# Does Liquidity Management Induce Fragility in Treasury Prices? Evidence from Bond Mutual Funds*

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**Abstract**

Mutual funds investing illiquid corporate bonds actively manage Treasury positions to buffer redemption shocks. We argue and show that this liquidity management practice can transmit and concentrate non-fundamental fund flow shocks onto the Treasuries funds hold, generating price pressure and fragility for Treasuries. Treasuries held more by bond funds tend to exhibit high return comovement during downside markets, left-skewed returns, and frequent liquidity co-jumps, compared to Treasuries with low fund ownership. We address endogeneity concerns by exploiting the 2003 mutual fund scandal as a shock to fund ownership. This mechanism contributes to the COVID-19 Treasury market turmoil in March 2020.

Keywords: liquidity management; bond mutual fund; price pressure; financial fragility; U.S. Treasury

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# 1 Introduction

While investors conventionally view the U.S. Treasury market as a safe haven, regulators have concerns about the increasing fragility in the Treasury market. In 2016, Jerome Powell, the current chair of the Federal Reserve, pointed out that "spikes in volatility and sudden declines in liquidity have become more frequent in both Treasury and equity markets ... [t]here is also evidence that liquidity shifts more rapidly and hence is less predictable in these markets."[1] Several recent episodes in the Treasury market exemplify this statement, including the "taper tantrum" in 2013, the "flash rally" in 2014, and the COVID-19 turmoil in March 2020.[2] It is not completely clear what economic mechanism drives the increasing fragility in the Treasury market—the most liquid market around the world.

In this paper, we argue that the common practice of liquidity management among open-end bond mutual funds contributes to the increased fragility in Treasury prices. Mutual funds that invest in corporate bonds (or other illiquid assets such as bank loans, real estate, and emerging market stocks) perform liquidity transformation—holding illiquid assets but issuing liquid claims (i.e., fund shares) to investors. These funds often face run risks arising from strategic complementarities among investors (e.g., Chen, Goldstein, and Jiang, 2010a). To mitigate the risk, bond mutual funds actively engage in liquidity management, that is, maintaining a large amount of cash-like or highly liquid assets—mostly Treasuries—as a buffer for investor withdraws. As a result, their tradings on Treasuries appear to be excessively sensitive to investors' demand for liquid claims (see Jiang, Li, and Wang, 2021; Choi, Hoseinzade, Shin, and Tehranian, 2020). We argue that this liquidity management practice can potentially transmit and concentrate the non-fundamental shocks driven by fund flows onto the price of Treasuries the funds hold, generating fragility in the Treasury market.[3] Such mechanism has been particularly

[1] Testimony by Governor Powell on Trends in fixed-income markets (April 14, 2016).

[2] For the discussion on the "taper tantrum," see Adrian, Fleming, Stackman, and Vogt (2015a); for the discussion on the "flash rally," see the joint staff report by U.S. Department of the Treasury, the Fed, SEC, and CFTC (2016); for the discussion on the Treasury market performance during March 2020, see Duffie (2020), Fleming and Ruela (2020), He, Nagel, and Song (2022), Schrimpf, Shin, and Sushko (2020), and the Financial Stability Report (2020).

[3] The term "fragility" in this paper follows Greenwood and Thesmar (2011), who denote the price impact of flow-induced trades on stocks as stock price "fragility."

relevant in recent years, as the total size of open-end funds investing in illiquid assets has increased manyfold.[4]

To test the asset pricing implications of liquidity management on Treasuries, we focus on U.S. open-end bond mutual funds (for brevity, we label them as "bond funds" hereafter) from 2002 to 2019. Bond funds are ideal for testing our argument because they have several unique features. First, bond funds usually trade two major asset classes with distinct liquidity levels, that is, U.S. Treasuries and corporate bonds. Second, detailed data on fund holdings are available at quarterly frequency for a long period, which allows us to directly analyze funds' trading behaviors. Third, we can precisely measure investors' demand of liquid claims by fund flows.

