446,379	266,659	713,038
R-squared	0.10	0.12	0.11	0.13	0.18	0.15
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓	✓	✓
Controls interacted with $\mathbb{1}[LR\ Period]$	–	–	✓	–	–	✓

Table 4
LS Funds' Liquidity Provision and Investment-Grade Bonds' Exposure to Leverage Constraints

This table displays estimates for the regression:

$$\begin{aligned} Fund\,Position\,Change_{i,j,t} = {} & \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[Constr.\,Bond_{j,t}] + \beta_3\,\mathbb{1}[LS\,Fund_{i,t}] \\ & + \beta_4\,\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_5\,\mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr.\,Bond_{j,t}] \\ & + \beta_6\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] + \beta_7\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr\,Bond_{j,t}] \\ & + \theta_{\mathbf{1}}'\,\mathbf{M_{j,t}} + \theta_{\mathbf{2}}'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,. \end{aligned}$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December), and zero otherwise. $\mathbb{1}[LS\,Fund]$ is an indicator that is one if the fund is defined as a liquidity-supplying fund, and zero otherwise. $\mathbb{1}[Constr.\,Bond]$ is an indicator that equals one if the bond is defined as constrained in period t, and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. In column 4, the constrained bond indicators are constructed by considering separately the inventory holdings of two groups of bank-affiliated dealers with distance to the regulatory minimum capital above and below the volume-weighted median. $\mathbf{1}[Constr.\,Bond\,|\,\Delta\,LR\,Min. > 50\%]$ is an indicator that equals one if the bond is defined as constrained in period t based on the inventories of bank-affiliated dealers with above-median distance to the regulatory minimum capital. $\mathbf{1}[Constr.\,Bond\,|\,\Delta\,LR\,Min. \leq 50\%]$ is an indicator that equals one if the bond is defined as constrained in period t based on the inventories of bank-affiliated dealers with below-median distance to the regulatory minimum capital. The sample includes only positions in investment-grade bonds during the leverage ratio period. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

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Table 4 - continued

Regulatory Period	Leverage Ratio Period			
Fund Type	LS	Non-LS	All	
	(1)	(2)	(3)	(4)
$\mathbf{1}[QE]$	0.041*	0.052*	0.037	0.047*
	(0.023)	(0.027)	(0.025)	(0.026)
$\mathbf{1}[Constr.\,Bond]$	0.006	-0.059**	-0.057**	
	(0.016)	(0.024)	(0.027)	
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond]$	**0.089****	-0.033	-0.017	
	(0.033)	(0.048)	(0.046)	
$\mathbf{1}[LS\,Fund]$			0.032	0.041
			(0.023)	(0.024)
$\mathbf{1}[QE] \times \mathbf{1}[LS\,Fund]$			0.034	0.020
			(0.023)	(0.024)
$\mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			0.063	
			(0.048)	
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			**0.085****	
			(0.037)	
$\mathbf{1}[Constr.\,Bond\,\vert\,\Delta\,LR\,Min. \leq 50\%]$				0.117*
				(0.066)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\vert\,\Delta\,LR\,Min. \leq 50\%]$				-0.080
				(0.058)
$\mathbf{1}[Constr.\,Bond\,\vert\,\Delta\,LR\,Min. > 50\%]$				-0.084***
				(0.024)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\vert\,\Delta\,LR\,Min. > 50\%]$				-0.003
				(0.043)
$\mathbf{1}[Constr.\,Bond\,\vert\,\Delta LR\,Min. \leq 50\%] \times \mathbf{1}[LS\,Fund]$				-0.083
				(0.055)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\vert\,\Delta\,LR\,Min. \leq 50\%] \times \mathbf{1}[LS\,Fund]$				**0.115****
				(0.054)
$\mathbf{1}[Constr.\,Bond\,\vert\,\Delta\,LR\,Min. > 50\%] \times \mathbf{1}[LS\,Fund]$				0.090*
				(0.049)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\vert\,\Delta\,LR\,Min. > 50\%] \times \mathbf{1}[LS\,Fund]$				0.068
				(0.040)
Observations	1,410,791	1,895,858	3,308,036	3,308,036
R-squared	0.10	0.10	0.09	0.09
Bond x Year FE	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓

Table 5
LS Funds' Liquidity Provision and Trade Performance

This table displays estimates for the regression:

$$
\begin{aligned}
Trade\ Return_{i,j,t} = {} & \beta_0 + \beta_1\, \mathbb{1}[QE] + \beta_2\, \mathbb{1}[Constr.\, Bond_{j,t}] \\
& + \beta_3\, \mathbb{1}[QE] \times \mathbb{1}[Constr.\, Bond_{j,t}] + \beta_4\, \mathbb{1}[LR\ Period] \times \mathbb{1}[Constr.\, Bond_{j,t}] \\
& + \beta_5\, \mathbb{1}[QE] \times \mathbb{1}[LR\ Period] + \beta_6\, \mathbb{1}[QE] \times \mathbb{1}[LR\ Period] \times \mathbb{1}[Constr.\, Bond_{j,t}] \\
& + \theta_1'\, \mathbf{M_{j,t}} + \theta_2'\, \mathbf{M_{i,t}} + \eta_s \times \lambda_q + \varepsilon_{i,j,t}\,.
\end{aligned}
$$

The dependent variable, $Trade\ Return_{i,j,t}$, is the change in position of fund i in bond j from period $t-1$ to t (scaled by the fund's TNA at $t-1$) multiplied by the abnormal return of bond j from period t to $t+1$, and is expressed in basis points. For a given bond, the abnormal return is calculated as the difference between the bond's excess return and the bond market model excess return. In columns 1-4, the market factor is the bond's credit-rating-matched index. In column 5, the bond market model excess return is computed using the two-factor model proposed by van Binsbergen et al. (2025). The factor loadings are estimated over a 36-month rolling window. The sample includes only strictly positive position changes of LS funds in investment-grade bonds. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December), and zero otherwise. $\mathbf{1}[LR\ Period]$ is an indicator that equals one during the leverage ratio period (01/2015-12/2019), and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_s \times \lambda_q$ represents issuer-year-quarter fixed effects. Standard errors, double-clustered at the fund-issuer and year-quarter level, are in parentheses. Observations are weighted by the change in position of fund i in bond j from periods $t-1$ to t. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

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Table 5 - continued

Bond Type	Investment-Grade				
Bond Pricing Model	1-Factor Model				2-Factor Model
Regulatory Period	LR	Pre-LR	All		
	(1)	(2)	(3)	(4)	(5)
$\mathbf{1}[QE]$	**0.020****	-0.051***	-0.051***	-0.045**	-0.045***
	(0.009)	(0.016)	(0.016)	(0.018)	(0.016)
$\mathbf{1}[QE] \times \mathbf{1}[LR\ Period]$			**0.071*****	0.059***	0.060***
			(0.018)	(0.020)	(0.018)
$\mathbf{1}[Constr.\ Bond]$				0.013	0.010
				(0.012)	(0.010)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\ Bond]$				-0.022*	-0.024**
				(0.011)	(0.009)
$\mathbf{1}[LR\ Period] \times \mathbf{1}[Constr.\ Bond]$				-0.019	-0.016
				(0.013)	(0.012)
$\mathbf{1}[QE] \times \mathbf{1}[LR\ Period] \times \mathbf{1}[Constr.\ Bond]$				**0.052*****	**0.047*****
				(0.014)	**(0.014)**
Observations	94,700	18,990	113,690	113,690	113,690
R-squared	0.60	0.60	0.59	0.59	0.58
Issuer x Year-Quarter FE	✓	✓	✓	✓	✓
Bond Controls	✓	✓	✓	✓	✓
Fund Controls	✓	✓	✓	✓	✓

Table 6
Fund Performance by Regulatory Period

This table reports OLS estimates for panel regressions of fund alpha (in percent) on an indicator for liquidity-supplying funds and its interaction with an indicator for the leverage ratio period. For each fund i in month t, the dependent variable, alpha, is calculated using Chen and Qin (2017) four-factor model:

$$R_{i,t} - R_{f,t} = \alpha + \beta_{i,STK} \times STK_t + \beta_{i,BOND} \times BOND_t + \beta_{i,DEF} \times DEF_t + \beta_{i,OPTION} \times OPTION_t\,.$$

$R_{i,t} - R_{f,t}$ represents the return of fund i in month t in excess of the risk-free rate. STK_t is the excess return on the CRSP value-weighted stock index, $BOND_t$ is the excess return on the U.S. aggregate bond index, DEF_t is the return spread between the high-yield bond index and the intermediate government bond index, and $OPTION_t$ is the return spread between the GNMA mortgage-backed security index and the intermediate government bond index. All bond indices are from Bank of America Merrill Lynch, and are downloaded from DataStream. The parameters, $\beta_{i,STK}$, $\beta_{i,BOND}$, $\beta_{i,DEF}$, $\beta_{i,OPTION}$ are estimated on a rolling window that goes from months $t-24$ to $t-1$ for alpha in month t. $\mathbb{1}[LS\,Fund]$ is an indicator that is one if the fund is defined as liquidity supplying, and zero otherwise. $\mathbb{1}[LR\,Period]$ is an indicator that is one during the leverage ratio period (01/2015 - 12/2019), and zero otherwise. All columns include Morningstar's fund category-month fixed effects, and fund controls, including lagged flow, lagged alpha, broker affiliation dummy, time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)), and time-varying fund characteristics (log(1 + fund age), log(1 + fund size), log(1 + family size), and average maximum rear load). All controls are as of the end of period $t-1$. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Fund Specialization	IG-Focused Funds	HY-Focused Funds	IG-Focused Funds	
Month	All		1	2-3
	(1)	(2)	(3)	(4)
$\mathbb{1}[LS\,Fund]$	-0.001	0.027*	0.008	-0.007
	(0.009)	(0.016)	(0.012)	(0.010)
$\mathbb{1}[LS\,Fund] \times \mathbb{1}[LR\,Period]$	**0.022****	-0.017	**0.035****	0.016
	(0.010)	(0.018)	**(0.014)**	(0.011)
Observations	41,694	25,117	13,329	28,365
R-squared	0.44	0.41	0.44	0.44
Fund cat. x Period FE	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓

Table 7
Bank-Affiliated Funds' Liquidity Provision and Performance

This table reports OLS regression estimates for the relationships between fund liquidity supply, fund performance, and bank-affiliation status. In columns 1-4, the observations are at the fund-bond-period level, and the sample includes only investment-grade bonds. Columns 1-2 include only LS funds. Columns 3-4 include only non-LS funds. The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), expressed in basis points. In columns 5-6, the observations are at the fund-month level, and the sample includes all investment-grade-focused funds. The dependent variable, $\alpha_{i,t}$, represents the alpha of fund i in month t, estimated as in Table 6. In all columns, variables are defined as follows. $\mathbb{1}[Bank - aff.]$ is an indicator that is one if either the fund management company or the fund advisor is affiliated with a constrained bank dealer and zero otherwise. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. $\mathbb{1}[Constr.\,Bond]$ is an indicator that equals one if the bond is defined as constrained in month t and zero otherwise. $\mathbb{1}[LS\ Fund]$ is an indicator that is one if the fund is defined as liquidity-supplying and zero otherwise. Fund controls include lagged flow, time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)), and time-varying fund characteristics (log(1 + fund age), log(1 + fund size), log(1 + family size), and average maximum rear load). Bond controls include log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. Columns 1-4 include bond-year fixed effects, bond controls, and fund controls. Columns 5-6 include fund category-period fixed effects and fund controls. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Cont'd next page

