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

Mariassunta Giannetti
Stockholm School of Economics, CEPR, and ECGI

Chotibhak Jotikasthira
Southern Methodist University

Andreas C. Rapp
Federal Reserve Board of Governors

Martin Waibel
Stockholm School of Economics

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Abstract

We show that after the introduction of the leverage ratio constraints on bank-affiliated dealers, bond mutual funds have engaged in more liquidity provision in investment-grade corporate bonds and that the performance of funds with liquidity-supplying strategies has benefited. Not only have regulations transferred profits associated with liquidity provision in the corporate bond market to mutual funds, but the liquidity and returns of investment-grade corporate bonds have become more exposed to redemptions from the bond mutual fund industry, suggesting that the regulations have made investment-grade corporate bonds more volatile. Accordingly, we observe that investment-grade corporate bonds that are more exposed to leverage ratio constraints experienced a more severe deterioration in liquidity and returns at the onset of the COVID-19 pandemic.

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*Giannetti (mariassunta.giannetti@hhs.se) is with the Stockholm School of Economics, the Swedish House of Finance, CEPR, and ECGI. Jotikasthira (cjotikasthira@mail.smu.edu) is with Southern Methodist University. Rapp (andreas.c.rapp@frb.gov) is with the Federal Reserve Board of Governors. Waibel (martin.waibel@phdstudent.hhs.se) is with the Stockholm School of Economics. We thank our discussants Alexey Ivashchenko, Sven Klingler, Jose-Luis Peydro, Marco Rossi, Russ Wermers, Yao Zheng and seminar and conference participants at the NBER Financial Market Frictions and Systemic Risks Meeting, the 11th Annual Conference on Financial Market Regulation, the Bank of Italy/Bocconi/CEPR Conference on Financial Stability and Regulation, the 1st University of Illinois Chicago Finance Conference, the FSU Beach Conference, the Paris Hedge Fund Conference, the 7th World Symposium on Investment Research, Cheung Kong Graduate School of Business, Fudan University, Imperial College, the Nova School of Business and Economics, the University of Alberta, and the University of Texas San Antonio. Giannetti acknowledges financial support from the Jan Wallander and Tom Hedelius Foundation and the Karl-Adam Bonnier Foundation. We thank the Financial Industry Regulatory Authority (FINRA) for providing the regulatory version of the TRACE data used in this study. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or any other person associated with the Federal Reserve System.

1 Introduction

Due to prudential regulations implemented in response to the global financial crisis, banks have become significantly more 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. 2023; Rapp and Waibel 2023). What remains unknown, however, is how unregulated market participants respond and how their performance is affected. Not only have the regulations changed trading frictions and opportunities for unregulated intermediaries, but how unregulated intermediaries respond to these regulations may, in turn, 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 are affecting liquidity conditions could significantly impact mutual funds' strategies and performance. The sign of this effect, 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 liquidity provision by regulated financial institutions 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. While mutual funds' behavior improves liquidity in the bond market on average, we show that it has also increased the extent to which bond returns and liquidity are subject to large redemptions from the bond mutual fund industry, suggesting that tighter regulations may have made liquidity conditions in the bond market more volatile.

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 were introduced in the aftermath of the global financial crisis and could have similar effects to those of the leverage ratio requirements, the design of the Basel III leverage ratio increases the intermediation costs for investment-grade 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 requirement 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, large 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 create regulatory pressure on dealers' investment-grade holdings. The leverage ratio may, therefore, constrain dealers' willingness to hold and provide liquidity in investment-grade bonds.

Furthermore, the leverage ratio requirements become most binding at quarter-ends, when bank-affiliated dealers sharply contract their corporate bond inventories (Du et al. 2018; 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 time-varying proxy for mutual funds' strategies inspired by Anand et al. (2021). Specifically, we classify the extent to which a fund has a liquidity-demanding strategy based on the correlation of the fund's trades with dealers' inventory cycles. 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 sells like the rest of the market, exerting additional pressure on the dealers' balance sheets.

We find that the leverage ratio constraints affect mutual funds' trading: Following the introduction of the leverage ratio requirements, at quarter-ends, liquidity-supplying (LS) funds appear to purchase bonds that are predominantly intermediated by dealers subject to the leverage ratio constraints and thus likely in need of liquidity supply. 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 entire sample period. Importantly, the quarter-end purchases of investment-grade bonds predominantly intermediated by dealers subject to the leverage ratio constraints subsequently outperform other purchases of LS mutual 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 more negatively affected by the leverage constraints. In addition, we show that the alpha of LS funds, after the introduction of the leverage constraints, 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, those affiliated with dealers subject to the leverage ratio constraints benefit significantly more in terms of performance. This suggests that mutual funds have not only partially substituted bank-affiliated dealers in their liquidity provision but also complement banks that may transfer profits to their affiliated funds.

We also evaluate the aggregate implications of the changes in mutual funds' behavior for the bond market. We show that the extent to which mutual funds adopt liquidity-supplying strategies and engage in liquidity provision depends on their previous performance and flows. Poorly performing mutual funds are more likely to adopt liquidity-demanding strategies, partly because they need to sell to meet redemptions. As a result, in periods in which LS mutual funds experience poor performance and outflows, the probability that bond mutual funds engage in liquidity provision drops. For this reason, the liquidity and returns of investment-grade bonds have arguably become more exposed to large redemptions from the bond mutual fund industry after the adoption of the leverage ratio constraints.

We validate this interpretation of our empirical evidence by considering cross-sectional differences in bond liquidity and returns during the onset of the COVID-19 pandemic. We show that when this 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 constraints. Since we control for flow-induced fire sales by bond mutual funds, this result suggests that the retraction of mutual funds from providing liquidity impacted market conditions.

Overall, our results suggest that recent banking regulations have transferred profits associated with liquidity provision in the bond market to unregulated institutions. While mutual funds play an important role in the supply of liquidity, helping to manage dealers' regulatory pressures at quarter-ends, the fact that liquidity provision is now reliant on open-ended investment funds makes the corporate bond market more susceptible to investor redemptions.

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. 2023). 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 focuses on dealers' behavior and provides little evidence on how the same regulations may have indirectly affected unregulated market participants. Unregulated intermediaries, however, have been shown to engage in liquidity provision, especially in periods of market stress. For instance, insurance companies and hedge funds provided liquidity during the March 2020 bond market meltdown, primarily supporting the dealers with prior trading relationships (O'Hara et al. 2022; Kruttli et al. 2024). Not only did prior work not consider the spillover effects of the regulations affecting bank-affiliated dealers, but insurers and hedge funds have more stable liabilities than mutual funds and have therefore different investment horizons and strategies (Cella et al. 2013; Giannetti and Kahraman 2018; Chodorow-Reich et al. 2021; Coppola 2022; Huang et al. 2021). The nature of their liquidity provision and its effects on bond markets will also likely differ. Hence, we are the first to explore the extent to which unregulated market participants provide liquidity to dealers subject to regulatory constraints and to consider mutual funds and the effects of leverage ratio constraints on their performance, bond liquidity, and bond returns. In this respect, we contribute to the growing literature documenting the interlinkages between banks and non-bank financial intermediaries in other domains (Acharya et al. 2024).

By focusing on the leverage ratio regulations, we also contribute to a growing literature that studies the distortions created by the leverage ratio constraints on fixed income and short-term money markets (Duffie 2018). Existing studies focus on parity deviations (Du et al. 2018; Jermann 2020; Cenedese et al. 2021), temporary money market dislocations (dAvernas and Vandeweyer 2022; Correa et al. 2022; He et al. 2022), the yield curve (Du et al. 2022), and changes in the repo market structure and bank risk-taking (Allahrakha et al. 2018; Choi et al. 2020). 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 their changed behavior may increase volatility in the corporate bond market during periods of turmoil.

Finally, others have identified quarterly trading patterns of equity mutual funds aiming to window-dress portfolios 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). Window-dressing behavior cannot explain the patterns we document for bond mutual funds' quarter-end behavior because the effects emerge after the adoption of Basel III, while incentives to window-dress should be unchanged over the sample period. In addition, there is no reason to believe that incentives to window-dress should exist for investment-grade bonds but not high-yield bonds.

2 Changes in Regulatory Environment

Since the global financial crisis of 2007-2008, banks must comply with a wide range of regulations impacting their capital and liquidity requirements. These regulations are likely to 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 the 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 caused a distortionary reduction in the incentives for banks to intermediate markets for 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 started reporting their leverage ratios to regulators in January 2013. Effects on financial markets have been found to coincide with the public disclosure of the leverage ratio in January 2015 (Du et al. 2018; Jermann 2020). Thus, even if compliance with the leverage ratio requirements became mandatory only in 2018, consistent with the literature, we consider 2015 as the starting point for the regulation. 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 risk. 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 has to set aside depends on the risk of the assets, risk-weighted capital regulations increase banks' inventory costs for riskier bonds, thus likely constraining bank-affiliated dealers' liquidity provision in these bonds. Since 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 and performance in investment-grade bonds but not in high-yield bonds.

Moreover, although leverage ratio requirements were subject to variation 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. Notably, U.S. banks historically 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, rendering the leverage ratio constraint more stringent. Although their leverage ratio is calculated as an average over the quarter, compliance with the constraint is obligatory by the end of each quarter when the constraint becomes binding. Conversely, for international banks, the non-risk-weighted capital requirements were not only newly introduced after the global financial crisis but are also calculated based on the leverage ratio at the end of each quarter. This implementation of the regulation changed in 2017 for U.K. banks, for which the leverage ratio requirement started to be averaged over the quarter, as 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, 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 leverage ratio constraint thus appears to be binding for bank-affiliated dealers at quarter ends. Overall, the dealers subject to the leverage ratio regulations constitute a significant part of the market and can, therefore, affect bond market conditions.