Before testing the asset pricing implications, we first confirm our premise that bond funds indeed use Treasuries as a buffer to manage liquidity. Specifically, we examine whether bond funds disproportionately adjust their holdings of Treasuries and corporate bonds in response to fund flows. We find that, for example, with a 1% fund inflow, funds increase their holdings on Treasuries by about 1.42% but only increase their holdings in corporate bonds by 0.86%. Moreover, the difference in the trading-to-flow sensitivity between Treasuries and corporate bonds is more pronounced when funds experience outflows. That is, with a 1% fund outflow, funds tend to decrease their holdings on Treasuries by 1.76% but only reduce their corporate bond holdings by 0.82%. These patterns are consistent with liquidity management. That is, when funds experience outflows, they are more likely to subject to financial fragility (Goldstein, Jiang, and Ng, 2017), and thus selling Treasuries becomes more urgent to meet redemption.

Second, we examine if such flow-induced trading can have material price impacts on Treasuries, which are arguably the most liquid assets around the world. To this end, we first follow Lou (2012) and aggregate bond funds' flow-induced trading over a month onto the Treasury level and scale it by the total amount of the Treasury security held by bond funds (denoted as "Flow-Induced Trading", or *FIT*). We find that *FIT* is associated with a contemporaneous price pressure followed by a subsequent reversal, and such effect is twice stronger when funds experience outflows. Also, the economic

[4] According to Investment Company Institute (2020), total assets under management of open-end mutual funds with primary investment in illiquid assets, such as corporate bonds, municipal bonds, and bank loans, increased from 1.3 trillion USD in 2002 to about 7.3 trillion in 2019.

magnitude is sizeable: a one standard deviation shock of the outflow-induced $FIT$ implies a 7.76 basis point lower beta-adjusted return in the contemporaneous month, which is 13.6% of the interquartile of Treasuries' beta-adjusted returns in the sample.[5] Such a contemporaneous price impact from $FIT$ with subsequent reversal not only shows that fund flow-induced trading generates large price pressures on Treasuries, but also suggests that demand shocks arising from fund flows are largely non-fundamental.[6] Noting that, while the fund flow-induced price pressure has been widely identified in stock markets (e.g., Lou, 2012; Coval and Stafford, 2007; Huang, Song, and Xiang, 2020), we are the first, to our best knowledge, to document that bond funds can also transmit non-fundamental demand shocks from fund flows into the highly liquid Treasury market.

The previous two findings confirm that bond funds aggressively trade Treasuries as a liquidity buffer in response to fund flows, which in turn generates large price pressure on Treasuries. The fund flow-induced price pressure naturally induces Treasuries with high bond funds' ownership to have excess return comovement, which arises from the systematic exposure to non-fundamental fund flow shocks (for detailed argument, see Greenwood and Thesmar, 2011; Anton and Polk, 2014). Such exposure becomes a defining factor for Treasury prices as mutual funds are now one of the major players in the Treasury market. Liang (2020) estimates that the percentage of marketable Treasury shares held by long-term mutual funds increased from 3% in 2008 to 8% in 2019—more than the amount held by banks and broker-dealers, and bond funds trade much more actively than other major market participants, such as pension funds and insurance companies.

To test our argument, we examine the cross-sectional association between bond funds' ownership and the non-fundamental comovement in Treasury prices. It is well-known that return correlations among individual assets within a particular asset class (i.e., Treasuries in our context) largely determine the total return variance of the asset class, i.e., a natu-

[5]The beta-adjusted return is the return after controlling for risk factors and is tradeable by construction. Specifically, for each Treasury $i$ at month $t$, we first run the regression of Equation (6) using daily returns from months $t-3$ to $t-1$ and obtain the beta estimates on the factors, i.e., aggregate returns on the Treasury market, investment-grade corporate bonds, and high-yield corporate bonds. Then, we use these beta estimates with daily returns of these factors in month $t$ to compute daily adjusted returns for Treasury $i$ in month $t$ and denote them as beta-adjusted returns.