Table 7 - continued

Dependent Variable	Fund Position Change				Fund Alpha	
Fund Type	LS Funds		Non LS Funds		All	
Regulatory Period	LR	Pre-LR	LR	Pre-LR	LR	Pre-LR
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[QE]$	0.052**	-0.046	0.050	0.075		
	(0.021)	(0.045)	(0.029)	(0.045)		
$\mathbb{1}[Constr. Bond]$	0.010	-0.042	-0.059**	-0.246***		
	(0.018)	(0.046)	(0.026)	(0.047)		
$\mathbb{1}[Bank-aff.]$	0.047	0.172	0.031	0.118*	-0.001	0.034
	(0.111)	(0.120)	(0.039)	(0.061)	(0.009)	(0.024)
$\mathbb{1}[QE] \times \mathbb{1}[Constr. Bond]$	**0.090****	0.026	-0.045	0.043		
	(0.034)	(0.062)	(0.051)	(0.076)		
$\mathbb{1}[QE] \times \mathbb{1}[Bank-aff.]$	-0.128	-0.046	0.048	0.010		
	(0.141)	(0.129)	(0.040)	(0.075)		
$\mathbb{1}[Constr. Bond] \times \mathbb{1}[Bank-aff.]$	-0.035	0.118	-0.017	-0.026		
	(0.061)	(0.126)	(0.047)	(0.085)		
$\mathbb{1}[QE] \times \mathbb{1}[Constr. Bond] \times \mathbb{1}[Bank-aff.]$	0.008	0.010	0.067	-0.075		
	(0.082)	(0.090)	(0.068)	(0.093)		
$\mathbb{1}[LS\ Fund]$					0.011*	0.001
					(0.006)	(0.010)
$\mathbb{1}[LS\ Fund] \times \mathbb{1}[Bank-aff.]$					**0.031****	0.023
					(0.014)	(0.024)
Observations	1,399,416	486,226	1,811,602	1,277,596	22,453	19,053
R-squared	0.10	0.16	0.10	0.12	0.46	0.42
Bond x Year FE	✓	✓	✓	✓		
Fund cat. x Period FE					✓	✓
Bond controls	✓	✓	✓	✓		
Fund controls	✓	✓	✓	✓	✓	✓

Table 8
Fund Liquidity Supply Relative to Dealer Inventories

Panel A reports LS funds' volume-weighted average monthly net liquidity supply relative to the dealer sector's mean inventories in constrained and unconstrained investment-grade bonds during positive inventory cycles. For each month from January 2010 to December 2019, the net liquidity supply in a given bond is defined as the dollar par amount of that bond purchased minus the dollar par amount sold by all LS funds, divided by the dealer sector's mean inventory. The resulting ratio is expressed as a percentage. Panel B reports LS funds' volume-weighted average monthly net liquidity supply in constrained and unconstrained investment-grade bonds during positive inventory cycles (i.e., the numerator of the ratio in Panel A), expressed in millions of dollars. Volume-weighted (across-bond) averages are computed using weighted linear regressions, in which the net liquidity supply relative to dealer inventories (Panel A) and the net liquidity supply (Panel B) are regressed on two indicator variables: One distinguishing constrained from unconstrained investment-grade bonds (top versus bottom quintiles of constrained dealers' inventory holdings, as defined in Equation 2, excluding bonds with zero inventory holdings due to no trading in the first 20 days of the month), and one distinguishing quarter-end months (March, June, September, December) from non-quarter-end months. We use each bond's total monthly trading volume by all mutual funds as the weight. Standard errors, double-clustered at the bond and year-month level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Panel A: Net Liquidity Supply over Mean Inventories (in %)

	Pre-Leverage Ratio n=26,984		Leverage Ratio n=32,467	
Bond	Non-Quarter-End Month	Quarter-End Month	Non-Quarter-End Month	Quarter-End Month
Constrained	4.22***	**1.29**	0.59	**9.02*****
	(1.47)	**(1.37)**	(1.51)	**(3.07)**
Unconstrained	-0.76	-1.35	-3.05	-8.19
	(2.60)	(1.70)	(2.45)	(5.19)

Panel B: Net Liquidity Supply (in $ million)

	Pre-Leverage Ratio n=26,984		Leverage Ratio n=32,467	
Bond	Non-Quarter-End Month	Quarter-End Month	Non-Quarter-End Month	Quarter-End Month
Constrained	0.86***	0.38	0.86***	**1.99*****
	(0.23)	(0.26)	(0.27)	**(0.46)**
Unconstrained	-0.028	-0.24	-0.32	-0.57
	(0.26)	(0.19)	(0.25)	(0.54)

Table 9
Large Redemptions from LS Funds and Bond Illiquidity

This table reports OLS estimates for the following panel regression:

$$\begin{aligned} Illiquidity_{j,t} = \beta_0 &+ \beta_1\, \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_2\, \mathbb{1}[Flow_t \in [0\%, 20\%]] + \beta_3\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in [0\%, 20\%]] \\ &+ \beta_4\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[LR\,Period] + \beta_5\, \mathbb{1}[Flow_t \in [0\%, 20\%]] \times \mathbb{1}[LR\,Period] \\ &+ \beta_6\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in [0\%, 20\%]] \times \mathbb{1}[LR\,Period] + \beta_7\, Agg.\,Flows_t \\ &+ \gamma'\, \mathbf{M_{j,t}} + \eta_s + \lambda_q + \varepsilon_{j,t}\,. \end{aligned}$$

The dependent variables are the equally-weighted averages of different daily illiquidity measures for bond j across all trading days in month t. In columns 1-3, we proxy for daily bond illiquidity by the first principal component of the following four individual liquidity measures: the interquartile range measure, the Hendershott and Madhavan (2015) cost measure, the imputed round-trip cost, and the effective bid-ask spread. In columns 4-7, the dependent variable is each of the four individual illiquidity measures as listed in the column heading. $\mathbb{1}[Constr.\,Bond_{j,t}]$ is an indicator that is one if the bond is defined as constrained during month t, and zero otherwise. $\mathbb{1}[Flow \in [0\%, 20\%]]$ is an indicator that is one if the aggregate flows to LS funds in month t are in the bottom 20 percent of the sample and zero otherwise. $\mathbb{1}[LR\,Period]$ is an indicator that is one in the leverage ratio period (01/2015 - 12/2019) and zero otherwise. $\mathbf{M_{j,t}}$ denotes a vector of bond-level controls, including log(1 + bond age), log(1 + bond maturity), log(1 + bond issue size), flow-induced fire purchases and sales, as well as upgrade and downgrade indicators. We also include aggregate bond fund flows, computed as the sum of dollar flows across all share classes and bond funds, presented as a fraction of aggregate fund TNA at the beginning of the month. The sample includes only investment-grade bonds. η_s denotes issuer fixed effects. λ_q denotes year-quarter fixed effects. Standard errors, double-clustered by issuer and year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

Dependent Variable	Average Illiquidity			Individual Illiquidity Measures			
	LR	Pre-LR	All	IQR	Hendershott & Madhavan	IRT	Eff. Bid-Ask Spread
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\mathbb{1}[Constr.\,Bond]$	-7.051***	-10.800***	-11.973***	-2.720***	-5.208***	-3.812***	-11.643***
	(0.499)	(1.244)	(1.373)	(0.637)	(0.848)	(0.438)	(1.196)
$\mathbb{1}[Flow \in [0\%, 20\%)]$	1.539	5.785*	6.379**	3.188**	1.589*	0.921	5.234**
	(1.312)	(3.321)	(2.977)	(1.518)	(0.933)	(0.559)	(2.428)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in [0\%, 20\%)]$	**3.748****	-2.833	-2.492	-0.762	-0.284	-1.698**	-0.672
	(1.409)	(2.371)	(2.379)	(1.135)	(1.314)	(0.782)	(2.024)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LR\,Period]$			4.992***	0.061	4.932***	2.507***	5.085***
			(1.407)	(0.758)	(0.888)	(0.468)	(1.226)
$\mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			-6.047*	-4.012**	-1.831*	-0.725	-4.283
			(3.107)	(1.688)	(0.921)	(0.542)	(2.607)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			**6.202****	**3.358***	**2.970***	**1.914****	**3.518**
			(2.833)	**(1.844)**	**(1.639)**	**(0.924)**	**(2.245)**
R-Squared	0.47	0.50	0.48	0.39	0.13	0.19	0.36
Observations	186,345	126,360	312,739	324,068	444,726	414,897	367,128
Issuer FE	✓	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓	✓	✓	✓

Table 10
Large Redemptions from LS Funds and Bond Returns

This table reports OLS estimates for the following panel regression:

$$\begin{aligned} Abn.\,Return_{j,t} = {} & \beta_0 + \beta_1\, \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_2\, \mathbb{1}[Flow_t \in [0\%, 20\%]] + \beta_3\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in [0\%, 20\%]] \\ & + \beta_4\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[LR\,Period] + \beta_5\, \mathbb{1}[Flow_t \in [0\%, 20\%]] \times \mathbb{1}[LR\,Period] \\ & + \beta_6\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in [0\%, 20\%]] \times \mathbb{1}[LR\,Period] + \beta_7\, Agg.\,Flows_t \\ & + \gamma'\, \mathbf{M_{j,t}} + \eta_s + \varepsilon_{j,t}\,. \end{aligned}$$

The dependent variable, $Abn.\,Return_{j,t}$, denotes the percentage abnormal return of bond j in month t. For a given bond, the abnormal return is calculated as the difference between the bond's excess return and the bond market model excess return. In columns 1-3, the market factor is the bond's credit-rating-matched index. In column 4, the bond market model excess return is computed using the two-factor model proposed by van Binsbergen et al. (2025). In both cases, factor exposures are estimated over a 36-month rolling window. $\mathbb{1}[Constr.\,Bond_{j,t}]$ is an indicator that is one if the bond is defined as constrained during month t and zero otherwise. $\mathbb{1}[Flow \in [0\%, 20\%]]$ is an indicator that is one if the aggregate flows to LS funds in month t are in the bottom 20 percent of the sample and zero otherwise. $\mathbb{1}[LR\,Period]$ is an indicator that is one in the leverage ratio period (01/2015 - 12/2019) and zero otherwise. $\mathbf{M_{j,t}}$ denotes a vector of bond-level controls, including log(1 + bond age), log(1 + bond maturity), log(1 + bond issue size), flow-induced fire purchases and sales, as well as upgrade and downgrade indicators. We also include aggregate bond fund flows, computed as the sum of dollar flows across all share classes and bond funds, presented as a fraction of aggregate fund TNA at the beginning of the month. The sample includes only investment-grade bonds. η_s denotes issuer fixed effects. Standard errors, double-clustered by issuer and year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