As we explain below, in our empirical analysis, we leverage that the regulation becomes more stringent at quarter ends and is expected to primarily affect investment-grade bonds to identify the effects of the leverage ratio constraints on mutual funds' strategies and performance. Specifically, we exploit the within-quarter timing of mutual funds' trades and portfolio performance and exploit cross-sectional variation in the extent to which recent market makers of a bond are affected by the leverage ratio constraints. We also expect any effects of the leverage ratio requirements 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 and high-yield bonds differently. For instance, risk-weighted capital requirements were already present before 2015 and, more importantly, are expected to disproportionately affect inventories of the riskier high-yield bonds, not investment-grade bonds. The introduction of other regulations, such as additional capital requirements for globally systemically important banks (G-SIBs), known as G-SIB surcharges, the Volcker Rule, and liquidity directives, partly overlap with the introduction of the leverage ratio. However, G-SIB surcharges, which also increase the cost of balance sheet space for institutions whose holding companies have been identified as a G-SIB, are binding only at year-end. As we will show, our results are invariant to the exclusion of the last quarter of a year. The Volcker rule restricts banking entities from engaging in proprietary trading and impacts dealers' cost of intermediation because higher values of bond inventories may indicate proprietary trading. However, the Volcker rule does not become binding at quarter ends, and there is no reason to believe that it should have stronger effects 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) 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. More importantly, contrary to the leverage ratio, .both LCR and NSFR are ameliorated by holdings of liquid investment-grade bonds and should, therefore, incentivize banks to retain the 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. Our main 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 a variety of 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 80% of the fund reporting-period observations in our sample 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

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 implement this intuition empirically, we follow Anand et al. (2021). Specifically, using the regulatory version of TRACE transactions data, we compute, on each trading day, the inventory change in a given bond for an individual dealer and then aggregate the inventory change across all dealers to obtain a measure of the change in the dealer sector's inventory in the bond.[1]

[1]We consider only principal trades (not agency trades) to compute changes in dealers' inventories.

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:

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

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 report their positions monthly and the remaining quarterly, the period can be either a month or a quarter.

Since fund strategies should not vary much over time, but at the same time, we want to capture the effects of regulations on funds' strategies, we define funds' strategies over a rolling window of 24 months. In most of the empirical analysis, we classify funds with a positive rolling average *LS_score* as liquidity-supplying (LS) and all remaining funds as liquidity-demanding (non-LS). 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 (58,048 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.[2]

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 in terms of bond issue size, rating, age, or effective duration are very similar to those of other funds. Also, both LS and non-LS funds invest about 55% of their portfolios in corporate bonds, 15% in government bonds, and 21% in other securities.

Bond mutual funds have relatively high turnover. In our sample, the turnover in corporate bonds within a fund's portfolio is 16.28% per month, which is equivalent to almost 200% over a year for funds that report their positions monthly. Table 1, Panel B shows that bond mutual funds trade a number of bonds in each reporting period, with each bond accounting for just about 0.23 basis points of the fund's TNA, on average. However, LS funds trade in a more concentrated manner, with each transaction representing a higher fraction of 0.30 basis points, on average, of the fund's TNA in each reporting period.

[2]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.

Most of our analysis focuses on LS funds, and we consider non-LS funds in placebo tests to validate our conjectures on the effects of the leverage ratio constraints. We control for a host of fund characteristics to assuage concerns that other characteristics of their portfolios may be driving our findings.

3.4 Bonds and Dealers

As is common in the literature (see, e.g., 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 5 trades over the sample period; ii) bonds with a reported trade size that exceeds the bond's 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 a 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 leverage constraints. We use the regulatory version of TRACE, which includes unmasked dealers' identities. In line with the literature, we define European and Japanese bank-affiliated dealers and U.S. bank-affiliated dealers that become 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 build up in bond j during the first twenty days of a month relative to bond j's issue size:

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

where d refers to a dealer 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.[3] 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. 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). Then, each month, we sort bonds into quintiles based on their change in inventory by constrained dealers relative to the bond issue size during month m (Constr. Dealers' Inventory Holdings$_{j,m}$). We define bonds in the top quintile as *constrained bonds* because constrained dealers are likely to have more inventories than desired and may want to unload them to contract their balance sheets. More importantly, since market-making in a bond tends to be provided by the same dealers (Breckenfelder and Ivashina 2021), unregulated dealers willing to accumulate further inventories may be particularly scarce for constrained bonds, making these securities particularly suitable for liquidity provision by mutual funds.

Table 1, Panel C reports descriptive statistics on the characteristics of the bonds in our sample. The first five columns highlight the full sample (767,819 bond-period observations). On average, the bond maturity is 9.5 years, the issue size is $734 million, and the bond age is 5.3 years. Approximately 72% 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 the average bond issue in our sample.

The last two columns of Table 1, Panel C report the average characteristics separately for constrained and unconstrained bonds. Throughout our sample period, constrained dealers' shares of inventory holdings relative to the bond issue size are around 2.6% for constrained bonds but just 0.36% 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 for customer trades. For this reason, it is

[3] Due to the 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).

important to compare the characteristics of constrained and unconstrained bonds, which tend to be similar, with a few exceptions. Constrained bonds tend to be 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 several liquidity measures. Overall, this evidence suggests that dealers are willing to hold larger inventories in bonds that involve less risk and 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 end in a way that may affect the interpretation of our findings, we show that our 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 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 that are in the fourth quintile of $Constr.Dealers'InventoryHoldings$ 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

We begin by examining the impact of the leverage ratio regulations on mutual funds' trading behavior, focusing on distinct subsets of mutual funds as well as 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 (Rapp and Waibel 2023). In addition, we focus on investment-grade bonds because inventories of high-yield bonds were always subject to Basel II risk-weighted capital ratio 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. We estimate the following fund-bond-month level regression:

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

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, while $\mathbb{1}[QE]$ is an indicator variable capturing the last month of each quarter. We control for bond and fund characteristics, $M_{j,t}$ and $M_{i,t}$, 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 (QE) 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 requirements (column 1), whereas this pattern is not observed before the introduction of the regulation (column 2). In column 3, we show that the difference between coefficients is not only statistically significant but also economically meaningful, as the 0.19 increase in quarter-end purchases amounts to more than 60% of the average position change made by an LS fund (that is, 0.19 divided by 0.30). 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 constraints and, if anything, increased after 2018 when the leverage ratio requirements started to be enforced.

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 leverage ratio constraints, this could suggest that the finding in Table 2 is not directly linked to the introduction of the regulatory requirements. Thus, in columns 1 to 3, we consider non-LS funds as a placebo group and test whether they began to purchase more investment-grade bonds at quarter ends once the leverage ratio regulations were introduced. Since non-LS funds are unlikely to engage in liquidity provision, any indication that they shifted their purchases could suggest that other forces drive the change in mutual funds' trading patterns. However, 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 requirements. More importantly, the finding 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 during the whole sample period.

To further sharpen our tests, we consider that mutual funds' liquidity provision at quarter ends should be particularly necessary for investment-grade bonds in which dealers affected by the regulations have already accumulated large inventories. Not only may market participants want to sell these bonds in large quantities, but bank-affiliated dealers may not want to further increase their positions, while unregulated dealers do not appear to be involved in providing liquidity in these securities. We thus test whether LS funds purchase relatively more investment-grade bonds in which bank-affiliated dealers have accumulated substantial inventories, as captured by the dummy *Constr. Bond*. To do so, we augment our fund, bond, month level regression with a triple-interaction term, as follows:

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

where $\mathbb{1}[LS\ Fund]$ 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, as a control group to address the concern that Table *constrained* investment-grade bonds may differ along unobserved dimesnions.

Table 4 reports the estimates. During quarter-end months, LS funds indeed appear to purchase larger volumes of *constrained* investment-grade bonds—that is, bonds in which dealers subject to the leverage ratio constraints have accumulated substantial inventories—relative to other funds. The effect is both statistically and economically significant, as the increased purchases at quarter-ends for constrained bonds in column 3 are equivalent to more than 25% of the average change in an LS fund's position size (that is, 0.079 divided by 0.30). The estimates in column 2 show that not only liquidity demanding funds do not purchase *constrained* investment-grade bonds at quarter ends.

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. Then, we re-estimate Table 4 in our matched bond sample. The results in Table A3 in the Appendix are qualitatively and quantitatively unchanged.

So far, we have attributed LS funds' propensity to purchase more investment-grade bonds at quarter ends to the leverage ratio constraints, which negatively affect bank-affiliated dealers' willingness to intermediate investment-grade bonds. However, the G-SIB surcharges were introduced in addition to the leverage ratio requirements during our sample period. Because the 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 LS funds' propensity to provide liquidity at the end of the year due to G-SIB surcharges or the effect of the leverage ratio requirements. In this case, even though the economic mechanism would be similar, as a temporary retraction of bank-affiliated dealers from liquidity provision due to higher regulatory costs would drive LS funds' behavior, we should not attribute the observed effect to the leverage ratio regulations. To address this concern, we re-estimate Tables 2 and 4 separately for quarters one to three and quarter four. Tables A4 and A5 in the Internet Appendix show that our results are qualitatively invariant when we consider LS funds' trading in investment-grade bonds during the first three quarters of a year. Interestingly, the estimated effects are particularly large when we consider the last quarter of a year, suggesting that bank-affiliated dealers' propensity to retract from liquidity provision is stronger at year ends when the costs of G-SIB supplemental capital requirements magnify the effects of the leverage ratio regulations.[4]

Because the changes in LS funds' trading patterns appear economically relevant, we explore whether their quarter-end trades in constrained bonds are particularly profitable. Table 5 presents the average next-month portfolio returns of all bonds purchased by our sample funds during quarter-end versus non-quarter-end months, distinguishing between pre- and post-leverage ratio periods, investment-grade and high-yield bonds, and constrained and unconstrained bonds. It appears that funds' purchases of constrained investment-grade bonds during the last month of a quarter outperform other purchases after the introduction of the leverage constraints (Panel A). This effect is economically meaningful, as the outperformance of constrained bond purchases over other purchases is 0.23% per month higher at quarter ends than non-quarter ends (or 2.76% on an annualized basis). Moreover, we find no statistically significant outperformance for quarter-end purchases of constrained investment-grade bonds before the introduction of the leverage ratio constraints.