[6]Note that the non-fundamental nature of fund flows is not surprising as most mutual fund investors are households with behavior biases, limited financial knowledge, and insufficient information. As reported by the 2017 ICI Fact Book, more than 90% of the mutual fund shares were held by households in the U.S.

ral measure of fragility. More importantly, during downside markets when fund investors withdraw, the co-variance component plays a more important role and captures the contagion effect that can lead to market-wide turmoil. In this sense, our focus on the return comovement among Treasury pairs can shed light on the systematic risk in the Treasury market and has an intellectual link to prior studies on the heightened systematic risk (i.e., contagion or excess return comovement) during crisis periods (see, King and Wadhwani, 1990; King, Sentana, and Wadhwani, 1994; Forbes and Rigobon, 2002; Rigobon, 2002; Bekaert, Harvey, and Ng, 2005).

We admit that it is not new in the literature to test how fund ownership drives the return comovement of the assets that funds hold, but in the context of liquidity management, some novel predictions arise. Greenwood and Thesmar (2011) and Anton and Polk (2014), for example, find that stocks commonly held by mutual funds tend to comove in price due to correlated fund trading. This mechanism should naturally work on bond funds. Therefore, we first hypothesize that Treasuries commonly held more by bond funds (termed as *common ownership* for brevity) should exhibit a stronger excess return comovement. More importantly, the liquidity management practice further reinforces the mechanism and offers several unique predictions for Treasuries and corporate bonds, respectively. One is the asymmetric pattern, that is, the effect of common ownership on the Treasury return comovement should be stronger in presence of fund outflows or during market downturns. Again, this is due to the urgency of selling Treasuries to meet fund redemption, which is confirmed by our study. The other prediction is that the effect should be weaker for corporate bonds, as they are much less sensitive to outflow shocks when bond funds use Treasuries as the liquidity buffer to prevent flow shocks from transmitting to illiquid holdings.

To test these hypotheses, we conduct cross-sectional tests and link the excess return comovement among Treasuries or corporate bonds to bond funds' ownership. It is worth noting that cross-sectional tests have unique advantages to help pin down the underlying economic mechanism and to rule out confounding effects from the time-series. More specifically, for each Treasury or corporate bond pair in each quarter, we first calculate the correlation between the two securities' daily risk-adjusted returns to measure their excess return comovement. Here, a bond's daily risk-adjusted returns are computed as the residuals from a regression model that adjusts for average returns on Treasuries, investment-grade corporate bonds, and junk bonds.[7]

Before discussing the cross-sectional results, we can first have a glance at the aggregate trends. In Figure 1, we plot the time-series of the average risk-adjusted return correlation from Treasuries (solid blue line) and from corporate bonds (dashed yellow line), as well as the total assets under management (AUM) of bond funds (in billion USD). As one can see, since the early 2000s, when the total AUM of bond funds started to grow quickly, the average excess return comovement among Treasuries has significantly increased from about 1% to 7%, which echoes regulators' concern about the stability of the Treasury market (see, Powell, 2016). In sharp contrast, such a trend does not appear on corporate bonds. Although there are other potential driving forces, these time-series patterns are nonetheless consistent with our main argument that the increasing size of the bond fund sector contributes to the increased fragility of Treasury prices.

To avoid confounding driving forces from the time trend, we run Fama and MacBeth (1973) cross-sectional regressions to examine the effect of fund common ownership on the Treasury return comovement. In these regressions, we follow Anton and Polk (2014) and control for the Treasury pair's similarities in bond characteristics, including maturity, liquidity, and coupon rate. We have several findings. First, common ownership positively forecasts comovement among Treasuries. A one standard deviation increase in common ownership is associated with a 7.9% (or 18.8% of the standard deviation) increase in the return correlation between two Treasury securities. For comparison, we find a much smaller effect on corporate bonds. A one standard deviation increase in common ownership is only associated with a 0.5% (or 3.1% of the standard deviation) increase in the return correlation between two corporate bonds.