Dependent Variable	Abnormal Bond Return (1-Factor Model)			Abnormal Bond Return (2-Factor Model)
Regulatory Period	LR	Pre-LR	All	
	(1)	(2)	(3)	(4)
$\mathbb{1}[Constr.\,Bond]$	-0.088***	-0.088***	-0.090***	-0.108***
	(0.022)	(0.018)	(0.020)	(0.018)
$\mathbb{1}[\text{Flow} \in [0\%, 20\%)]$	0.093	0.248**	0.227*	0.036
	(0.114)	(0.114)	(0.122)	(0.091)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[\text{Flow} \in [0\%, 20\%)]$	**-0.147****	0.058	0.063	0.081*
	(0.059)	(0.073)	(0.072)	(0.041)
$\mathbb{1}[LR\,Period]$			-0.128***	-0.042
			(0.047)	(0.044)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LR\,Period]$			-0.003	0.010
			(0.033)	(0.024)
$\mathbb{1}[\text{Flow} \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			-0.099	0.040
			(0.163)	(0.145)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			**-0.206****	**-0.184****
			(0.092)	**(0.082)**
R-Squared	0.02	0.02	0.02	0.02
Observations	259,879	184,835	444,726	444,726
Issuer FE	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓

Table 11
Leverage Constraints, Bond Illiquidity, and Bond Returns around the COVID-19 Outbreak

This table reports OLS estimates for the following panel regression:

$$
\begin{aligned}
Y_{j,t} &= \beta_1\, \mathbb{1}[March\ 2020] + \beta_2\, \mathbb{1}[Constr.\, Bond_{j,t-1}] \\
&\quad + \beta_3\, \mathbb{1}[Constr.\, Bond_{j,t-1}] \times \mathbb{1}[March\ 2020] + \beta_4\, Agg.\, Flows_t + \eta_s + \gamma'\, \mathbf{M_{j,t}} + \varepsilon_{j,t}\,.
\end{aligned}
$$

The dependent variable, $Y_{j,t}$, is the average illiquidity (column 1) or the percentage abnormal return (column 2) of bond j in month t. The average illiquidity is the equally-weighted average of daily illiquidity across all trading days in a given month. We proxy for daily bond illiquidity by the first principal component of four individual liquidity measures: the interquartile range measure, the Hendershott and Madhavan (2015) cost measure, the imputed round-trip cost, and the effective bid-ask spread. For a given bond, the abnormal return is calculated as the difference between the bond's excess return and the bond market model excess return, where the market factor is the bond's credit-rating-matched index. In March 2020, we end the computation of the illiquidity measure, as well as the bond return, before the announcement of the Secondary Market Corporate Credit Facility (SMCCF) by the Federal Reserve on March 23, 2020. $\mathbb{1}[March\, 2020]$ is an indicator that is one during the first 22 calendar days in March 2020, and zero otherwise. $\mathbb{1}[Constr.\, Bond_{j,t-1}]$ is an indicator that is one if the bond is defined as constrained during month $t-1$, and zero otherwise. $\mathbf{M_{j,t}}$ denotes a vector of bond-level controls including log(1 + bond age), log(1 + bond maturity), log(1 + bond issue size), and flow-induced fire purchases and sales. We also include aggregate bond fund flows, computed as the sum of dollar flows across all share classes and funds, presented as a fraction of aggregate fund TNA at the beginning of the month. η_s denotes bond issuer fixed effects. The sample includes only investment-grade bonds during the period from January 2 to March 22, 2020. Standard errors, clustered by issuer, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Dependent Variable	Average Illiquidity	Abnormal Bond Return
	(1)	(2)
$\mathbb{1}[March\, 2020]$	88.445***	0.315
	(6.159)	(0.239)
$\mathbb{1}[Constr.\, Bond_{j,t-1}]$	-9.316***	0.144*
	(1.689)	(0.081)
$\mathbb{1}[March\, 2020] \times \mathbb{1}[Constr.\, Bond_{j,t-1}]$	**12.244****	**-1.305*****
	(4.992)	**(0.318)**
R-Squared	0.52	0.27
Observations	9,568	12,973
Issuer FE	✓	✓
Bond controls	✓	✓

Internet Appendix

Variable Definitions and Data Sources

This table defines the variables used in the analyses.

Variable	Definition
Fund-level variables	
<u>*Frequency:*</u> *fund-month or coarser, depending on each fund's reporting frequency.*	
<u>*Source:*</u> *Morningstar, Morningstar Direct, CRSP, and Regulatory TRACE.*	
Alpha	The fund's monthly return minus the benchmark return. The benchmark return is calculated using the factor model of Chen and Qin (2017). The factor loadings are estimated on a rolling basis, using the most recent 24 months.
Avg. maximum rear load	Value-weighted average across all share classes of the maximum charge for redeeming the mutual fund shares, as of the previous report date.
Bank affiliation	Dummy variable that equals one if either the fund management company or the fund advisor is affiliated with a bank dealer, and zero otherwise.
Broker affiliation	Dummy variable that equals one if the fund's family is affiliated with a (FINRA-registered) broker-dealer institution, and zero otherwise. The variable is obtained directly from Anand et al. (2021).
Cash as % of portfolio	Holdings of cash and cash equivalents, as a percentage of TNA, as of the previous report date.
Corporate bonds as % of portfolio	Holdings of corporate bonds, as a percentage of TNA, as of the previous report date.
Flow	Sum of dollar flows across all share classes in the current month, as a fraction of TNA at the beginning of the month. Aggregate flow is the value-weighted average flow of all taxable bond mutual funds.

Variable Definitions and Data Sources [continued]

Variable	Definition
Government bonds as % of portfolio	Holdings of (U.S. and foreign) government bonds, as a percentage of TNA, as of the previous report date.
log(1 + Fund age)	Natural log of 1 plus the fund's age in years, as of the previous report date.
log(1 + Fund TNA)	Natural log of 1 plus the fund's total net assets (TNA) in dollars, as of the previous report date.
log(1 + Family TNA)	Natural log of 1 plus the TNA in dollars of all taxable bond funds in the fund's family, as of the previous report date.
log(1 + Portfolio avg. bond age)	Natural log of 1 plus the value-weighted average bond age in years, based on the offering date of each bond from Mergent FISD and the fund's portfolio positions as of the previous report date from Morningstar. The offering dates from Mergent FISD are only available for corporate bonds.
log(1 + Portfolio avg. bond issue size)	Natural log of 1 plus the value-weighted average bond issue size in $1,000, based on the offering amount of each bond from Mergent FISD and the fund's portfolio positions as of the previous report date from Morningstar. The offering amounts from Mergent FISD are only available for corporate bonds.
Portfolio avg. coupon rate	Value-weighted average coupon rate, based on the coupon rate and the market value of each bond position as of the previous report date from Morningstar.
Portfolio avg. credit rating	Value-weighted average credit rating, based on the credit ratings from Moody's, S&P, and Fitch (obtained through Mergent FISD) and the fund's portfolio positions as of the previous report date from Morningstar. The ratings are only available for corporate bonds. If the ratings are available from all three agencies, the middle rating is used. If the ratings are available from two agencies, the worse rating is used. Rating scales are 1 for AAA (and equivalent), 2 for AA+, 3 for AA, and so on.
Portfolio average duration	Average modified duration in years, based on the authors' calculation given bond characteristics from Morningstar and Mergent FISD, within a fund's portfolio, weighted using the market value of each bond position as of the previous report date from Morningstar. Equity duration is assumed to be zero.
Return	Value-weighted average of return across all share classes in the current month.

Variable Definitions and Data Sources [continued]

Variable	Description
LS score	Liquidity supply score of the fund in the current month, calculated as in Anand et al. (2021).
LS fund	Dummy variable that equals one if the moving average of the fund-specific monthly *LS_score* over the past 24 months is positive, and zero otherwise.
LS fund performance$_{t-1,t-12}$	12-month rolling average of the equally-weighted average monthly alpha of all LS funds. This is a time-series variable.
Position-level variables	
Frequency: fund-bond-month or coarser, depending on each fund's reporting frequency.	
Source: Morningstar, unless specified.	
Position change (in basis point of fund TNA)	Change in the fund's position in a bond as a fraction of the fund's total net assets (TNA) on the previous report date ($t-1$). All position changes are calculated using prices at $t-1$. Values are expressed in basis points.
Trade return	Change in position of fund i in bond j from period $t-1$ to t (scaled by the fund's TNA at $t-1$) multiplied by the abnormal return of bond j from period t to $t+1$. Values are expressed in basis points.
Bond-level variables	
Frequency: bond-month	
Source: Mergent FISD, Morningstar and Regulatory TRACE.	
Abnormal return	Abnormal return is calculated as the difference between the bond's excess return and the bond market model excess return, where the excess return is the return minus the risk-free rate, proxied by the one-month Treasury bill rate. We consider two versions of bond market model. The first version is a one-factor model, in which we use the credit-rating-matched bond index return as the return of the relevant market portfolio. The second version is the duration-adjusted bond market CAPM, a two-factor model proposed by van Binsbergen et al. (2025). The model considers as separate factors the duration-matched Treasury return and the duration-adjusted return components of the corporate bond market return. In both cases, factor exposures are estimated over a 36-month rolling window.

Variable Definitions and Data Sources [continued]

Variable	Description
Flow-induced fire sales (FIFS) and *Flow-induced fire purchases (FIFP)*	Following Coval and Stafford (2007), $FIFS_{j,t}$ is the sum of notional sales driven by redemptions in bond j in month t across all funds, normalized by the bond's issue size. Only redemptions from funds experiencing flows in the bottom decile (largest outflows, pooled sort) of the January 2010-March 2020 sample are assumed to trigger fire sales. $$FIFS_{j,t} = \frac{\sum_i -1 \times \mathbb{1}_{\text{flow in bottom decile}} \times (H_{i,j,t} - H_{i,j,t-1} \| H_{i,j,t} < H_{i,j,t-1})}{Issue\,Size_j}$$ where $\mathbb{1}_{\text{flow in bottom decile}}$ is a dummy variable that equals 1 if $Flow_{i,t}$ is in the bottom decile of the sample, and zero otherwise; $H_{i,j,t}$ is the par amount (in dollars) of bond j held by fund i at the end of month t; and, $Issue\,Size_j$ is the issue size (in dollars) of bond j. Similarly, $FIFP_{j,t}$ is defined as: $$FIFP_{j,t} = \frac{\sum_i \mathbb{1}_{\text{flow in top decile}} \times (H_{i,j,t} - H_{i,j,t-1} \| H_{i,j,t} > H_{i,j,t-1})}{Issue\,Size_j}$$
Bond illiquidity	First principal component of four standard metrics of corporate bond liquidity: the Hendershott and Madhavan (2015) cost measure, the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure (Adrian et al. 2017).
- *Hendershott & Madhavan cost measure*	Following Hendershott and Madhavan (2015), we estimate transaction costs for customer-dealer trades as the log ratio of the trade price to the most recent inter-dealer price, multiplied by trade direction from the customer's perspective (1 for purchases, –1 for sales). We scale this measure by 10,000 to express costs in basis points. Since corporate bonds trade infrequently, the inter-dealer benchmark may be stale. To reduce noise and outliers, we restrict inter-dealer trades to those occurring within the past 10 trading days.
- *Effective bid-ask spread*	Following Boyarchenko et al. (2021), we define the daily effective bid-ask spread as the difference between the trade-size-weighted average prices of trades in which customers buy from dealers and those in which customers sell to dealers. We set negative observations to zero to maintain the intuition of the measure as a transaction cost. We aggregate the effective bid-ask spread to the bond-month level by computing the volume-weighted average of the daily measure.