In Panel B, we consider the monthly returns of the high-yield bonds purchased by mutual

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

funds. We find that quarter-end purchases of constrained high-yield bonds outperform other purchases even during the pre-leverage ratio period. This is consistent with risk-weighted capital ratio requirements constraining bank-affiliated dealers' willingness to provide liquidity throughout the sample period. Unsurprisingly, the returns from liquidity provision in the more illiquid high-yield bonds are higher and, consistent with our interpretation of the empirical evidence, do not increase following the introduction of the leverage ratio constraints.

5 Leverage Constraints and Funds' Performance

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 explore how this behavior affects LS funds' overall performance.

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 constraints controlling for funds' strategic focus using 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, effective 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 regulations, we use non-LS funds as a control sample and estimate the following difference-in-differences regression at the fund-month level:

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

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. $\mathbb{1}[LS\ Fund]$ is equal to 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 constraints for LS funds relative to non-LS funds.

Table 6 reports the results. In columns 1 and 2, we consider funds focusing on investment-grade bonds. Consistent with our earlier findings, we find that LS funds outperform non-LS funds during the leverage ratio period. Importantly, following the introduction of the leverage ratio constraint, the outperformance of investment-grade LS funds, relative to non-LS funds, appears not only statistically but also economically significant at approximately 2.2 basis points per month or 0.26% per annum (column 1). The estimates are qualitatively and quantitatively similar when we exclude the Taper tantrum months (02/2013-05/2013) from the control sample. The taper tantrum is a period of turmoil before the introduction of the leverage ratio constraint, during which liquidity provision by LS funds may have been particularly profitable. Therefore, it is unsurprising that we estimate a slightly larger alpha for LS funds after the introduction of the leverage ratio regulation in column 2. Figure 2 provides dynamic estimates of the performance of LS funds focusing on investment-grade bonds. Not only does it confirm that their alpha becomes statistically different from zero after the introduction of the leverage ratio constraints, but also that the effect emerges in all post-leverage-ratio years

In columns 3 and 4 of Table 6, we consider a placebo based on funds focusing on high-yield bonds. Consistent with our prior, we find no evidence that high-yield LS funds' performance, relative to other high-yield 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 rules disproportionately increases the cost of holding inventories in the safest 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 the performance of investment-grade funds benefits to a larger extent from the leverage ratio rules. Interestingly, high-yield focused LS funds exhibit an alpha only when we exclude the taper tantrum months, suggesting that liquidity provision in high-yield bonds is associated with more volatile returns.

To provide additional evidence that the newly introduced regulations affect mutual funds' performance, we consider the months of a quarter during which an LS fund obtains a higher alpha. The leverage constraints are 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 the leverage ratio constraint. If the outperformance of LS funds indeed derives from the fact that the leverage constraints increase the profitability of supplying liquidity when bank-affiliated dealers are constrained, we should observe that the positive alpha is realized during the first month of each quarter, i.e., the month following each quarter-end month. This is precisely what we observe in Table 7. Following the introduction of the leverage ratio constraints, LS investment-grade funds significantly outperform other investment-grade 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.

6 Which Funds Take Advantage of Liquidity Provision?

Our results demonstrate that the Basel III leverage ratio requirements have created profitable trading opportunities for bond mutual funds in investment-grade bonds. Constrained bank dealers have been shown to sell their bond holdings primarily to investors and non-bank financial intermediaries in their networks (Rapp and Waibel 2023). As a result, banks could further favor the affiliated funds within their network to retain potential profits from liquidity provision to their affiliated dealers. However, since engaging in liquidity provision for investment-grade bonds is profitable and involves limited risk, all mutual fund managers should have incentives to compete for these trades, irrespective of their affiliation with a dealer. Exclusively relying on affiliated funds for liquidity support may be infeasible and is further hampered by the fact that bank-affiliated dealers may need to swiftly reduce their inventories in many bond positions at quarter ends. It is thus an empirical question whether all funds engage in liquidity provision to benefit from the opportunities created by the regulation or exclusively bank-affiliated mutual funds.

Column 1 of Table 8 considers to what extent affiliated mutual funds are more likely to engage in liquidity provision in investment-grade bonds. To identify funds affiliated with a given dealer, we match the fund management companies and fund advisors from CRSP to our set of constrained banks by name. We then define a fund as affiliated with a given (constrained) dealer if either the fund management company or the fund advisor is affiliated with the constrained bank dealer. For this test, we focus only on the leverage ratio period and LS funds trading in investment-grade bonds. The estimates confirm our earlier results that LS funds provide liquidity in constrained investment-grade bonds at quarter-ends. 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, as 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 comes as no surprise that this finding contrasts with evidence that when liquidity dried up at the onset of the COVID-19 pandemic, insurance companies with stable funding and not 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 represents a period of significant turmoil for the corporate bond market, during which purchasing dealers' inventories involved significant risks of future downgrades and further price drops. The expected risk-adjusted payoff of engaging in liquidity provision was, therefore, likely low. Even among institutions with stable funding conditions, such as insurance companies, only those with close relationships to dealers, which 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 normal 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 equally provide liquidity to constrained banks, it appears plausible that constrained bank dealers favor affiliated funds by directing more profitable trades to them. We test this hypothesis by exploring whether bank-affiliated funds perform better when engaging in liquidity provision. We consider all investment-grade focused funds and test whether bank-affiliated LS funds outperform other LS funds. This is precisely what we observe in column 2 of Table 8. While all investment-grade bond funds generate an alpha from LS strategies after the introduction of the leverage ratio regulations, the alpha of investment-grade LS funds that are bank-affiliated is over three times larger than that of other LS funds. Even if our data does not allow us to observe whether mutual funds indeed trade with the dealers they are affiliated with, and all bank-affiliated dealers in the network may benefit, this finding suggests that constrained bank dealers direct their best trades to their own affiliated funds. Thus, mutual funds appear not only to have substituted bank-affiliated dealers in their liquidity provision but also to complement banks that appear to transfer profits to less regulated entities, possibly within the same financial conglomerate.

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 constraints has led more investment-grade funds to adopt liquidity-supplying strategies. We conjecture that funds should be more likely to adopt LS strategies if they expect such strategies 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.

We test these conjectures by relating the probability that a fund has a positive LS score during a month to a rolling average of the performance of all LS funds over the previous 12 months. We also consider whether the flows (rolling averages over the past 12 months) of an individual fund affect its propensity to provide liquidity, controlling for the fund's strategic focus and other characteristics by including fund Morningstar category dummies and time-varying fund and portfolio characteristics.[5]

Table 9 shows that investment-grade focused funds with higher recent flows are more likely to have a positive LS score. Importantly, the probability that a fund has a positive LS score is also positively related to the previous performance of LS strategies. Both net flows

[5]We use as our measure of LS strategy, the dependent variable of the regressions, a dummy that equals one if the fund's LS_score is positive at time t to be able to detect short-term changes in strategies.

and recent performance only affect investment-grade funds' LS strategies in the leverage ratio period, suggesting that the industry has adjusted to the trading opportunities created by the new regulations. In terms of economic magnitude, a standard deviation increase in the past 12-month average alpha of LS strategies (0.08) raises the probability of a fund pursuing an LS strategy by about 0.04 (that is, 0.511 times 0.08), which is highly significant from an economic point of view, given that the average fraction of LS funds is just 0.24-0.27. Importantly, 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 the profitability of 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. These findings raise concerns that liquidity provision in the bond market is dependent on fund flows and performance. Thus, liquidity in 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 shift in liquidity provision from bank-affiliated dealers to open-ended bond mutual funds has had systematic effects on 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 can be large enough to affect bond liquidity and returns, we identify LS funds' monthly net liquidity supply in investment-grade corporate bonds during a positive inventory cycle and relate it to the dealer sector's average inventories in the same bonds. While LS funds do not necessarily trade with constrained dealers, this metric gives an idea of the magnitude of LS funds' liquidity provision in the aggregate.

Table 10 shows how the extent as well as the pattern of mutual funds' liquidity provision have changed after the introduction the leverage ratio regulations. We start by focusing on bonds that LS funds are trading in a given month (Panel A), but the overall message is unchanged if we consider all bonds traded by mutual funds in a given month (Panel B). After the introduction of the leverage ratio regulation, LS funds' liquidity provision is concentrated in the last month of the quarter and involves only constrained bonds. In 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 prevalent in bonds in which regulated financial institutions had accumulated larger inventories.

Since LS funds help absorb, on average, 16% of dealers' mean inventories in constrained bonds at quarter ends, funding shocks affecting bond mutual funds can potentially have significant effects on the corporate bond market. In what follows, we evaluate to what extent this is the case.

8.2 Liquidity

So far, we have shown that mutual funds provide substantial liquidity in the corporate bond market at quarter-ends when bank-affiliated dealers' constraints are particularly binding. However, mutual funds are open-ended organizations, subject to redemptions. Since mutual funds' liabilities are unstable, their ability to provide liquidity depends on their investors' willingness to hold their shares. This implies that liquidity conditions and returns of corporate bonds that regulated dealers intermediate may have become more dependent on mutual funds' flows.

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

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

The dependent variable, $Illiquidity_{j,t}$, is a bond's monthly illiquidity. Following Adrian et al. (2017), we construct three standard metrics of corporate bond market illiquidity: effective bid-ask spread, imputed round-trip cost, and the interquartile price range. We then extract the first principal component of the three individual measures and use it as our main illiquidity proxy.[6] As in our earlier specifications, $\mathbb{1}[LR\,Period]$ is an indicator that takes the value of one after 2015 and the indicator $\mathbb{1}[Constrained_{j,t}]$ captures bonds in which bank-affiliated dealers have accumulated substantial inventories; $\mathbb{1}[Flow \in [0\%, 20\%]]$ is an indicator that equals one if the aggregate fund flows during month t are in the bottom 20 percent of the sample and zero otherwise; $\mathbf{M_{j,t}}$ refers to the standard set of bond-month controls; η_s denotes issuer fixed effects, and λ_q denotes quarter fixed effects.