Second, we examine the asymmetry in the association between common ownership and return comovement during downside and upside markets. Within each quarter, we first sort all trading days into two equal groups (downside markets and upside markets) based on the aggregate Treasury market returns. We then calculate return comovement for each group and take the difference in return comovement between downside and upside

[7] We find similar results by including additional factors into the regression model, such as the unexpected changes in interest rates ($TERM$), shifts in economic conditions that change the likelihood of default ($DEF$) (Fama and French, 1993), and the level of $VIX$ (or the percentage change in $VIX$).

markets. We denote this difference as *Down-minus-up*. Since *Down-minus-up* is based on the same pair of Treasuries, it has a unique advantage to eliminate potential similarities in unobservable bond characteristics that may drive return comovement. Then, we run Fama-MacBeth regressions of *Down-minus-up* on common ownership to examine the asymmetric effect of common ownership on Treasury comovement between downside and upside markets.

Our analysis uncovers an intriguing pattern on Treasuries. That is, the association between common ownership and the Treasury return comovement is stronger during downside markets than that during upside markets. Specifically, a one standard deviation increase in common ownership is associated with a 0.8% higher *Down-minus-up*. The magnitude is economically meaningful, given that the average correlation of risk-adjusted returns is 6.2% among Treasuries, and the average *Down-minus-up* is about 0.3%. In contrast, we do not find such a pattern on corporate bonds.[8]

To strengthen our argument on the role of bond funds' ownership and the fragility on Treasury prices, we consider two alternative fragility measures. The first measure is liquidity co-jump, which is also at the Treasury pair level. Here, liquidity co-jump measures whether the bid-ask spreads of two Treasuries simultaneously spike. This is motivated by the observation during recent market-wide events that the most liquid market experienced sudden liquidity dry-ups, such as the "flash rally" in 2014 and the COVID-19 turmoil in March 2020 (e.g., Adrian, Fleming, Stackman, and Vogt, 2015a; Fleming and Ruela, 2020). The second measure is the negative skewness of risk-adjusted returns, which is at the individual Treasury level. This is a widely used measure for the likelihood of price crashes in the literature (Chen, Hong, and Stein, 2001; Brunnermeier, Nagel, and Pedersen, 2008). Based on these two measures, we find consistent results that Treasuries owned more by bond funds are more likely to experience fragility.

We are aware of potential endogeneity issues related to our aforementioned findings. For example, Treasuries in the portfolio of a bond fund may have similar but unobservable characteristics and thus naturally comove in prices. While this is unlikely to explain

[8]As an alternative setting, we find that the association between common ownership and return comovement on Treasuries is larger for common funds with outflows than for common funds with inflows, and we do not find a similar pattern for corporate bonds. In addition, in untabulated results, we find that there is no such asymmetric pattern on stocks, which further highlights the uniqueness of our finding on Treasuries.

the asymmetric pattern on the return comovement among Treasuries, we nonetheless exploit the 2003 mutual fund scandal as a quasi-natural experiment. As documented in prior studies (Kisin, 2011; Anton and Polk, 2014; Koch, Ruenzi, and Starks, 2016), the mutual fund families involved with this scandal experienced large fund outflows, which were plausibly uncorrelated with the fundamentals of the funds' portfolio holdings. In this sense, we use this mutual fund scandal as a quasi-natural negative shock to bond funds' ownership on Treasuries heavily owned by the scandal funds, in order to pin down the causal link between bond funds' ownership and the fragility in Treasury prices. Specifically, we follow Koch et al. (2016) and conduct a difference-in-differences regression. We find that Treasuries held more by the scandal funds, resulting in a lower common ownership during the post-scandal period, tend to exhibit lower *Down-minus-up*, less frequent liquidity co-jumps, and fewer left-skewed returns during the scandal period, compared to the non-scandal period. With these results, we are comfortable to draw the causal conclusion that common ownership can induce fragility in Treasury prices.