Variable Definitions and Data Sources [continued]

Variable	Description
- *Imputed round-trip cost*	Following Dick-Nielsen et al. (2012), we impute a round-trip of trades by identifying all trades in a respective bond that have the same trade size and occur on the same date. We then compute the percentage difference between the highest price and the lowest price within an imputed round-trip. We aggregate the imputed round-trip cost to the bond-day level by computing the volume-weighted average across all round-trips within the day, and to the bond-month level by computing the volume-weighted average of the daily measure.
- *Interquartile range*	Following Schestag et al. (2016), we define the interquartile range by dividing the difference between the 75th and the 25th percentiles of intraday trade prices in a given bond by the equally-weighted average trade price of the bond on that day. We require at least three trades in the bond on a given date for the measure to be valid. We aggregate the interquartile range to the bond-month level by computing the volume-weighted average of the daily measure.
Downgrade	Dummy variable that equals one if the bond is downgraded from investment to non-investment grades within plus and minus two months from the current month, and zero otherwise.
Investment grade	Dummy variable that equals one if the bond is an investment-grade bond, and zero otherwise. An investment-grade bond is a bond whose credit rating is equivalent to BBB- or better. The credit ratings are from Moody's, S&P, and Fitch. If the ratings are available from all three agencies, the middle rating is used. If the ratings are available from two agencies, the worse rating is used.
log(1 + bond age)	Natural log of 1 plus the bond's age in years. Age is the time between the offering date and a particular date.
log(1 + bond issue size)	Natural log of 1 plus the bond's issue size in $1,000. Issue size is the offering amount as reported by Mergent FISD.
log(1 + bond maturity)	Natural log of 1 plus the bond's maturity in years. Maturity is the time between a particular date and the bond's maturity date.
Mutual fund ownership	Ownership in a particular bond of all taxable bond mutual funds in the Morningstar database, as of the previous report date, computed as a fraction of the bond issue size.

Variable Definitions and Data Sources [continued]

Variable	Description
Return	Current month return, calculated as the percentage change in volume-weighted average price (VWAP) from the last day on which there are transactions in the previous month to the last day on which there are transactions in the current month. Only returns calculated from VWAP that lie in the last 10 days of each month are used. In case, there are no transactions during the last 10 days of the previous month but there are transactions in the first 10 days of the current month, the previous month VWAP is replaced by the VWAP from the first day on which there are transactions in the current month. We include the accrued interest and the coupon payments, if any, and compute the monthly bond return in month t as: $$r_{j,t} = \frac{P_{j,t} + AI_{j,t} + C_{j,t}}{P_{j,t-1} + AI_{j,t-1}} - 1,$$ where $P_{j,t}$ denotes the volume-weighted transaction price, $AI_{j,t}$ denotes the accrued interest, and $C_{j,t}$ is the coupon payment. Duration-adjusted bond return is the difference between a bond's return, $r_{j,t}$, and its duration-matched risk-free return.
Upgrade	Dummy variable that equals one if the bond is upgraded from non-investment to investment grades within plus and minus two months from the current month, and zero otherwise.

Figure A1: Non-LS Funds' Liquidity Supply over Time

This figure displays the coefficients β_k for $k \in \{2010, \ldots, 2019\} \setminus \{2014\}$ from the regression:

$$
\begin{aligned}
Fund\,Position\,Change_{i,j,t} = \beta_0 + \beta_1\,\mathbb{1}[QE] + \sum_{k=2010\,\setminus\,\{2014\}}^{2019} \beta_k\,\mathbb{1}[Year = k] \times \mathbb{1}[QE] \\
+ \theta_1'\,\mathbf{M_{j,t}} + \theta_2'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,.
\end{aligned}
$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[Year = k]$ is an indicator that is one in year k. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. Standard errors are double-clustered at the fund and year-quarter level. The gray shaded area represents the 90% confidence interval. The regression sample is restricted to non-LS funds and investment-grade bonds.

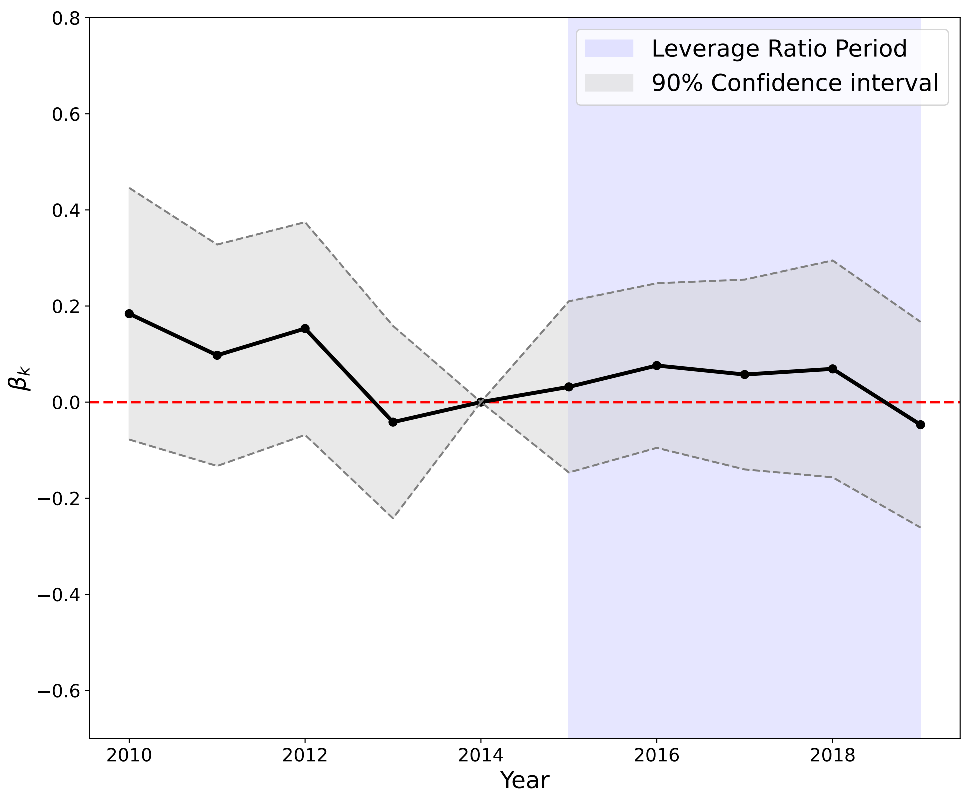


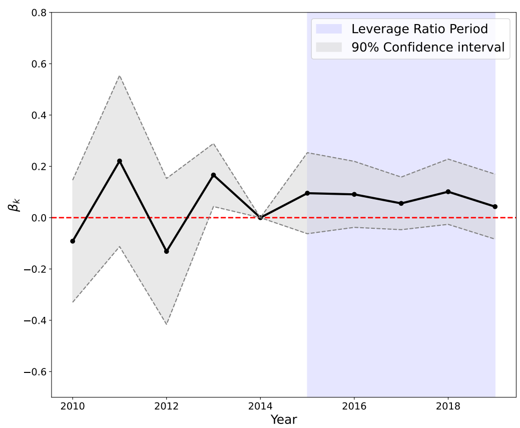
Figure A2: Fund Liquidity Supply over Time in Constrained and Unconstrained Bonds

This figure displays the coefficients β_k for $k \in \{2010, \ldots, 2019\} \setminus \{2014\}$ from the regression:

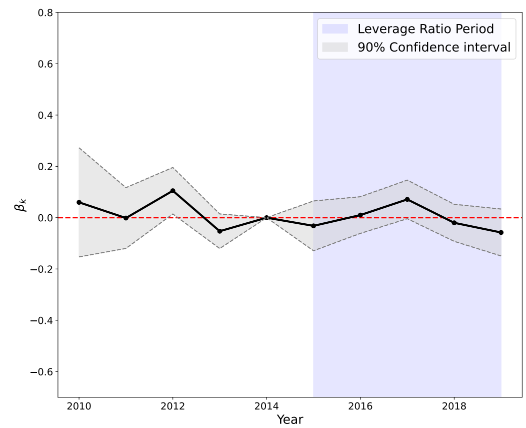
$$
\begin{aligned}
Fund\,Position\,Change_{i,j,t} = \beta_0 + \beta_1\, \mathbb{1}[QE] + \sum_{k=2010 \setminus \{2014\}}^{2019} \beta_k\, \mathbb{1}[Year = k] \times \mathbb{1}[QE] \\
+ \boldsymbol{\theta_1'}\, \mathbf{M_{j,t}} + \boldsymbol{\theta_2'}\, \mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,.
\end{aligned}
$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[Year = k]$ is an indicator that is one in year k. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. Standard errors are double-clustered at the fund and year-quarter level. The gray shaded areas represent the 90% confidence intervals. Panel (a) (Panel (c)) is restricted to LS funds and investment-grade bonds in the bottom (top) 40% of the bond constraint distribution. Panel (b) (Panel (d)) is restricted to non-LS funds and investment-grade bonds in the bottom (top) 40% of the bond constraint distribution.