Our objective is to test whether bond mutual funds' funding constraints impact liquidity conditions for investment-grade bonds to a larger extent after the introduction of the leverage ratio requirements. Similar to our previous tests, we anticipate that the effect will be driven by investment-grade bonds in which bank-affiliated dealers accumulated inventories during previous months, which we hence define as *Constrained*. Throughout the analysis, in addition to usual bond characteristics, we control for the selling pressure that a bond would experience if the mutual fund owners liquidated their portfolio pro rata when they experience large redemptions (flows in the bottom decile) using the variable flow-induced fire sales or $FIFS$.[7] We also control for aggregate mutual fund flows. These controls capture forced sales by mutual funds and allow us to isolate the effect of missing liquidity provision by LS funds in constrained investment-grade bonds when large redemptions from the mutual

[6]During our sample period, the first principal component of the three illiquidity proxies explains around 68% of the variation.

[7]Since our proxy for FIFSs does 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.

fund industry occur.

Column 1 of Table 11 reports the results. After the introduction of the leverage ratio, constrained bonds appear to be less illiquid, which is consistent with the evidence that bank-affiliated dealers are more inclined to accumulate inventories in liquid securities. More importantly, in periods in which the net flows to the bond mutual fund industry are in the bottom quintile, constrained bonds have become even more illiquid. Since we control for the extent of flow-induced fire sales experienced by a security, we interpret the indicator for constrained bonds to capture the missing liquidity provision by bond mutual funds. This result thus suggests that mutual funds' retraction has important effect on liquidity conditions.

Not only do the statistically significant estimates support our interpretation of the empirical evidence, but the effects of the regulations on bond liquidity are also economically significant. Specifically, after the introduction of the leverage ratio period, illiquidity increases by about 4.5, or around 6.5% of its standard deviation, more for constrained investment-grade bonds when mutual funds experience significant redemptions, as captured by the indicator for bond mutual funds' flows in the bottom quintile. Importantly, the estimates are qualitatively and quantitatively unchanged in the matched sample (Table A6), indicating that the leverage ratio regulations are likely to have increased the exposure of constrained bonds to liquidity risk arising from mutual fund redemptions.

8.3 Returns

Until now, we have shown that following the introduction of the leverage ratio requirements, the liquidity of investment-grade corporate bonds has become more exposed to redemptions from the bond mutual fund industry. Negative realizations of liquidity risk could, in turn, affect bond returns (Bao et al. 2011). In this section, we adapt our methodology to test whether the leverage constraints also change the determinants of bond returns.

As is common in the literature, we compute monthly returns for bond j during 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 transaction price[8], $AI_{j,t}$ denotes the accrued interest, and $C_{j,t}$ is the

[8] We compute monthly bond prices, $P_{j,t}$, by applying the following steps. First, using TRACE transaction

coupon payment. Lastly, we compute the monthly excess return, $R_{j,t}$, as the difference between $r_{j,t}$ and the risk-free rate as proxied by the one-month Treasury bill rate.

In our regression model, we relate bond returns to the relevant (credit-rating-matched) index, which is the only factor that has been shown to consistently matter for bond returns (Dickerson et al. 2023). In addition, to take into account that bond duration has large effects on bond valuations when interest rates change (van Binsbergen et al. 2024), we allow a bond's exposure to the index to vary with bond maturity. Moreover, in addition to usual bond characteristics, we control for a bond's FIFS and aggregate flows to bond mutual funds. We then include our variables of interest, capturing intermediaries' constraints. Specifically, we test whether corporate bonds that during the previous month have been intermediated to a larger extent by bank-affiliated dealers are more exposed to liquidity risk deriving from large outflows from the bond mutual fund industry and underperform when mutual funds' liquidity provision is constrained because their flows are in the bottom quintile. As before, we control for time-varying bond characteristics and include issuer and quarter fixed effects.

Column 2 of Table 11 reports the results. Following the introduction of the leverage ratio constraints, constrained investment-grade bonds experience significant losses whenever the mutual fund industry experiences significant redemptions. These effects emerge only after the introduction of the leverage ratio regulations and are obtained controlling for a bond's exposure to flow-induced fire sales. The estimates thus suggest that the missing liquidity provision by LS mutual funds can have large negative effects on stock returns. The effects are not only statistically, but also economically significant. Constrained investment-grade excess bond returns drop by an additional 24.7 basis points relative to unconstrained investment-grade bonds during periods of large mutual fund outflows. This effect is notably different from the weakly significant increase in excess returns in constrained investment-grade bonds during periods with no major outflows from the mutual fund industry. Importantly, these results are qualitatively and quantitatively unchanged in the matched bond sample (Table

data, we compute the daily bond price as the volume-weighted average of all intraday transaction prices. Second, we compute monthly returns using two definitions: A return from the end of month $t-1$ to the end of month t, and from the beginning of month t to the end of month t. We denote the end (beginning) of a month as the last (first) ten trading days within a month. If there are multiple transactions within the last (first) ten trading days, we select the last (first) transaction in the ten-day window. We then match the accrued interest to the date on which the price is taken for the return computation. Finally, if we can compute a monthly return under both definitions, we use the return from the end of month $t-1$ to the end of month t.

A6).

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 constraints faced by banks, the liquidity and returns of investment-grade corporate bonds have become particularly sensitive to mutual funds' funding conditions. This section explores to what extent the introduction of leverage ratio constraints can help explain why liquidity conditions and returns sharply deteriorated for corporate bonds at the onset of the COVID-19 pandemic when especially investment-grade bonds experienced pronounced price dislocations (Haddad et al. 2021; Kargar et al. 2021; O'Hara and Zhou 2021).

In the first three weeks of March 2020, before the Federal Reserve's intervention, bond mutual funds experienced unprecedented redemptions that depressed bonds' valuations (Falato et al. 2021). While the tendency of mutual funds to sell liquid assets to meet redemptions contributed to the large 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 leverage ratio constraints experienced larger price dislocations than other investment-grade bonds. This would indicate that leverage constraints contributed to amplifying the shock when mutual funds experiencing large outflows had to retract from liquidity provision.

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

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 intervening to calm the U.S. corporate bond market and stabilize mutual fund flows on March 23. We thus consider a sample that includes bond issues' monthly returns for

February 2020 and the first 22 days of March 2020. We test whether constrained bonds performed particularly poorly during March 2020.

Table 12 reports the results from the panel regressions of our bond illiquidity measure and bond returns. We include issuer fixed effects to control for bond characteristics. The positive sign on the interaction term between the indicator variable capturing March 2020 and the constrained bond indicator suggests that illiquidity increased more for investment-grade bonds affected by the leverage ratio constraints. Since we control for a bond's exposure to flow-induced fire sales, the effect of the proxy for the inventories accumulated by bank-affiliated dealers can be interpreted as capturing the effect of the retraction in bond mutual funds' liquidity provision during periods of large outflows. The effects appear economically significant.

Specifically, in March 2020, investment-grade bonds, in which dealers subject to leverage ratio constraints built up inventory positions in February 2020, experienced a 13% (that is, 14.13 divided by 108.41) additional increase in illiquidity compared to unconstrained bonds. Similarly, the returns of constrained investment-grade bonds decreased more than twice as much during March 2020 compared to those of other investment-grade bonds. Overall, this evidence confirms that the leverage ratio constraints can contribute to amplifying the effects of negative shocks in the corporate bond market.

10 Conclusion

We provide the first evidence that banking regulations that reduce bank-affiliated dealers' willingness 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 help substitute dealers' market-making activities and provide more liquidity in the corporate bond market. Importantly, the regulation has benefited mutual funds' performance.

However, bond mutual funds' liquidity supply depends on their performance and flows and drastically decreases when the funds experience significant redemptions. As a consequence, liquidity in the corporate bond market has become more dependent on mutual funds' funding conditions. Not only does corporate bond liquidity deteriorate significantly when there are large redemptions from the bond mutual fund industry, but bonds' valuations also significantly decline.

Our findings show that unregulated institutions, substituting bank-affiliated dealers, can dampen the regulatory costs in normal market conditions. However, smaller balance sheets for regulated institutions and lower prospective bailout costs for the taxpayers entail a trade-off and come at the cost of more volatile returns and liquidity conditions for investment-grade corporate bonds. While we refrain from drawing normative conclusions from our analysis, policymakers will have to consider these costs, together with those that the previous literature has identified for government securities and repo markets (Duffie 2018), in their evaluation of the leverage ratio requirements.

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11 Figures

Figure 1: LS Funds' Liquidity Supply - Dynamic Results

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

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

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. Due to noisy data in the pre-leverage ratio period, we group 2012 and 2013 into one indicator variable, which smooths the point estimate over the two years. $\mathbb{1}[QE]$ 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, age, size, family size, average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age). $M_{j,t}$ represents bond controls and includes bond age, bond maturity, downgrade and upgrade indicators, and the first principal component extracted from the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_q$ represents bond-year-quarter fixed effects. Standard errors are double-clustered at the fund family and year-quarter level. The gray shaded areas represent the 90% confidence intervals. The regression is restricted to the subset of LS funds and the subset of investment-grade bonds.