Finally, we document several observations during the recent Treasury market turmoil in March 2020 and find that they are consistent with our proposed mechanism with liquidity management. As shown in Panel A of Figure 2, starting from the second week of March 2020 (the week when WHO announced the global pandemic), bond funds experienced significant fund outflows (around 5% between March 11 and 31). We find that during this period when Treasuries had dramatic price declines, (1) the price decline is much more pronounced among Treasuries with high bond funds' ownership (see Panel B of Figure 2), and (2) Treasuries exhibit an increased return comovement, and this increase was more significant among Treasury pairs held more by bond funds. Both patterns are consistent with our argument that when bond funds experience large outflows, they tend to liquidate Treasuries to meet investor redemption, exerting a significant and correlated downward price pressure on the Treasuries being sold.

**Related Literature.** Our study contributes to several strands of literature. First, our study is closely related to the growing literature on financial fragility and liquidity management of mutual funds. When mutual funds perform liquidity transformation—holding illiquid assets but issuing liquid claims to investors—they are often subject to financial fragility due to strategic complementarities among investors (e.g., Chen et al., 2010a), particularly during the COVID-19 pandemic (for detailed evidence, see, Falato, Goldstein, and Hortaçsu, 2021). To mitigate this financial fragility, mutual funds use cash or cash-like assets to manage their liquidity needs (see, Chernenko and Sunderam, 2016; Aragon, Ergun, and Girardi, 2021; Jiang et al., 2021; Choi et al., 2020; Ma, Xiao, and Zeng, 2021). For example, Ma et al. (2021) compare the liquidity management behaviors of fixed-income mutual funds and commercial banks during the COVID-19 pandemic, and they find that fixed-income mutual funds are more aggressive than commercial banks in using liquid assets—Treasuries—to meet fund outflows. In addition, Jotikasthira, Lundblad, and Ramadorai (2012) show that emerging market funds also prefer to trade holdings in more liquid markets when accommodating fund flow shocks. The main focus of these studies is to either identify the strategic complementarities among investors or to document the liquidity management practice of mutual funds. Our study incrementally extends this literature by systematically examining the pricing impact of liquidity management on the buffer assets, i.e., Treasuries. Specifically, we find that liquidity management induces a sizeable price pressure and return comovement among Treasuries.[9]

Our study is also related to some contemporaneous studies on the economic mechanisms underlying the COVID-19 Treasury market turmoil in March 2020. For example, Duffie (2020) emphasizes the frictions in the market-making mechanism, whereas Schrimpf et al. (2020) and Kruttli, Monin, Petrasek, and Watugala (2021) highlight the role of margin spirals and hedge funds. He, Nagel, and Song (2022) focus on the interaction between leveraged investors financing with Repo and dealers subject to balance sheet constraints. We complement this strand of literature by providing a novel perspective from liquidity management practice of bond funds. Specifically, we argue that when bond funds, particularly those with large illiquid corporate bond holdings (e.g., Falato et al., 2021), experienced large fund outflows during the COVID-19 pandemic,

[9]Our findings on Treasuries are also related to Greenwood and Vayanos (2010), who present anecdotal evidence from two events (the U.K. pension reform of 2004 and the U.S. Treasury's buyback program of 2000-2001) to show that the government bond market can be affected by short-term price pressures. Our findings on corporate bonds also echo those from Choi, Hoseinzade, Shin, and Tehranian (2020), who show that due to the practice of liquidity management, flow shocks have little impact on corporate bond prices.

liquidity management induced dramatic fire sales on Treasuries from those funds, which could at least partially contribute to the Treasury market turmoil during the COVID-19 pandemic. Another important difference between our study and this strand of literature is that we focus on a long sample period and use data with rich information (e.g., detailed bond holdings and fund characteristics). The more generalized setting not only allows us to conduct cross-sectional tests to pin down the underlying mechanism, but also help demonstrate that the liquidity management practice together with the fast-growing bond fund sector has contributed to the increased fragility in the Treasury market over the past decades.

There are also a few papers examining the corporate bond market rather than the Treasury market (our focus) during the COVID-19 episode. For example, Kargar, Lester, Lindsay, Liu, Weill, and Zúñiga (2021) and O'Hara and Zhou (2021) examine the market liquidity and microstructure. Haddad, Moreira, and Muir (2021) find that corporate bonds with better credit ratings tended to exhibit more severe price crashes, which was likely driven by the selling pressure from mutual funds. Jiang, Li, Sun, and Wang (2020) find that corporate bonds with higher latent fragility, measured by the asset illiquidity of their mutual fund holders, experienced more negative returns in March 2020.