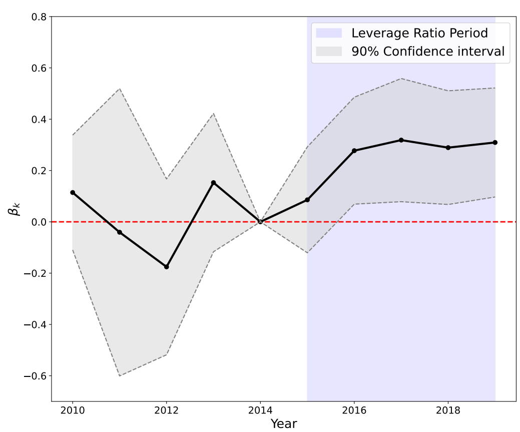
Figure A2 — continued



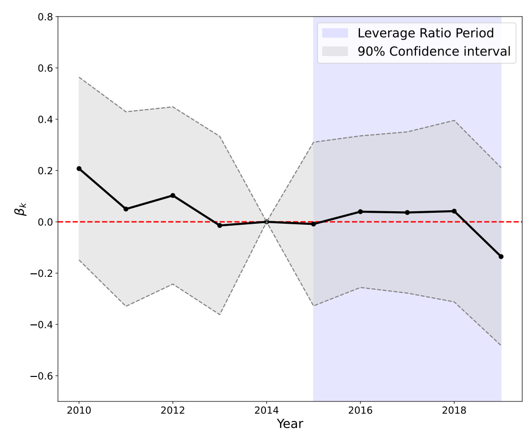
(a) LS Funds & Unconstrained Bonds



(b) Non-LS Funds & Unconstrained Bonds



(c) LS Funds & Constrained Bonds



(d) Non-LS Funds & Constrained Bonds

Table A1
Determinants of Bond Constrainedness

We estimate cross-sectional logistic regressions of the constrained bond indicator on the variables displayed in the table. We report the time-series average of the monthly estimates. *Bond age* represents the logarithm of the bond's age (in years). *Bond maturity* represents the logarithm of the bond's maturity (in years). *Bond issue size* represents the logarithm of the bond's issue amount (in $ million). *Bond rating* represents the bond's numeric credit rating (AAA = 1). *Bond illiquidity* refers to the first principal component of four standard metrics of corporate bond liquidity computed over the first 20 calendar days of a month: the effective bid-ask spread, the imputed round-trip cost, the Hendershott and Madhavan (2015) cost measure, and the interquartile range measure. Average p-values of the cross-sectional parameter estimates are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Average Coefficients				
$\hat{\beta}_{Age}$	$\hat{\beta}_{Maturity}$	$\hat{\beta}_{Size}$	$\hat{\beta}_{Rating}$	$\hat{\beta}_{Illiquidity}$
-0.646***	0.339***	0.147*	0.189*	-0.196**
(0.000)	(0.000)	(0.090)	(0.070)	(0.040)

Table A2
Covariate Balance in the Propensity Score Matched Sample

This table displays covariate balance statistics for the one-to-one matched bond sample, distinguishing between constrained and matched unconstrained bonds. Matching is performed based on propensity score estimates computed using monthly logistic regressions of the constrained indicator on a set of bond characteristics, including *Bond age*, *Bond maturity*, *Bond issue size*, and *Bond illiquidity*. Each constrained bond in month t is matched to the unconstrained bond with the smallest absolute distance based on the estimated propensity score. We consider only unconstrained bonds in the bottom three quintiles of *Constrained Dealers' Inventory Holdings*. *Bond age* represents the logarithm of the bond's age (in years). *Bond maturity* represents the logarithm of the bond's maturity (in years). *Bond issue size* represents the logarithm of the bond's issue amount (in $ million). *Bond rating* represents the bond's numeric credit rating (AAA = 1). *Bond illiquidity* refers to the first principal component of four standard metrics of corporate bond liquidity computed over the first 20 calendar days of a month: the effective bid-ask spread, the imputed round-trip cost, the Hendershott and Madhavan (2015) cost measure, and the interquartile range measure. The last column assesses covariate balance based on the absolute value of the standardized difference in means.

	Constrained Bonds			(Matched) Unconstrained Bonds			Covariate Balance
	Obs.	Mean	Std	Obs.	Mean	Std	Std. Difference
Bond age	118,176	1.06	0.67	118,176	1.08	0.64	0.02
Bond maturity	118,176	2.05	0.71	118,176	2.05	0.73	0.00
Bond issue size	118,176	13.50	0.62	118,176	13.50	0.67	0.00
Bond rating (1 = AAA)	118,176	10.56	5.02	118,176	10.97	6.11	0.07
Bond illiquidity	118,176	-29.23	65.58	118,176	-29.01	68.72	0.00

Table A3
LS Funds' Liquidity Provision in Constrained Investment-Grade Bonds - Continuous Bond Constraint Measure

This table reproduces Table 4 using the continuous constrained dealers' inventory holdings measure (Equation 2), instead of the constrained bond indicator variable. The continuous bond constraint measure, *Constr. Bond* (*cont.*), is defined as the cumulative inventory changes of constrained bank-affiliated dealers in the bond calculated over the first 20 days of the month, scaled by the bond's issue size and expressed in percent. $Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. \leq 50\%}$ ($Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. > 50\%}$) is the continuous bond constraint measure calculated separately using only inventory changes of bank-affiliated dealers with below-(volume-weighted) median (above- (volume-weighted) median) distance to the regulatory minimum capital.

Regulatory Period	Leverage Ratio Period			
Fund Type	LS	Non-LS	All	All
	(1)	(2)	(3)	(4)
$\mathbf{1}[QE]$	0.018 (0.022)	0.058* (0.034)	0.042 (0.033)	0.046 (0.033)
$Constr.\ Bond\ (cont.)$	0.076*** (0.020)	0.185*** (0.031)	0.177*** (0.030)	
$\mathbf{1}[QE] \times Constr.\ Bond\ (cont.)$	**0.067***** **(0.022)**	-0.023 (0.037)	-0.015 (0.036)	
$\mathbf{1}[LS\ Fund]$			0.098*** (0.030)	0.098*** (0.030)
$\mathbf{1}[QE] \times \mathbf{1}[LS\ Fund]$			0.008 (0.028)	0.006 (0.028)
$Constr.\ Bond\ (cont.) \times \mathbf{1}[LS\ Fund]$			-0.088** (0.036)	
$\mathbf{1}[QE] \times Constr.\ Bond\ (cont.) \times \mathbf{1}[LS\ Fund]$			**0.072**** **(0.029)**	
$Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. \leq 50\%}$				0.186*** (0.059)
$\mathbf{1}[QE] \times Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. \leq 50\%}$				-0.089 (0.072)
$Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. > 50\%}$				0.173*** (0.023)
$\mathbf{1}[QE] \times Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. > 50\%}$				0.029 (0.036)
$Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. \leq 50\%} \times \mathbf{1}[LS\ Fund]$				-0.113** (0.044)
$\mathbf{1}[QE] \times Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. \leq 50\%} \times \mathbf{1}[LS\ Fund]$				**0.115**** **(0.047)**
$Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. > 50\%} \times \mathbf{1}[LS\ Fund]$				-0.072 (0.043)
$\mathbf{1}[QE] \times Constr.\ Bond\ (cont.)_{\Delta\, LR\, Min. > 50\%} \times \mathbf{1}[LS\ Fund]$				0.047 (0.036)
Observations	1,410,791	1,895,858	3,308,036	3,308,036
R-squared	0.10	0.10	0.09	0.09
Bond x Year FE	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓

Table A4
Fund Liquidity Provision in Constrained Investment-Grade Bonds - Distinguishing Bank Dealers' Regulatory Reporting Standards

This table considers different definitions of $\mathbb{1}[Constr.\,Bond]$. Specifically, in columns 1-3, we consider only those dealers subject to the leverage ratio constraint who report the leverage ratio based on quarter averages (U.S. bank dealers and U.K. bank dealers from 2017 onwards). In columns 4-6, we consider only those dealers subject to the leverage ratio constraints who report the leverage ratio based on quarter-end snapshots (European and Japanese bank dealers and U.K. bank dealers before 2017). The table displays estimates for the regression:

$$
\begin{aligned}
Fund\,Position\,Change_{i,j,t} = {} & \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[Constr.\,Bond_{j,t}] + \beta_3\,\mathbb{1}[LS\,Fund_{i,t}] \\
& + \beta_4\,\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_5\,\mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr.\,Bond_{j,t}] \\
& + \beta_6\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] + \beta_7\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr\,Bond_{j,t}] \\
& + \boldsymbol{\theta_1'}\,\mathbf{M_{j,t}} + \boldsymbol{\theta_2'}\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,.
\end{aligned}
$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. $\mathbb{1}[LS\,Fund_{i,t}]$ is an indicator that is one if the fund is defined as a liquidity-supplying fund and zero otherwise. The constrained bond indicator, $\mathbb{1}[Constr.\,Bond_{j,t}]$, is calculated separately for each constrained dealer subset−that is, for those bank dealers reporting quarter averages and for those reporting quarter-end snapshots of the leverage ratio. Specifically, following our definition in Equation 2, we sum the constrained dealers' changes in inventory separately for each dealer subset. Bonds are then defined as constrained if they are in the top quintile of the group-specific distribution of cumulative inventory holdings. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. The sample includes only positions in investment-grade bonds during the leverage ratio period. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Cont'd next page

Table A4 - continued

Regulatory Period	Leverage Ratio Period					
Dealer Regulatory Reporting Standard	Quarter-Averaging			Quarter-End		
Fund Type	LS	Non-LS	All	LS	Non-LS	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{1}[QE]$	0.038	0.052*	0.036	0.037	0.057**	0.040
	(0.022)	(0.027)	(0.025)	(0.022)	(0.027)	(0.025)
$\mathbb{1}[Constr.\,Bond]$	-0.011	-0.097***	-0.090**	0.037	0.037	0.049
	(0.015)	(0.023)	(0.027)	(0.024)	(0.038)	(0.044)
$\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond]$	**0.098*****	-0.002	0.012	**0.087****	-0.097	-0.083
	(0.033)	(0.040)	(0.038)	**(0.039)**	(0.063)	(0.062)
$\mathbb{1}[LS\,Fund]$			0.024			0.030
			(0.023)			(0.023)
$\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund]$			0.032			0.030
			(0.023)			(0.022)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LS\,Fund]$			0.069			-0.027
			(0.042)			(0.067)
$\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LS\,Fund]$			**0.072***			**0.156****
			(0.035)			**(0.061)**
Observations	1,345,118	1,796,177	3,142,706	1,196,929	1,574,279	2,772,599
R-squared	0.11	0.10	0.09	0.11	0.11	0.10
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓	✓	✓

Table A5
Fund Liquidity Provision in Constrained and Unconstrained Bonds - Propensity Score Matched Sample

This table reproduces the first three columns of Table 4 in the matched sample of constrained and unconstrained bonds. We restrict the sample to investment-grade bonds and the leverage ratio period (01/2015-12/2019). Propensity scores are estimated based on a monthly cross-sectional logistic regression of the constrained bond indicator on a set of bond characteristics, including *Bond age*, *Bond maturity*, *Bond issue size*, and *Bond illiquidity*. *Bond age* represents the logarithm of the bond's age (in years). *Bond maturity* represents the logarithm of the bond's maturity (in years). *Bond issue size* represents the logarithm of the bond's issue amount (in $ million). *Bond rating* represents the bond's numeric credit rating (AAA = 1). *Bond illiquidity* refers to the first principal component of four standard metrics of corporate bond liquidity computed over the first 20 calendar days of a month: the effective bid-ask spread, the imputed round-trip cost, the Hendershott and Madhavan (2015) cost measure, and the interquartile range measure. Each constrained bond in month t is matched, with replacement, to the unconstrained bond in month t with the smallest absolute distance based on the estimated propensity score. We consider only unconstrained bonds in the bottom three quintiles of *Constrained Dealers' Inventory Holdings*. Standard errors, double-clustered by fund and year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Regulatory Period	Leverage Ratio Period		
Bond Type	Investment-Grade		
Fund Type	LS	Non-LS	All
	(1)	(2)	(3)
$\mathbf{1}[QE]$	0.058*	0.092**	0.066
	(0.031)	(0.039)	(0.038)
$\mathbf{1}[Constr.\,Bond]$	0.028	0.065	0.086*
	(0.023)	(0.044)	(0.042)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond]$	**0.105****	-0.052	-0.022
	(0.038)	(0.067)	(0.064)
$\mathbf{1}[LS\,Fund]$			0.118***
			(0.039)
$\mathbf{1}[QE] \times \mathbf{1}[LS\,Fund]$			0.041
			(0.037)
$\mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			-0.025
			(0.053)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			**0.093***
			(0.046)
Observations	462,557	691,795	1,155,652
R-Squared	0.16	0.15	0.13
Bond x Year FE	✓	✓	✓
Bond Controls	✓	✓	✓
Fund Controls	✓	✓	✓

Table A6
LS Funds' Trading in Investment-Grade Bonds across Regulatory Periods - Alternative LS Fund Definition

This table replicates Table 2 using an alternative definition of LS funds. Funds with a rolling average LS score over the previous 24 months above the 80th percentile of the full panel (pooled sort) are classified as liquidity-supplying (LS), while all other funds are classified as liquidity-demanding (non-LS).