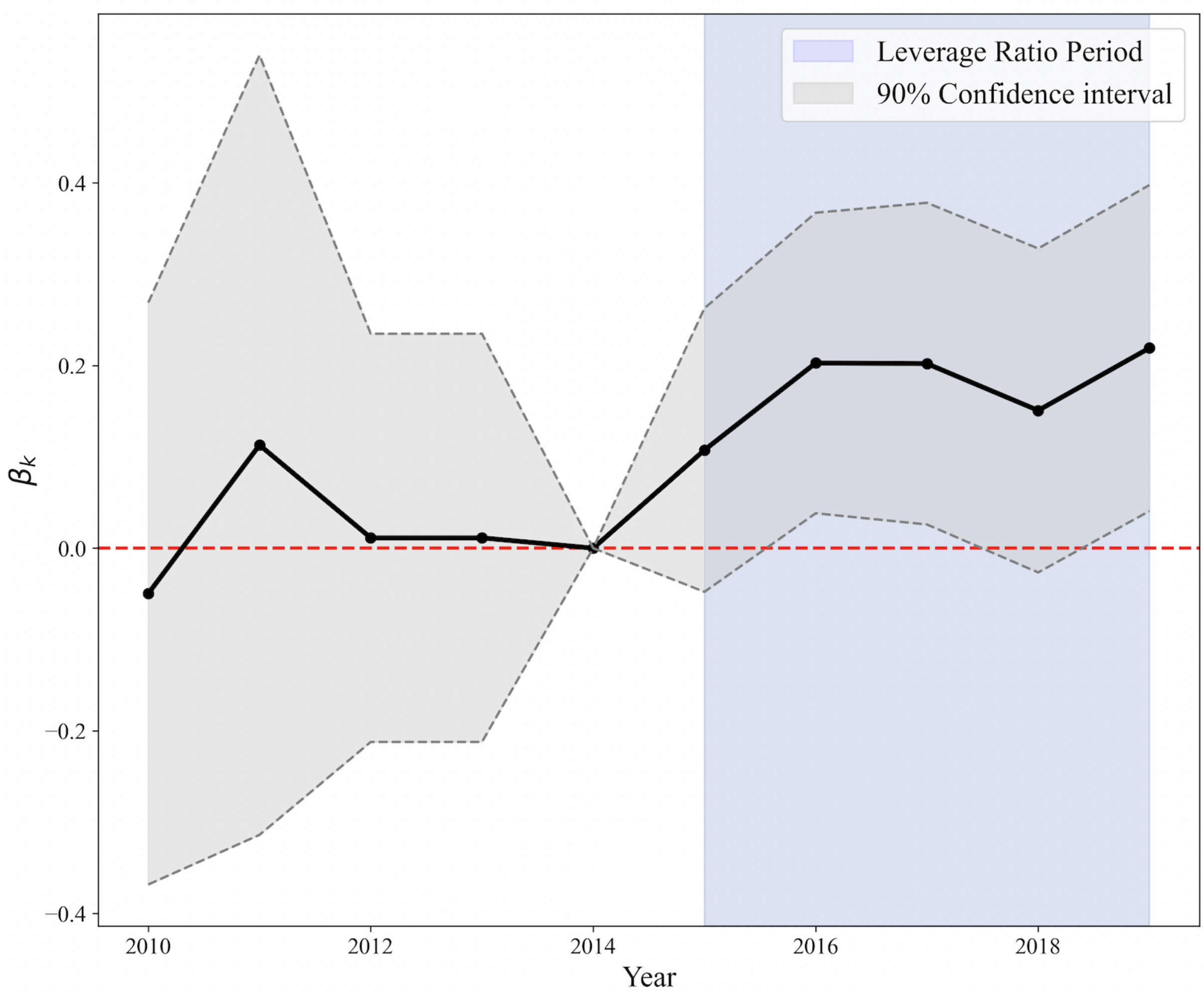
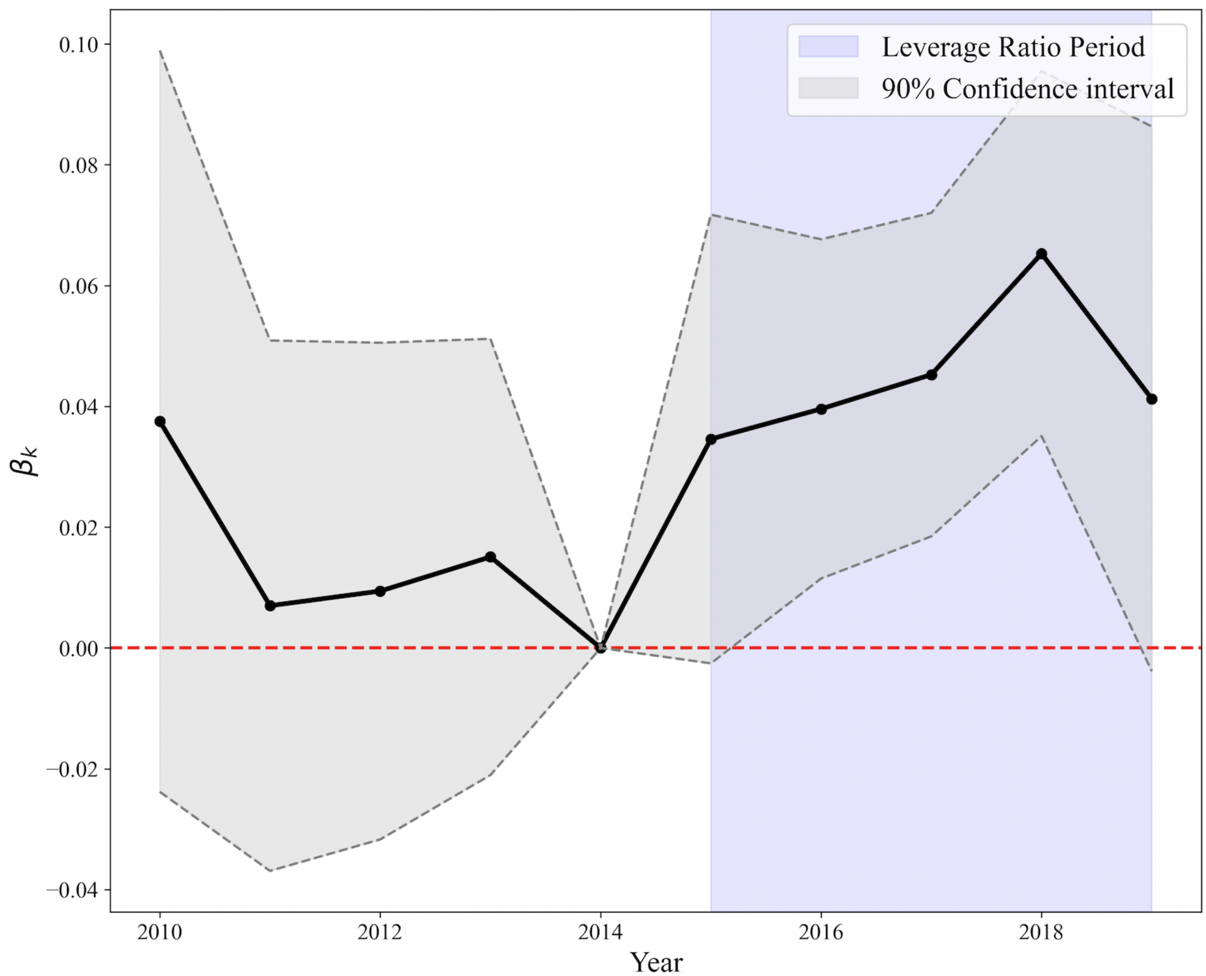


Figure 2: LS Funds' Performance - Dynamic Results

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

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

The dependent variable, $Fund\,Alpha_{i,t}$, represents the fund alpha (in percent). For each fund i in month t, the dependent variable, alpha, is calculated using the Chen and Qin (2017) 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, age, size, family size, average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age). All controls are as of the end of period $t-1$. $\eta_c \times \lambda_q$ represents fund category-quarter fixed effects. Standard errors are double-clustered at the fund family and year-quarter level. The gray shaded areas represent 90% confidence intervals. The regression is restricted to the subset of IG-focused funds.



12 Tables

Variable Definitions and Data Sources

This table defines the variables used in the analyses.

Variable	Definition
Fund-level variables	
Frequency: fund-month or coarser, depending on each fund's reporting frequency.	
Source: 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 (SEC-registered) broker-dealer institution, and zero otherwise.
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, presented as a fraction of TNA at the beginning of the month.
Government bonds as % of portfolio	Holdings of (U.S. and foreign) government bonds, as a percentage of TNA, as of the previous report date.

Variable Definitions and Data Sources [continued]

Variable	Definition
ln(1 + Fund age)	Natural log of 1 plus the fund's age in years, as of the previous report date.
ln(1 + Fund TNA)	Natural log of 1 plus the fund's total net assets (TNA) in dollars, as of the previous report date.
ln(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.
ln(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.
ln(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.

Variable Definitions and Data Sources [continued]

Variable	Description
Portfolio avg. credit rating	Value-weighted average credit rating, based on the credit ratings from Moody's, S&P, and Fitch 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 effective duration	Average effective 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 across all share classes of return in the current month.
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 month is positive, and zero otherwise.

Variable Definitions and Data Sources [continued]

Variable	Description
LS fund performance$_{t-1,t-12}$	12-month rolling average of the equally-weighted average monthly alpha of all LS funds.
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 previous period $(t-1)$ total net assets (TNA). All position changes are calculated at prices as of the previous report date. Values are expressed in basis points.
Bond-level variables Frequency: *bond-month* Source: *Mergent FISD, Morningstar and Regulatory TRACE.*	
Flow-induced fire sales (FIFS)	$FIFS_{j,t}$ 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 sample are considered to trigger fire sales. $FIFS_{j,t} = \frac{\sum_i Flow_{i,t} \times \mathbb{1}_{\text{flow in bottom decile}} \times H_{i,j,t-1}}{Issue\,Size_j}$ where $Flow_{i,t}$ is the percentage flows of fund i in month t, $\mathbb{1}_{\text{flow in bottom decile}}$ is a dummy variable that equals 1 if $Flow_{i,t}$ is in the bottom decile of the sample, and zero otherwise, $H_{i,j,t-1}$ is the par amount (in dollars) of bond j held by fund i at the end of month $t-1$, and $Issue\,Size_j$ is the issue size (in dollars) of bond j.

Variable Definitions and Data Sources [continued]

Variable	Description
Bond illiquidity	First principal component of three standard metrics of corporate bond market liquidity: effective bid-ask spread, imputed round-trip cost, and the interquartile range measure (Adrian et al. 2017).
-*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 price 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.
-*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 that the bond have at least three trades 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.

Variable Definitions and Data Sources [continued]

Variable	Description
Downgrade	Dummy variable that equals one if the bond is downgraded from investment to non-investment grade 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.
ln(1 + bond age)	Natural log of 1 plus the bond age in years. Age is the time between the offering date and a particular date.
ln(1 + bond issue size)	Natural log of 1 plus bond issue size in $1,000. Issue size is the offering amount as reported by Mergent FISD.
ln(1 + bond maturity)	Natural log of 1 plus maturity in years. For each bond, 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.
Upgrade	Dummy variable that equals one if the bond is upgraded from non-investment to investment grade within plus and minus two months from the current month, and zero otherwise.

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.