Regulatory Period	Leverage Ratio	Pre-Leverage Ratio	All	
	(1)	(2)	(3)	(4)
$\mathbb{1}[QE]$	**0.068****	-0.051	-0.078	-0.051
	(0.030)	(0.057)	(0.055)	(0.056)
$\mathbb{1}[QE] \times \mathbb{1}[LR\ Period]$			**0.157****	**0.118***
			(0.060)	**(0.062)**
Observations	1,043,568	382,913	1,426,481	1,426,481
R-squared	0.12	0.16	0.14	0.14
Bond x Year FE	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓
Controls interacted with $\mathbb{1}[LR\ Period]$	–	–	–	✓

Table A7
Fund Liquidity Provision across Regulatory Periods - Placebos & Alternative LS Fund Definition

This table replicates Table 3 using an alternative definition of LS funds. Funds with a rolling average LS score over the previous 24 months above the 80th percentile of the full panel (pooled sort) are classified as liquidity-supplying (LS), while all other funds are classified as liquidity-demanding (non-LS).

Fund Type	Non-LS Funds			LS Funds		
Bond Type	Investment-Grade			High-Yield		
Regulatory Period	LR	Pre-LR	All	LR	Pre-LR	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[QE]$	0.044	0.081	0.081	0.154	0.169	0.169
	(0.026)	(0.051)	(0.050)	(0.100)	(0.131)	(0.130)
$\mathbb{1}[QE] \times \mathbb{1}[LR\ Period]$			-0.036			-0.015
			(0.056)			(0.155)
Observations	2,262,874	1,471,056	3,733,930	316,507	177,331	493,838
R-squared	0.09	0.12	0.11	0.14	0.20	0.17
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓	✓	✓
Controls interacted with $\mathbb{1}[LR\ Period]$	–	–	✓	–	–	✓

Table A8
LS Funds' Liquidity Provision and Investment-Grade Bonds' Exposure to Leverage Constraints - Alternative LS Fund Definition

This table replicates Table 4 using an alternative definition of LS funds. Funds with a rolling average LS score over the previous 24 months above the 80th percentile of the full panel (pooled sort) are classified as liquidity-supplying (LS), while all other funds are classified as liquidity-demanding (non-LS).

Regulatory Period	Leverage Ratio Period			
Fund Type	LS	Non-LS	All	
	(1)	(2)	(3)	(4)
$\mathbf{1}[QE]$	0.048*	0.050*	0.040*	0.049*
	(0.027)	(0.024)	(0.023)	(0.023)
$\mathbf{1}[Constr.\,Bond]$	0.014	-0.051**	-0.063***	
	(0.016)	(0.022)	(0.022)	
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond]$	**0.100****	-0.025	-0.013	
	(0.032)	(0.046)	(0.044)	
$\mathbf{1}[LS\,Fund]$			0.004	0.009
			(0.022)	(0.023)
$\mathbf{1}[QE] \times \mathbf{1}[LS\,Fund]$			0.037	0.023
			(0.026)	(0.026)
$\mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			0.105***	
			(0.029)	
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			**0.096****	
			(0.033)	
$\mathbf{1}[Constr.\,Bond\,\|\,\Delta\,LR\,Min. \leq 50\%]$				0.096
				(0.059)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\|\,\Delta\,LR\,Min. \leq 50\%]$				-0.065
				(0.052)
$\mathbf{1}[Constr.\,Bond\,\|\,\Delta\,LR\,Min. > 50\%]$				-0.084***
				(0.019)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\|\,\Delta\,LR\,Min. > 50\%]$				-0.005
				(0.042)
$\mathbf{1}[Constr.\,Bond\,\|\,\Delta LR\,Min. \leq 50\%] \times \mathbf{1}[LS\,Fund]$				-0.040
				(0.040)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\|\,\Delta\,LR\,Min. \leq 50\%] \times \mathbf{1}[LS\,Fund]$				**0.099****
				(0.048)
$\mathbf{1}[Constr.\,Bond\,\|\,\Delta\,LR\,Min. > 50\%] \times \mathbf{1}[LS\,Fund]$				0.121***
				(0.034)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,\|\,\Delta\,LR\,Min. > 50\%] \times \mathbf{1}[LS\,Fund]$				0.092**
				(0.042)
Observations	1,410,791	1,895,858	3,308,036	3,308,036
R-squared	0.10	0.10	0.09	0.09
Bond x Year FE	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓

Table A9
LS Funds' Liquidity Provision in Investment-Grade Bonds - Q1-3 vs. Q4

This table displays estimates for the regression:

$$\begin{aligned} Fund\,Position\,Change_{i,j,t} = \beta_0 + \beta_1\, \mathbb{1}[QE] + \beta_2\, \mathbb{1}[QE] \times \mathbb{1}[LR\ Period] \\ + \theta_1'\, \mathbf{M_{j,t}} + \theta_2'\, \mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,. \end{aligned}$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[QE]$ is an indicator variable that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. $\mathbf{1}[LR\ Period]$ is an indicator that is one during the leverage ratio period (01/2015-12/2019) and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. The sample includes only positions of LS funds in investment-grade bonds. In columns 1-3, we further restrict the sample to quarters 1, 2, and 3. In columns 4-6, we restrict the sample to quarter 4. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Quarter	Quarters 1-3			Quarter 4		
Regulatory Period	LR	Pre-LR	All	LR	Pre-LR	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[QE]$	0.062*	-0.020	-0.072	0.101	-0.050	-0.192
	(0.035)	(0.060)	(0.057)	(0.057)	(0.080)	(0.112)
$\mathbb{1}[QE] \times \mathbb{1}[LR\,Period]$			**0.153****			**0.350****
			(0.062)			**(0.130)**
Observations	1,045,533	360,190	1,405,723	364,308	129,175	493,483
R-squared	0.13	0.18	0.15	0.16	0.29	0.22
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond Controls	✓	✓	✓	✓	✓	✓
Fund Controls	✓	✓	✓	✓	✓	✓

Table A10
LS Fund Liquidity Provision in Constrained Investment-Grade Bonds - Q1-3 vs. Q4

This table displays estimates for the regression:

$$\begin{aligned} Fund\,Position\,Change_{i,j,t} = {} & \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[Constr.\,Bond_{j,t}] + \beta_3\,\mathbb{1}[LS\,Fund_{i,t}] \\ & + \beta_4\,\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_5\,\mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr.\,Bond_{j,t}] \\ & + \beta_6\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] + \beta_7\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr\,Bond_{j,t}] \\ & + \theta_1'\,\mathbf{M_{j,t}} + \theta_2'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,. \end{aligned}$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in position of fund i in bond j in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[QE]$ is an indicator variable that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. $\mathbb{1}[LS\,Fund_{i,t}]$ is an indicator that is one if the fund is defined as a liquidity-supplying fund and zero otherwise. $\mathbb{1}[Constr.\,Bond_{j,t}]$ is an indicator variable that equals one if the bond is defined as constrained and zero otherwise. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. The sample includes only positions of LS funds in investment-grade bonds. In columns 1-3, we further restrict the sample to quarters 1, 2, and 3. In columns 4-6, we restrict the sample to quarter 4. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

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Table A10 - continued

Quarter	Quarters 1-3			Quarter 4		
Fund Type	LS	Non-LS	All	LS	Non-LS	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{1}[QE]$	0.045	0.076*	0.051	0.121*	0.170**	0.135**
	(0.035)	(0.036)	(0.031)	(0.053)	(0.043)	(0.036)
$\mathbb{1}[Constr.\,Bond]$	-0.003	-0.072*	-0.070*	0.038	-0.029	-0.036
	(0.017)	(0.039)	(0.038)	(0.024)	(0.033)	(0.030)
$\mathbf{1}[QE] \times \mathbb{1}[Constr.\,Bond]$	0.088**	-0.074	-0.061	-0.120	-0.462**	-0.389**
	(0.037)	(0.064)	(0.060)	(0.066)	(0.128)	(0.118)
$\mathbf{1}[LS\,Fund]$			0.030			0.026
			(0.029)			(0.024)
$\mathbf{1}[QE] \times \mathbf{1}[LS\,Fund]$			0.034			0.047
			(0.038)			(0.022)
$\mathbb{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			0.062			0.079*
			(0.055)			(0.035)
$\mathbf{1}[QE] \times \mathbb{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$			**0.140****			**0.166****
			(0.050)			**(0.056)**
Observations	1,045,533	1,410,918	2,457,924	364,308	484,035	849,715
R-squared	0.13	0.12	0.11	0.16	0.17	0.14
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond Controls	✓	✓	✓	✓	✓	✓
Fund Controls	✓	✓	✓	✓	✓	✓

Table A11
LS Funds' Liquidity Provision and Investment-Grade Bonds' Exposures to Leverage Constraints and Volcker Rule Constraints

This table displays estimates for the regression:

$$
\begin{aligned}
Fund\,Position\,Change_{i,j,t} = {} & \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[Constr.\,Bond_{j,t}] + \beta_3\,\mathbb{1}[LS\,Fund_{i,t}] \\
& + \beta_4\,\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_5\,\mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr.\,Bond_{j,t}] \\
& + \beta_6\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] + \beta_7\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] \times \mathbb{1}[Constr.\,Bond_{j,t}] \\
& + \beta_8\,\mathbf{1}[Constr.\,Bond_{j,t}\,|\,Volcker\,constr.] \\
& + \beta_9\,\mathbb{1}[QE] \times\ \mathbf{1}[Constr.\,Bond_{j,t}\,|\,Volcker\,constr.] \\
& + \beta_{10}\,\mathbb{1}[LS\,Fund_{i,t}] \times\ \mathbf{1}[Constr.\,Bond_{j,t}\,|\,Volcker\,constr.] \\
& + \beta_{11}\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] \times \mathbf{1}[Constr.\,Bond\,|\,Volcker\,constr.] \\
& + \beta_{12}\,\mathbf{1}[Constr.\,Bond_{j,t}\,|\,Volcker\,unconstr.] \\
& + \beta_{13}\,\mathbb{1}[QE] \times\ \mathbf{1}[Constr.\,Bond_{j,t}\,|\,Volcker\,unconstr.] \\
& + \beta_{14}\,\mathbb{1}[LS\,Fund_{i,t}] \times\ \mathbf{1}[Constr.\,Bond_{j,t}\,|\,Volcker\,unconstr.] \\
& + \beta_{15}\,\mathbb{1}[QE] \times \mathbb{1}[LS\,Fund_{i,t}] \times \mathbf{1}[Constr.\,Bond_{j,t}\,|\,Volcker\,unconstr.] \\
& + \theta_1'\,\mathbf{M_{j,t}} + \theta_2'\,\mathbf{M_{i,t}} + \eta_j \times \lambda_y + \varepsilon_{i,j,t}\,.
\end{aligned}
$$

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in bond j of fund i in period t, relative to the fund's TNA at the end of the previous period ($TNA_{i,t-1}$), and is expressed in basis points. $\mathbb{1}[QE]$ is an indicator variable that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. $\mathbb{1}[LS\,Fund_{i,t}]$ is an indicator that is one if the fund is defined as a liquidity-supplying fund and zero otherwise. $\mathbb{1}[Constr.\,Bond]$ is an indicator that equals one if the bond is defined as constrained in period t by the leverage ratio and zero otherwise. $\mathbf{1}[Constr.\,Bond\,|\,Volcker\,constr.]$ is an indicator variable that equals one if the bond is defined as constrained in period t based on the inventories of U.S. bank-affiliated dealers subject to the Volcker Rule, whose 30-day proxies for market-making activity fall on average below the volume-weighted sample median. $\mathbf{1}[Constr.\,Bond\,|\,Volcker\,unconstr.]$ is defined analogously, using the inventories of U.S. bank-affiliated dealers subject to the Volcker Rule, whose market-making proxies fall above the volume-weighted sample median. We use three proxies for market-making activity: Inventory turnover, the share of customer-dealer trades, and the share of agency capacity trades. Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). $M_{j,t}$ represents bond controls and includes log(1 + bond age), log(1 + bond maturity), downgrade and upgrade indicators, and bond illiquidity. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. The sample includes only positions in investment-grade bonds during the leverage ratio period. Standard errors, double-clustered at the fund and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

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Table A11 - continued

Regulatory Period	Leverage Ratio	
Fund Type	All	
	(1)	(2)
$\mathbf{1}[QE]$	0.026 (0.026)	0.029 (0.026)
$\mathbf{1}[Constr.\,Bond\,|\,Volcker\,constr.]$	0.027 (0.028)	0.064* (0.033)
$\mathbf{1}[LS\,Fund]$	0.038 (0.024)	0.034 (0.023)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,|\,Volcker\,constr.]$	-0.003 (0.070)	0.020 (0.068)
$\mathbf{1}[QE] \times \mathbf{1}[LS\,Fund]$	0.041 (0.026)	0.035 (0.025)
$\mathbf{1}[Constr.\,Bond\,|\,Volcker\,constr.] \times \mathbf{1}[LS\,Fund]$	0.050 (0.043)	0.014 (0.036)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,|\,Volcker\,constr.] \times \mathbf{1}[LS\,Fund]$	0.043 (0.061)	0.002 (0.060)
$\mathbf{1}[Constr.\,Bond\,|\,Volcker\,unconstr.]$	-0.035 (0.036)	-0.007 (0.036)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,|\,Volcker\,unconstr.]$	0.048 (0.042)	0.067 (0.044)
$\mathbf{1}[Constr.\,Bond\,|\,Volcker\,unconstr.] \times \mathbf{1}[LS\,Fund]$	-0.014 (0.039)	-0.040 (0.034)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond\,|\,Volcker\,unconstr.] \times \mathbf{1}[LS\,Fund]$	0.030 (0.044)	-0.002 (0.045)
$\mathbf{1}[Constr.\,Bond]$		-0.081** (0.029)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond]$		-0.050 (0.038)
$\mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$		0.072* (0.036)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS\,Fund]$		**0.087***** **(0.030)**
R-Squared	0.09	0.09
Observations	3,308,036	3,308,036
Bond x Year FE	✓	✓
Bond controls	✓	✓
Fund controls	✓	✓

Table A12
Average Abnormal Returns on Bonds Purchased by LS Funds

This table reports average monthly abnormal returns of constrained and unconstrained bonds purchased by liquidity-supplying funds. Every month from January 2010 to December 2019, each fund's portfolio is split into two sub-portfolios containing only constrained and only unconstrained bonds, respectively. The fund's position holdings in each sub-portfolio are then restricted further to bond positions that are purchased in month t. All abnormal returns are as of month $t+1$. For a given bond, the abnormal return is calculated as the difference between the bond's excess return and the bond market model excess return, where the market factor is the bond's credit-rating-matched index. The factor loadings are estimated over a 36-month rolling window. Average constrained and unconstrained portfolio abnormal returns are computed for each fund in each month using as weight the fund's position size, and then averaged across all funds, separately for quarter-end months (March, June, September, December) and non-quarter-end months. We restrict the analysis to investment-grade bonds. We report in brackets the standard deviations of the funds' portfolio abnormal returns, and for the columns with Δ in the heading, the absolute values of t-statistics for the difference in average abnormal return between constrained and unconstrained bond purchases in quarter-end months minus the difference in average abnormal return between constrained and unconstrained bond purchases in non-quarter-end months. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Regulatory Period	Pre-Leverage Ratio			Leverage Ratio		
Portfolio Formation	Non-Quarter-End Month	Quarter-End Month	Δ	Non-Quarter-End Month	Quarter-End Month	Δ
Constrained	0.06	-0.03		-0.22	0.05	
	(1.28)	(1.29)		(0.95)	(0.81)	
Unconstrained	0.00	-0.10		-0.08	-0.07	
	(1.03)	(1.04)		(0.72)	(1.21)	
Constrained - Unconstrained	**0.06**	**0.07**	**0.01**	**-0.14**	**0.12**	**0.26****
			(0.11)			**(2.47)**

Table A13
Investment-Grade-Focused Funds' Liquidity Provision, Performance, and Flows

This table reports OLS estimates for panel regressions of an indicator of whether a fund pursues liquidity supplying strategies on the average performance of all LS funds and the fund's flows in the prior 12 months:

$$\mathbb{1}[LS\_score_{i,t} > 0] = \beta_0 + \beta_1\, LS\,Fund\,Performance_{t-1,t-12} + \beta_2\, Fund\,Flow_{i,t-1,t-12} + \beta_3\, \mathbb{1}[Bank - aff._{i,t}] + \gamma'\, \mathbf{M_{i,t}} + \eta_c + \epsilon_{i,t}\,.$$

The dependent variable, $\mathbb{1}[LS\_score_{i,t} > 0]$, is an indicator that equals one if fund i has a positive LS_score in period t and zero otherwise. $LS\,Fund\,Performance_{t-1,t-12}$ denotes the average performance of all LS funds over the past 12 months, measured as the rolling average fund alpha in percent. $Fund\,Flow_{i,t-1,t-12}$ denotes the average monthly flows in percent of fund i over the past 12 months. $\mathbb{1}[Bank-aff.]$ is an indicator that equals one if either the fund management company or the fund advisor is affiliated with a constrained bank dealer and zero otherwise. $\mathbf{M_{i,t}}$ refers to fund-level controls, which include broker affiliation dummy, time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)), and time-varying fund characteristics (log(1 + fund age), log(1 + fund size), log(1 + family size), and average maximum rear load). All controls are as of the end of period $t-1$. η_c refers to fund category fixed effects. Column 1 considers the leverage ratio period (01/2015 - 12/2019). Column 2 considers the pre-leverage ratio period (01/2010 - 12/2014). Column 3 considers all periods. The sample includes only investment-grade-focused funds. Standard errors, double-clustered at the fund and year-month level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Regulatory Period	LR	Pre-LR	All
	(1)	(2)	(3)
$LS\,Fund\,Performance_{t-1,t-12}$	**0.511***** **(0.232)**	-0.052 (0.100)	-0.040 (0.100)
$Fund\ Flow_{i,t-1,t-12}$	0.328** (0.145)	-0.056 (0.120)	-0.092 (0.124)
$\mathbb{1}[Bank - aff.]$	-0.006 (0.025)	-0.016 (0.020)	-0.010 (0.017)
$\mathbb{1}[LR\ Period]$			0.007 (0.012)
$\mathbb{1}[LR\ Period] \times LS\,Fund\,Performance_{t-1,t-12}$			**0.542***** **(0.249)**
$\mathbb{1}[LR\ Period] \times Fund\ Flow_{i,t-1,t-12}$			**0.456***** **(0.189)**
Observations	18,233	15,264	33,497
R-squared	0.02	0.01	0.01
Fund cat. FE	✓	✓	✓
Fund controls	✓	✓	✓

Table A14
Funds' Liquid Asset Holdings at Quarter Ends

This table reports OLS estimates for the following panel regression:

$$Liquid\,Asset\,Holdings_{i,t} = \beta_0 + \beta_1\,\mathbb{1}[QE] + \beta_2\,\mathbb{1}[LR\,Period] + \beta_3\,\mathbb{1}[QE] \times \mathbb{1}[LR\,Period] + \gamma'\,\mathbf{M_{i,t}} + \eta_i + \lambda_q + \varepsilon_{i,t}\,.$$

The dependent variable, $Liquid\,Asset\,Holdings_{i,t}$, denotes the cash and government bond positions as a share of TNA of fund i in period t. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. $\mathbf{1}[LR\ Period]$ is an indicator that equals one during the leverage ratio period (01/2015-12/2019) and zero otherwise. $M_{i,t}$, includes lagged flow, broker affiliation dummy, log(1 + fund age), log(1 + fund size), log(1 + family size), average maximum rear load, and time-varying portfolio characteristics (% corporate bonds, average coupon rate, average credit rating, average duration, log(1 + average bond issue size), and log(1 + average bond age)). η_i represents fund fixed effects. λ_q represents year-quarter fixed effects. Standard errors, double-clustered by fund and year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

Dependent Variable	Cash + Government Bonds as % of TNA			
Fund Type	LS Fund			Non LS-Fund
Regulatory Period	Leverage Ratio	Pre-Leverage Ratio	All	
	(1)	(2)	(3)	(4)
$\mathbb{1}[QE]$	**-0.208****	0.264	0.360***	0.178
	(0.084)	(0.163)	(0.132)	(0.188)
$\mathbb{1}[LR\ Period] \times \mathbb{1}[QE]$			**-0.560*** **	-0.331
			(0.173)	(0.227)
R-Squared	0.91	0.92	0.90	0.84
Observations	5,027	3,692	8,769	25,962
Fund FE	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓

Table A15
Bond Illiquidity, Bond Returns, and Outflows from LS Funds- Propensity Score Matched Sample

This table reproduces the first three columns of Table 9 and Table 10 using the matched sample of constrained and unconstrained bonds. The sample period is 01/2010 to 12/2019. Propensity scores are estimated based on a monthly cross-sectional logistic regression of the constrained bond indicator on a set of bond characteristics, including *Bond age*, *Bond maturity*, *Bond issue size*, and *Bond illiquidity*. *Bond age* represents the logarithm of the bond's age (in years). *Bond maturity* represents the logarithm of the bond's maturity (in years). *Bond issue size* represents the logarithm of the bond's issue amount (in $ million). *Bond rating* represents the bond's numeric credit rating (AAA = 1). *Bond illiquidity* refers to the first principal component of four standard metrics of corporate bond liquidity computed over the first 20 calendar days of a month: the effective bid-ask spread, the imputed round-trip cost, the Hendershott and Madhavan (2015) cost measure, and the interquartile range measure. Each constrained bond in month t is matched, with replacement, to the unconstrained bond in month t with the smallest absolute distance based on the estimated propensity score. We consider only unconstrained bonds in the bottom three quintiles of *Constrained Dealers' Inventory Holdings*. The sample includes only investment-grade bonds. Standard errors, double-clustered by issuer and year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

Dependent Variable	Average Illiquidity			Abnormal Return		
Regulatory Period	LR	Pre-LR	All	LR	Pre-LR	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[Constr.\,Bond]$	-2.586***	-7.710***	-8.104***	-0.121***	-0.099***	-0.104***
	(0.538)	(1.243)	(1.174)	(0.023)	(0.023)	(0.023)
$\mathbb{1}[Flow \in [0\%, 20\%)]$	-0.347	4.281	5.166	0.181	0.052	0.072
	(1.280)	(4.258)	(4.065)	(0.188)	(0.154)	(0.146)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in [0\%, 20\%)]$	**5.722****	-1.923	-1.986	**-0.137***	-0.022	-0.018
	(2.042)	(2.103)	(2.053)	**(0.078)**	(0.089)	(0.089)
$\mathbb{1}[LR\,Period]$						0.206**
						(0.078)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LR\,Period]$			5.672***			-0.020
			(1.274)			(0.034)
$\mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			-7.107*			0.076
			(4.050)			(0.187)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			**7.726*****			-0.118
			(2.807)			(0.119)
Observations	45,653	29,114	74,897	45,653	29,114	74,897
R-Squared	0.46	0.51	0.48	0.08	0.04	0.06
Issuer FE	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓			
Bond controls	✓	✓	✓	✓	✓	✓

Table A16
Bond Illiquidity, Bond Returns, and Outflows from the LS Funds at Quarter Ends

This table reports OLS estimates for the following panel regression:

$$
\begin{aligned}
Y_{j,t} &= \beta_0 + \beta_1\, \mathbb{1}[Constr.\,Bond_{j,t}] + \beta_2\, \mathbb{1}[Flow_t \in\ [0\%, 20\%]] + \beta_3\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \\
&+ \beta_4\, \mathbb{1}[QE] + \beta_5\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[QE] + \beta_6\, \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \times \mathbb{1}[QE] \\
&+ \beta_7\, \mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \times \mathbb{1}[QE] + \beta_8\, Agg.\,Flows_t + \gamma'\, \mathbf{M_{j,t}} + \eta_s + \lambda_q + \varepsilon_{j,t}\,.
\end{aligned}
$$

The dependent variables, $Y_{j,t}$, are the average illiquidity (columns 1-3) and the abnormal return (columns 4-7) of bond j in month t. The average illiquidity is the equally-weighted average of daily illiquidity across all trading days in a given month. We proxy for daily bond illiquidity by the first principal component of the following four individual liquidity measures: the interquartile range measure, the Hendershott and Madhavan (2015) cost measure, the imputed round-trip cost, and the effective bid-ask spread. The abnormal return is calculated as the difference between the bond's excess return and the bond market model excess return. In columns 4-6, the market factor is the bond's credit-rating-matched index. In column 7, the bond market model return is computed using the two-factor model proposed by van Binsbergen et al. (2025). In both cases, factor exposures are estimated over a 36-month rolling window. $\mathbb{1}[Constr.\,Bond_{j,t}]$ is an indicator that is one if the bond is defined as constrained during month t and zero otherwise. $\mathbb{1}[Flow \in\ [0\%, 20\%]]$ is an indicator that is one if the aggregate flows to LS funds in month t are in the bottom 20 percent of the sample and zero otherwise. $\mathbb{1}[QE]$ is an indicator that equals one if the period is a quarter-end month (March, June, September, December) and zero otherwise. $\mathbf{M_{j,t}}$ denotes a vector of bond-level controls, including log(1 + bond age), log(1 + bond maturity), log(1 + bond issue size), flow-induced fire purchases and sales, as well as upgrade and downgrade indicators. We also include aggregate bond mutual fund flows, computed as the sum of dollar flows across all share classes and funds, presented as a fraction of aggregate fund TNA at the beginning of the month. The sample includes only investment-grade bonds during the leverage ratio period. η_s denotes issuer fixed effects. λ_q denotes year-quarter fixed effects. Standard errors, double-clustered by issuer and year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

Dependent Variable	Average Illiquidity			Abnormal Bond Return			
Bond Pricing Model				1-Factor Model			2-Factor Model
Month	QE	Non-QE	All	QE	Non-QE	All	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\mathbb{1}[Constr.\,Bond]$	-6.837***	-7.100***	-7.161***	-0.085***	-0.084***	-0.089***	-0.118***
	(0.576)	(0.604)	(0.632)	(0.027)	(0.024)	(0.021)	(0.020)
$\mathbb{1}[Flow \in\ [0\%, 20\%)]$		-2.015	-1.356	-0.153	0.108	0.019	0.073
		(2.275)	(1.745)	(0.238)	(0.116)	(0.122)	(0.175)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in\ [0\%, 20\%)]$	**7.257*****	3.025*	2.791*	**-0.198****	-0.127*	-0.129**	-0.063
	(1.611)	(1.513)	(1.399)	**(0.076)**	(0.064)	(0.061)	(0.080)
$\mathbb{1}[QE]$			-2.135**			-0.145	-0.050
			(0.756)			(0.104)	(0.083)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[QE]$			0.380			0.008	0.056
			(0.750)			(0.044)	(0.037)
$\mathbb{1}[Flow \in\ [0\%, 20\%)] \times \mathbb{1}[QE]$			9.334***			0.212	0.338
			(2.572)			(0.222)	(0.265)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in\ [0\%, 20\%)] \times \mathbb{1}[QE]$			4.651***			-0.054	-0.094*
			(1.605)			(0.061)	(0.052)
R-Squared	0.48	0.47	0.47	0.06	0.03	0.03	0.02
Observations	62,894	123,374	186,345	87,769	172,066	259,879	259,879
Issuer FE	✓	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓				
Bond controls	✓	✓	✓	✓	✓	✓	✓

Table A17
High Yield Bonds' Illiquidity and Returns and Outflows from LS Funds - Placebos

This table reports OLS estimates for the following panel regression:

$$\begin{aligned} Y_{j,t} &= \beta_0 + \beta_1\,\mathbb{1}[Constr.\,Bond_{j,t}] + \beta_2\,\mathbb{1}[Flow_t \in\ [0\%, 20\%]] + \beta_3\,\mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \\ &+ \beta_4\,\mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[LR\,Period] + \beta_5\,\mathbb{1}[Flow_t \in\ [0\%, 20\%]] \times \mathbb{1}[LR\,Period] \\ &+ \beta_6\,\mathbb{1}[Constr.\,Bond_{j,t}] \times \mathbb{1}[Flow_t \in\ [0\%, 20\%]] \times \mathbb{1}[LR\,Period] + \beta_7\,Agg.\,Flows_t \\ &+ \gamma'\,\mathbf{M_{j,t}} + \eta_s + \lambda_q + \varepsilon_{j,t}\,. \end{aligned}$$

In columns 1-3, the dependent variable, $Average\ Illiquidity_{j,t}$, denotes the average illiquidity of bond j in month t. We proxy for daily bond illiquidity by the first principal component of the following four individual liquidity measures: the interquartile range measure, the Hendershott and Madhavan (2015) cost measure, the imputed round-trip cost, and the effective bid-ask spread. In columns 4-6, the dependent variable, $Abn.\,Return_{j,t}$, denotes the percentage abnormal return of bond j in month t. For a given bond, the abnormal return is calculated as the difference between the bond's excess return and the bond market model excess return. The market factor is the bond's credit-rating-matched index. Factor exposures are estimated over a 36-month rolling window. $\mathbb{1}[Constr.\,Bond_{j,t}]$ is an indicator that is one if the bond is defined as constrained during month t and zero otherwise. $\mathbb{1}[Flow \in\ [0\%, 20\%]]$ is an indicator that is one if the aggregate flows to LS funds in month t are in the bottom 20 percent of the sample and zero otherwise. $\mathbb{1}[LR\,Period]$ is an indicator that is one in the leverage ratio period (01/2015 - 12/2019) and zero otherwise. $\mathbf{M_{j,t}}$ denotes a vector of bond-level controls, including log(1 + bond age), log(1 + bond maturity), log(1 + bond issue size), flow-induced fire purchases and sales, as well as upgrade and downgrade indicators. We also include aggregate bond fund flows, computed as the sum of dollar flows across all share classes and bond funds, presented as a fraction of aggregate fund TNA at the beginning of the month. The sample includes only high-yield bonds. η_s denotes issuer fixed effects. λ_q denotes year-quarter fixed effects. Standard errors, double-clustered by issuer and year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

Dependent Variable	Average Illiquidity			Abnormal Return		
Regulatory Period	LR	Pre-LR	All	LR	Pre-LR	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[Constr.\,Bond]$	-6.631***	-6.027***	-6.756***	-0.208***	-0.143***	-0.139***
	(0.856)	(1.156)	(1.226)	(0.035)	(0.040)	(0.039)
$\mathbb{1}[Flow \in\ [0\%, 20\%)]$	2.966	3.053*	2.855*	-0.116	0.197	0.148
	(2.063)	(1.742)	(1.653)	(0.135)	(0.156)	(0.175)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in\ [0\%, 20\%)]$	-0.937	-2.092	-1.942	0.146	0.052	0.041
	(0.813)	(1.354)	(1.256)	(0.165)	(0.072)	(0.071)
$\mathbb{1}[LR\,Period]$						-0.033
						(0.063)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LR\,Period]$			1.071			-0.067
			(1.441)			(0.054)
$\mathbb{1}[Flow \in\ [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			-0.465			-0.157
			(2.914)			(0.245)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Flow \in\ [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$			0.339			0.131
			(1.552)			(0.172)
R-Squared	0.53	0.50	0.48	0.06	0.05	0.05
Observations	59,475	45,962	105,582	67,468	59,214	126,924
Issuer FE	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓			
Bond controls	✓	✓	✓	✓	✓	✓