Panel A: Fund-Level Variables

	Main Sample (58,048 Fund-Periods)					Mean by LS-Fund Type (15,917 / 42,123 Fund-Periods)	
Variable	Mean	Std	10%	50%	90%	LS Funds	Non-LS Funds
Total net assets ($ Mil.)	2518.40	9698.86	42.30	542.90	5166.31	3262.46	2238.09
Portfolio avg. bond issue size	1060	292	710	1017	1467	1049	1064
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 effective 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	15.16	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	2.43	0.85	1.15	2.65	3.38	2.24	2.51
Broker affiliation	0.09	0.29	0.00	0.00	0.00	0.09	0.09
Turnover (%)	16.28	17.09	3.44	11.24	33.20	16.94	16.04
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

Variable	All Bonds (10,610,677 Fund-Bond-Periods) Mean	Std	10%	50%	90%	Mean by Fund Type (3,302,574 LS Bond-Periods 7,308,103 Non-LS Bond-Periods) LS Funds	Non-LS Funds
Fund pos. change / TNA_{t-1} (bp)	0.23	4.37	0.00	0.00	0.00	0.30	0.19
IG Bonds:	0.17	3.64	0.00	0.00	0.00	0.20	0.15
HY bonds:	0.32	5.34	0.00	0.00	0.78	0.61	0.25

Panel C: Bond-Level Variables

Variable	Main Sample (767,819 Bond-Periods) Mean	Std	10%	50%	90%	Mean by Bond Constr. Type (156,888 Constr. Bond-Periods 610,931 Unconstr. Bond-Periods) Constrained	Unconstrained
Bond rating (1 = AAA)	9.82	4.99	5.00	9.00	16.00	10.44	9.66
Bond age (year)	5.27	3.97	1.58	4.15	10.12	3.79	5.66
Bond maturity (year)	9.49	9.04	3.04	7.26	24.31	10.64	9.55
Bond issue size ($ mn)	734.02	542.16	249.97	500.00	1487.97	790.58	719.47
Investment grade	0.72	0.45	0.00	1.00	1.00	0.64	0.74
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 sales (FIFS)	0.03	0.08	0.00	0.00	0.08	0.05	0.03
Bond Illiquidity							
Interquartile range (bp)	44.30	47.97	7.57	28.10	102.50	43.16	44.64
Imputed roundtrip cost (bp)	15.45	23.56	0.11	7.53	37.09	13.82	15.87
Effective bid-ask spread (bp)	50.36	66.82	5.24	28.68	118.58	39.90	53.28
First principal component	-14.20	68.22	-68.31	-37.30	69.06	-22.10	-11.95
IG Bonds:	-14.81	69.45	-70.08	-37.96	71.04	-22.91	-12.99
HY Bonds:	-12.79	65.27	-61.76	-36.13	69.01	-21.86	-9.27

Table 1 (continued)

Panel C: Bond-Level Variables

	Main Sample (767,819 Bond-Periods)					Mean by Bond Constr. Type (156,888 Constr. Bond-Periods 610,931 Unconstr. Bond-Periods)	
Variable	Mean	Std	10%	50%	90%	Constrained	Unconstrained
Bond return (%)	-0.25	2.06	-2.29	-0.16	1.90	-0.27	-0.24
Bond constraint (%)							
Quintiles 1-4	0.36	0.47	0.01	0.21	0.87	-	-
Quintile 5	2.60	2.64	1.06	1.93	4.67	-	-

Table 2
LS Funds' Trading in Investment-Grade Bonds

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, age, size, family size, average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age). $M_{j,t}$ represents bond controls and includes bond age, bond maturity, downgrade and upgrade indicators, and the first principal component extracted from the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure. 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. Column 3 considers all periods. Standard errors, double-clustered at the fund family 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)
$\mathbb{1}[QE]$	**0.055****	-0.042	-0.107
	(0.026)	(0.080)	(0.072)
$\mathbb{1}[QE] \times \mathbb{1}[LR\ Period]$			**0.190****
			(0.079)
Observations	1,411,265	491,668	1,902,933
R-squared	0.103	0.147	0.127
Bond x Year FE	✓	✓	✓
Bond controls	✓	✓	✓
Fund controls	✓	✓	✓

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, age, size, family size, average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age). $M_{j,t}$ represents bond controls and includes bond age, bond maturity, downgrade and upgrade indicators, and the first principal component extracted from the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure. 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. Standard errors, double-clustered at the fund family and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Fund Type	Non-LS Fund			LS Fund		
Bond Type	Investment-Grade			High-Yield		
Regulatory Period	LR	Pre-LR	All	LR	Pre-LR	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[QE]$	0.039	0.108	0.067	0.172*	0.310*	0.244
	(0.031)	(0.083)	(0.077)	(0.097)	(0.175)	(0.154)
$\mathbb{1}[QE] \times \mathbb{1}[LR\ Period]$			-0.002			-0.019
			(0.083)			(0.157)
Observations	1,896,897	1,363,698	3,260,595	446,570	266,849	713,419
R-squared	0.096	0.109	0.103	0.127	0.178	0.157
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond controls	✓	✓	✓	✓	✓	✓
Fund controls	✓	✓	✓	✓	✓	✓

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

This table displays estimates for the regression:

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

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 previous period fund's TNA ($TNA_{i,t-1}$), 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, age, size, family size, average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age). $M_{j,t}$ represents bond controls and includes bond age, bond maturity, downgrade and upgrade indicators, and the first principal component extracted from the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure. 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 family and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Regulatory Period	Leverage Ratio Period		
Fund Type	LS	Non-LS	All
	(1)	(2)	(3)
$\mathbb{1}[QE]$	0.039	0.041	0.031
	(0.024)	(0.025)	(0.025)
$\mathbb{1}[Constr.\,Bond]$	0.036*	0.049*	0.034
	(0.020)	(0.027)	(0.029)
$\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond]$	**0.080****	-0.010	-0.003
	(0.035)	(0.044)	(0.042)
$\mathbb{1}[LS\,Fund]$			0.040*
			(0.022)
$\mathbb{1}[LS\,Fund] \times \mathbb{1}[QE]$			0.029
			(0.024)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LS\,Fund]$			0.025
			(0.061)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LS\,Fund] \times \mathbb{1}[QE]$			**0.079****
			(0.032)
Observations	1,369,784	1,831,521	3,202,648
R-squared	0.096	0.086	0.078
Bond x Year FE	✓	✓	✓
Bond controls	✓	✓	✓
Fund controls	✓	✓	✓

Table 5
Average Returns on Bonds Purchased by Mutual Funds

This table reports average monthly returns of constrained and unconstrained bond purchased by all mutual 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 only to bond positions that are purchased in month t. All bond returns are as of month $t+1$, and excess returns are calculated as bond returns minus the contemporaneous risk-free rate. Average constrained and unconstrained portfolio 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 (months 3,6,9,12) and non-quarter-end months. Panel A considers investment-grade bonds, and Panel B considers high-yield bonds. We report in brackets the standard deviations of the funds' portfolio returns, and for the columns with Δ in the heading, the absolute values of t-statistics for the difference in average return between constrained and unconstrained bond purchases in quarter-end months minus the difference in average return between constrained and unconstrained bond purchases in non-quarter-end months. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Panel A: Excess Returns - Investment-Grade Bonds

	Pre-Leverage Ratio			Leverage Ratio		
Porfolio	Non-Quarter-End Month	Quarter-End Month	Δ	Non-Quarter-End Month	Quarter-End Month	Δ
Constrained	-0.16 (0.99)	0.91 (1.25)		-1.30 (1.04)	-0.23 (1.80)	
Unconstrained	-0.10 (0.68)	0.85 (1.00)		-1.15 (0.92)	-0.31 (1.56)	
Constrained - Unconstrained	**-0.06**	**0.06**	**0.12** **(0.86)**	**-0.15**	**0.08**	**0.23**** **(2.02)**

Panel B: Excess Returns - High-Yield Bonds

	Pre-Leverage Ratio			Leverage Ratio		
Porfolio	Non-Quarter-End Month	Quarter-End Month	Δ	Non-Quarter-End Month	Quarter-End Month	Δ
Constrained	-0.36 (1.33)	0.99 (1.35)		-1.23 (1.41)	-0.18 (1.96)	
Unconstrained	-0.07 (1.10)	0.85 (1.30)		-0.97 (1.27)	-0.22 (1.87)	
Constrained - Unconstrained	**-0.29**	**0.14**	**0.43**** **(2.19)**	**-0.26**	**0.04**	**0.30*** **(1.84)**

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 fund 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:

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

The dependent variable, $R_{i,t} - R_{f,t}$, 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 for 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, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age), and time-varying fund characteristics (age, size, family size, and average maximum rear load). All fund-level controls are as of the end of month $t-1$. In columns 2 and 4, we exclude the Taper Tantrum period, which ranges from May to September 2013. Standard errors, double-clustered at the fund family and year-month level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Fund Specialization	IG-Focused Funds		HY-Focused Funds	
	(1)	(2)	(3)	(4)
$\mathbb{1}[LS\,Fund]$	-0.001	-0.003	0.027	0.036*
	(0.009)	(0.010)	(0.018)	(0.019)
$\mathbb{1}[LS\,Fund] \times \mathbb{1}[LR\,Period]$	**0.022****	**0.024****	-0.017	-0.025
	(0.011)	**(0.011)**	(0.020)	(0.021)
Observations	41,694	39,643	25,117	23,849
R-squared	0.44	0.44	0.41	0.41
Fund cat. x Period FE	✓	✓	✓	✓
Taper period excluded	–	✓	–	✓
Fund controls	✓	✓	✓	✓

Table 7
Within-Quarter Variation in Investment-Grade Focused Fund Performance

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

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

The dependent variable, $R_{i,t} - R_{f,t}$, 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 $OPTION$ 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 from months $t-24$ to $t-1$ for alpha in month t. $\mathbb{1}[LSFund]$ 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 for the leverage ratio period (01/2015 - 12/2019), and zero otherwise. The sample includes only investment-grade focused funds. 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, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age), and time-varying fund characteristics (age, size, family size, and average maximum rear load). All fund-level controls are as of the end of month $t-1$. Standard errors, double-clustered at the fund family and year-month level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Month of Quarter	Month 1	Months 2 & 3
	(1)	(2)
$\mathbb{1}[LS\,Fund]$	0.008	-0.007
	(0.012)	(0.011)
$\mathbb{1}[LS\,Fund] \times \mathbb{1}[LR\,Period]$	**0.035****	0.016
	(0.015)	(0.012)
Observations	13,329	28,365
R-squared	0.44	0.44
Fund cat. x Period FE	✓	✓
Fund controls	✓	✓

Table 8
Liquidity Provision and Performance of Bank-Affiliated Funds

This table reports OLS regression estimates for the relationships between fund liquidity supply, fund performance, and the bank-affiliation status during the leverage ratio period (01/2015 - 12/2019). In column 1, the observations are at the fund-bond-period level and the sample includes only investment-grade bonds and 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 column 2, 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. In both 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, broker affiliation dummy, time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age), and time-varying fund characteristics (age, size, family size, and average maximum rear load). Bond controls include bond age, bond maturity, downgrade and upgrade indicators, and the first principal component extracted from the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure. All controls are as of the end of period $t - 1$. Column 1 includes bond-year fixed effects, bond controls, and fund controls. Column 2 includes fund category-period fixed effects, and fund controls. Standard errors, double-clustered at the fund family and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

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Table 8 - continued

Dependent Variable	Fund Position Change	Fund Alpha
	(1)	(2)
$\mathbb{1}[QE]$	0.052* (0.027)	
$\mathbb{1}[Constr.\,Bond]$	0.043 (0.026)	
$\mathbb{1}[Bank-aff.]$	-0.053 (0.114)	-0.007 (0.009)
$\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond]$	**0.081**** **(0.037)**	
$\mathbb{1}[QE] \times \mathbb{1}[Bank-aff.]$	-0.183 (0.173)	
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Bank-aff.]$	-0.085 (0.071)	
$\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond] \times \mathbb{1}[Bank-aff.]$	0.023 (0.095)	
$\mathbb{1}[LS\,Fund]$		0.010* (0.006)
$\mathbb{1}[LS\,Fund] \times \mathbb{1}[Bank-aff.]$		**0.032**** **(0.016)**
Observations	1,358,674	22,453
R-squared	0.096	0.42
Bond x Year FE	✓	
Fund cat. × Period FE		✓
Bond controls	✓	
Fund controls	✓	✓

Table 9
Investment-Grade 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:

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

The dependent variable, $\mathbb{1}[LS\_score_{i,t} > 0]$, represents 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 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, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age), and time-varying fund characteristics (age, size, family size, and average maximum rear load). All fund-level controls are as of the end of month $t-1$. η_c refers to fund category fixed effects. Column 1 considers the pre-leverage ratio period (01/2010 - 12/2014). Column 2 considers the leverage ratio period (01/2015 - 12/2019). Column 3 considers all periods. The sample includes only investment-grade focused funds. Standard errors, double-clustered at the fund family and year-month level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Regulatory Period	Pre-Leverage Ratio	Leverage Ratio	All
	(1)	(2)	(3)
$LS\, Fund\, Performance_{t-1,t-12}$	-0.052	**0.511****	-0.040
	(0.103)	**(0.243)**	(0.104)
$Fund\ Flow_{i,t-1,t-12}$	-0.056	0.328**	-0.092
	(0.133)	(0.134)	(0.128)
$\mathbb{1}[Bank - aff.]$	-0.016	-0.006	-0.010
	(0.019)	(0.024)	(0.016)
$\mathbb{1}[LR\ Period] \times LS\, Fund\, Performance_{t-1,t-12}$			**0.542****
			(0.255)
$\mathbb{1}[LR\ Period] \times Fund\ Flow_{i,t-1,t-12}$			**0.456****
			(0.182)
Observations	15,264	18,233	33,497
R-squared	0.01	0.02	0.01
Fund cat. FE	✓	✓	✓
Fund controls	✓	✓	✓

Table 10
Fund Liquidity Supply Relative to Dealer Inventories

This table reports liquidity-supplying 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. In each month from January 2010 to December 2019, the net liquidity supply in a particular bond is defined as the dollar par amount of that bond purchased minus the dollar par amount of that bond sold by all LS funds divided by the dealer sector's mean inventory. The resulting ratio is reported in percent. Volume-weighted (across-bond) averages of the net liquidity supply are computed using weighted linear regressions in which the net liquidity supply is regressed on two indicator variables that differentiate constrained from unconstrained investment-grade bonds (top versus bottom quintiles of constrained dealers' inventory changes) and quarter-end months (March, June, September, December) from non-quarter-end months. We use a bond's monthly total trading volumes by either liquidity-supplying funds (Panel A) or all mutual funds (Panel B) as the weights. 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: Bonds Traded by Liquidity-Supplying Funds

	Pre-Leverage Ratio		Leverage Ratio	
Bond	Non-Quarter-End Month	Quarter-End Month	Non-Quarter-End Month	Quarter-End Month
Constrained	9.46***	**7.49***	-0.11	**16.28***
	(3.52)	**(4.42)**	(2.54)	**(4.91)**
Unconstrained	6.61	2.56	-1.21	-12.93
	(4.35)	(4.30)	(3.58)	(7.98)

Panel B: Bonds Traded by All Mutual Funds

	Pre-Leverage Ratio		Leverage Ratio	
Bond	Non-Quarter-End Month	Quarter-End Month	Non-Quarter-End Month	Quarter-End Month
Constrained	4.51***	**1.82**	-0.13	**7.57***
	(1.47)	**(1.51)**	(1.37)	**(2.91)**
Unconstrained	1.48	-0.25	-2.23	-10.23
	(1.85)	(1.10)	(1.72)	(4.20)

Table 11
Outflows from the Mutual Fund Industry, Leverage Constraints, and Investment-Grade Bond Illiquidity and Returns

This table reports OLS estimates for the following panel regression:

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

The dependent variable, $Y_{j,t}$, represents the monthly average illiquidity (column 1) and the monthly percentage bond return in excess of the one-month Treasury bill rate (column 2) of bond j in month t. The monthly 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 three individual liquidity measures: effective bid-ask spread, imputed round-trip cost, and the interquartile range measure. $\mathbb{1}[Constrained_{j,t}]$ 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 fund flows 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 the bond maturity, bond issue size, bond age, flow-induced fire sales, as well as upgrade and downgrade indicators. $Matched\ Ret_t$ represents the bond's credit-rating-matched index return. $Agg.\,Flow_t$ refers to the sum of dollar flows across all share classes and funds, presented as a fraction of aggregate TNA at the beginning of the month. The sample includes only investment-grade bonds. $\eta_s \times \lambda_q$ denotes issuer times quarter fixed effects. Standard errors, clustered by issuer-times-year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

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Table 11 - continued

Dependent Variable	Average Illiquidity	Excess Bond Return
	(1)	(2)
$\mathbb{1}[Constrained_{j,t}]$	-8.178***	0.028*
	(0.415)	(0.015)
$\mathbb{1}[Flow \in [0\%, 20\%)]$	5.075***	-0.076*
	(0.628)	(0.040)
$\mathbb{1}[Constrained_{j,t}] \times \mathbb{1}[Flow \in [0\%, 20\%)]$	-2.186**	0.029
	(0.947)	(0.042)
$\mathbb{1}[Constrained_{j,t}] \times \mathbb{1}[LR\,Period]$	1.643***	0.031*
	(0.510)	(0.018)
$\mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$	-4.676***	-0.282***
	(0.674)	(0.050)
$\mathbb{1}[Constrained_{j,t}] \times \mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$	**4.479***	**-0.247***
	(1.139)	**(0.052)**
Agg. Flows	-2.609***	0.168***
	(0.230)	(0.018)
ln(1 + Bond age)	21.463***	-0.121***
	(0.311)	(0.005)
ln(1 + Bond issue size)	-25.853***	-0.000
	(0.397)	(0.006)
FIFS	-5.934**	-0.066
	(2.356)	(0.086)
ln(1 + Bond maturity)	36.067***	-0.028***
	(0.233)	(0.006)
$\mathbb{1}[Downgrade]$	6.265***	-1.071***
	(2.300)	(0.244)
Matched Ret	-0.489***	-0.286***
	(0.009)	(0.023)
Matched Ret × ln(1 + Bond maturity)	0.367***	0.194***
	(0.007)	(0.013)
Observations	381,789	502,101
R-squared	0.56	0.33
Issuer x Quarter FE	✓	✓

Table 12
Leverage Constraints, Bond Illiquidity, and Bond Returns around the COVID-19 Outbreak

This table reports OLS estimates for the following panel regression:

$$Y_{j,t} = \beta_1 \mathbb{1}[March\ 2020] + \beta_2 \mathbb{1}[Constrained_{j,t-1}] + \beta_3 \mathbb{1}[Constrained_{j,t-1}] \times \mathbb{1}[March\ 2020] + \eta_s + \gamma' \mathbf{M_{j,t}} + \varepsilon_{j,t}\,.$$

The dependent variable, $Y_{j,t}$, represents the monthly average illiquidity (column 1) and the monthly percentage bond return in excess of the one-month Treasury bill rate (column 2) of bond j in month t. The monthly 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 three individual liquidity measures: effective bid-ask spread, imputed round-trip cost, and the interquartile range measure. 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. $\mathbb{1}[Constrained_{j,t-1}]$ 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 the bond maturity, bond issue size, bond age, and flow-induced fire sales. $Matched\ Ret_t$ represents the bond's credit-rating-matched index return. 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	Excess Bond Return
	(1)	(2)
$\mathbb{1}[March\,2020]$	108.407***	-0.840***
	(3.382)	(0.179)
$\mathbb{1}[Constrained_{j,t-1}]$	-10.605***	0.406***
	(2.645)	(0.079)
$\mathbb{1}[March\,2020] \times \mathbb{1}[Constrained_{j,t-1}]$	**14.128***	**-1.124***
	(5.179)	**(0.146)**
ln(1 + Bond age)	20.115***	0.569***
	(3.813)	(0.068)
ln(1 + Bond issue size)	-17.748***	-0.601***
	(3.091)	(0.073)
FIFS	-28.732***	-1.933***
	(6.860)	(0.225)
ln(1 + Bond maturity)	35.693***	0.004
	(1.507)	(0.035)
Matched Ret. × ln(1 + Bond maturity)		0.282***
		(0.009)
Observations	6,288	8,918
R-squared	0.51	0.74
Issuer FE	✓	✓

Appendix

Table A1
Determinants of Bond Constrainedness

We estimate cross-sectional logistic regressions of the bond constrained indicator on the variables displayed in the table. We report average estimates. *Bond age* and *bond maturity* are expressed in years. *Bond issue size* is expressed in $mn. *Bond rating* represents the bond's numeric credit rating (AAA = 1). Bond illiquidity represents the average bond illiquidity during the first 20 calendar days of a month. Average p-values of the cross-sectional parameter estimates are reported in parentheses.

Average Coefficients				
$\hat{\beta}_{Age}$	$\hat{\beta}_{Maturity}$	$\hat{\beta}_{Size}$	$\hat{\beta}_{Rating}$	$\hat{\beta}_{Illiquidity}$
-0.622***	0.302***	0.176*	0.156	-0.228***
(0.000)	(0.000)	(0.059)	(0.100)	(0.008)

Table A2
Covariate Balance in Propensity Score Matched Sample

This table displays covariate balance statistics for the one-to-one matched bond sample, separating 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 estimated propensity score. We consider as unconstrained only bonds in the bottom three quintiles for *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 $mn). *Bond rating* represents the bond's numeric credit rating (AAA = 1). *Bond illiquidity* refers to the effective bid-ask spread in basis points computed over the first 20 calendar days of the month. 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	142,817	1.07	0.67	142,817	1.09	0.64	0.02
Bond maturity	142,817	2.08	0.72	142,817	2.08	0.76	0.01
Bond issue size	142,817	13.43	0.63	142,817	13.43	0.66	0.00
Bond rating (1 = AAA)	142,817	10.52	5.05	142,817	10.84	6.10	0.06
Bond illiquidity (bp)	142,817	40.70	50.95	142,817	40.74	53.31	0.00

Table A3
Fund Liquidity Provision in Constrained and Unconstrained Bonds - Propensity Score Matched Sample

This table reproduces 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 indicator on a set of bond characteristics, including *Bond age* and *bond maturity*, expressed in years; *Bond issue size*, expressed in $mn; *Bond rating*, expressed in numeric values (AAA = 1, AA+ = 2, etc.); *Bond illiquidity*, measured as the average bond illiquidity during the first 20 calendar days of a month. Each constrained bond in month t is matched, with replacement, to the unconstrained bond in month t with the smallest absolute distance based on estimated propensity score. Standard errors, double-clustered at the fund family and year-quarter level, 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)
$\mathbf{1}[QE]$	0.062 (0.038)	0.061 (0.043)	0.051 (0.042)
$\mathbf{1}[Constr.\,Bond]$	0.012 (0.021)	-0.032 (0.036)	-0.037 (0.039)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond]$	**0.089**** **(0.032)**	0.008 (0.057)	0.013 (0.054)
$\mathbf{1}[LS-Fund]$			0.065** (0.031)
$\mathbf{1}[QE] \times \mathbf{1}[LS-Fund]$			0.036 (0.038)
$\mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS-Fund]$			0.058 (0.061)
$\mathbf{1}[QE] \times \mathbf{1}[Constr.\,Bond] \times \mathbf{1}[LS-Fund]$			**0.074*** **(0.040)**
Observations	505,765	754,804	1,262,012
R-Squared	0.151	0.141	0.126
Bond x Year FE	✓	✓	✓
Bond Controls	✓	✓	✓
Fund Controls	✓	✓	✓

Table A4
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 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. $\mathbf{1}[LR\ Period]$ is an indicator that is one for months during the leverage ratio period (01/2015-12/2019). Fund controls, $M_{i,t}$, include lagged flow, broker affiliation dummy, age, size, family size, average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age). $M_{j,t}$ represents bond controls and includes bond age, bond maturity, downgrade and upgrade indicators, and the first principal component extracted from the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure. All controls are as of the end of period $t-1$. $\eta_j \times \lambda_y$ represents bond-year fixed effects. All columns are restricted to LS funds and investment-grade bonds. Columns 1-3 restricts the sample to quarters 1, 2, and 3. Column 4-6 restricts the sample to only quarter 4. Standard errors, double-clustered at the fund family 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)
$\mathbb{1}[QE]$	0.059	-0.008	-0.109	0.107	-0.063	**-0.320***
	(0.042)	(0.079)	(0.076)	(0.063)	(0.142)	**(0.147)**
$\mathbb{1}[QE] \times \mathbb{1}[LR\,Period]$			**0.206****			**0.532****
			(0.086)			**(0.201)**
Observations	1,045,930	360,392	1,406,322	364,385	129,230	493,615
R-squared	0.126	0.174	0.153	0.156	0.271	0.226
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond Controls	✓	✓	✓	✓	✓	✓
Fund Controls	✓	✓	✓	✓	✓	✓

Table A5
LS Fund Liquidity Provision in Constrained Investment-Grade Bonds - Q1-3 vs. Q4

This table displays estimates for the regression:

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

The dependent variable, $Fund\,Position\,Change_{i,j,t}$, represents the change in bond j position of fund i at time t relative to the previous period fund TNA ($TNA_{i,t-1}$) 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. $\mathbb{1}[LS\,Fund]$ 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 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, age, size, family size, average maximum rear load, and time-varying portfolio characteristics (% cash, % government bonds, % corporate bonds, average coupon rate, average credit rating, effective duration, natural log of 1 + average bond issue size, and natural log of 1 + average bond age). $M_{j,t}$ represents bond controls and includes bond age, bond maturity, downgrade and upgrade indicators, and the first principal component extracted from the effective bid-ask spread, the imputed round-trip cost, and the interquartile range measure. 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 family and year-quarter level, are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Quarter	Quarters 1-3			Quarter 4		
Fund Type	LS	Non-LS	All	LS	Non-LS	All
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}[QE]$	0.044	0.058	0.040	0.109	0.174**	0.145**
	(0.039)	(0.033)	(0.030)	(0.064)	(0.045)	(0.045)
$\mathbb{1}[Constr.\,Bond]$	0.039	0.054	0.034	0.036	0.054	0.029
	(0.026)	(0.034)	(0.033)	(0.030)	(0.052)	(0.044)
$\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond]$	0.074	-0.046	-0.041	-0.101	-0.421**	-0.357**
	(0.044)	(0.057)	(0.053)	(0.065)	(0.127)	(0.123)
$\mathbb{1}[LS-Fund]$			0.035			0.044
			(0.025)			(0.029)
$\mathbb{1}[QE] \times \mathbb{1}[LS-Fund]$			0.034			0.010
			(0.038)			(0.032)
$\mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LS-Fund]$			0.033			0.039
			(0.070)			(0.046)
$\mathbb{1}[QE] \times \mathbb{1}[Constr.\,Bond] \times \mathbb{1}[LS-Fund]$			**0.117****			**0.168***
			(0.040)			**(0.061)**
Observations	1,013,588	1,360,072	2,375,042	355,360	470,642	827,264
R-squared	0.117	0.105	0.095	0.149	0.163	0.131
Bond x Year FE	✓	✓	✓	✓	✓	✓
Bond Controls	✓	✓	✓	✓	✓	✓
Fund Controls	✓	✓	✓	✓	✓	✓

Table A6
Bond Returns, Illiquidity, and Outflows from the Mutual Fund Industry - Propensity Score Matched Sample

This table reproduces Table 11 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 indicator on a set of bond characteristics, including *Bond age* and *bond maturity*, expressed in years; *Bond issue size*, expressed in $mn; *Bond rating*, expressed in numeric values (AAA = 1, AA+ = 2, etc.); *Bond illiquidity*, measured as the average bond illiquidity during the first 20 calendar days of a month. Each constrained bond in month t is matched, with replacement, to the unconstrained bond in month t with the smallest absolute distance based on estimated propensity score. We restrict the analysis to investment-grade bonds. Standard errors, clustered by issuer-times-year-quarter, are in parentheses. *, **, and *** indicate statistical significance at the 10 %, 5% and 1% levels.

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Table A6 - continued

Dependent Variable	Average Illiquidity	Excess Bond Return
	(1)	(2)
$\mathbb{1}[Constrained_{j,t}]$	-5.901***	0.033
	(0.588)	(0.022)
$\mathbb{1}[Flow \in [0\%, 20\%)]$	5.039***	-0.140*
	(1.268)	(0.073)
$\mathbb{1}[Constrained_{j,t}] \times \mathbb{1}[Flow \in [0\%, 20\%)]$	-1.801	0.039
	(1.341)	(0.062)
$\mathbb{1}[Constrained_{j,t}] \times \mathbb{1}[LR\,Period]$	2.328***	0.001
	(0.685)	(0.027)
$\mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$	-5.964***	-0.439***
	(1.408)	(0.087)
$\mathbb{1}[Constrained_{j,t}] \times \mathbb{1}[Flow \in [0\%, 20\%)] \times \mathbb{1}[LR\,Period]$	**4.854*****	**-0.214*****
	(1.567)	**(0.075)**
Agg. Flows	-2.370***	0.180***
	(0.351)	(0.031)
ln(1 + Bond age)	14.911***	-0.130***
	(0.360)	(0.011)
ln(1 + Bond issue size)	-17.299***	-0.004
	(0.415)	(0.014)
FIFS	-7.745**	-0.190
	(3.152)	(0.159)
ln(1 + Bond maturity)	28.103***	-0.039***
	(0.252)	(0.010)
$\mathbb{1}[Downgrade]$	7.399**	-1.628***
	(3.403)	(0.414)
$Matched\,Ret$	-0.591***	-0.316***
	(0.017)	(0.044)
$Matched\,Ret \times$ ln(1 + Bond maturity)	0.428***	0.244***
	(0.011)	(0.025)
Observations	120,051	133,148
R-Squared	0.57	0.41
Issuer x Quarter FE	✓	✓