Finally, our paper is related to the large body of literature on the role of institutional trading in generating price impacts and financial fragility. Edmans, Goldstein, and Jiang (2012) and Lou (2012) show that fund flow-induced trading has a significant price impact on stock markets. Anton and Polk (2014) show that fund common ownership forecasts the return correlation between stocks. Greenwood and Thesmar (2011) estimate the correlation between fund flows among mutual funds and link the correlated fund flows to the stock return comovement. Huang et al. (2020) document that the correlation between mutual fund flows contributes to a large portion of the variance-covariance in anomaly returns. Our study contributes to this literature by focusing on the role of liquidity management and bond funds. We find that the trading induced by liquidity management has different implications to assets with distinct liquidity levels, such as Treasuries versus corporate bonds. In addition, our findings highlight that liquidity management may exacerbate the contagion effect during market turmoil, even in the most liquid market.

# 2 Background, Data, and Methodology

In this section, we describe institutional background in Section 2.1, data sources and the sample construction in Section 2.2. Sections 2.3 and 2.4 describe our empirical methodology. Section 2.5 presents summary statistics. Detailed definitions of all variables are in Appendix Table A1.

## 2.1 Background

The recent decades witness the fast growth of open-end mutual funds that invest in relatively illiquid assets (e.g., corporate bonds). According to the report by the Investment Company Institute (2020), the total assets under management of open-end mutual funds with primary investments in corporate bonds, municipal bonds, bank loans, and international equities, increased from 1.3 trillion USD in 2002 to about 7.3 trillion in 2019.

At the same time, mutual funds' total ownership in Treasuries has also increased dramatically, becoming an important player in the Treasury market. Using the flow of funds data from the Federal Reserve, Figure 3 shows that the fraction of Treasury securities outstanding owned by U.S. mutual funds and money market funds rose from about 5% in 1990 to over 12% in 2019.[10] This pattern is also confirmed by Liang (2020), who finds that the number of marketable Treasury shares held by long-term mutual funds exceeded the amount held by banks and broker-dealers in 2019.

Unlike other major investors in the Treasury market, such as insurance companies, pensions, or sovereign wealth funds, who tend to be passive and buy-and-hold, open-end mutual funds trade frequently in the Treasury market to accommodate fund flows, and such trading-to-flow sensitivity could be further amplified by the liquidity management practice. Thus, the trading of open-end mutual funds can have a large price impact on Treasuries. This argument is supported by recent studies, such as Brooks, Katz, and Lustig (2020).

[10] The abnormal spike in 2008 was likely due to the flight-to-safety effect during the financial crisis.

## 2.2 Sample construction

We focus on U.S. actively managed open-end mutual funds whose majority of investment is in fixed-income securities (labeled as "bond funds"). We obtain the list of bond funds from Morningstar, and the list includes funds that fall under the Morningstar global broad category of "Fixed Income" and the U.S. category group of "Taxable Bond". Morningstar also provides detailed information on bond funds' portfolio holdings, including bond CUSIPs, the number of shares, and market values. The holding data is available from July 2002 at the quarterly frequency. To obtain fund characteristics, including fund returns and total net assets ($TNA$), we further match this list of bond funds with CRSP (Center for Research in Securities Prices) survivor-bias-free U.S. mutual fund database based on fund CUSIPs and tickers. Our final sample includes 2,293 unique bond funds from 2002 to 2019.

We obtain data on Treasuries from the CRSP and data on corporate bonds from the Trade Reporting and Compliance Engine (TRACE) and the Mergent Fixed Income Securities Database (Mergent-FISD). The CRSP provides data on daily Treasury prices, the total number of shares outstanding (i.e., shares held by the public), and issuance terms. The TRACE provides detailed transaction information on corporate bond trades, including the transaction prices and volumes.[11] The Mergent-FISD provides bond characteristics, such as credit ratings, the total number of shares outstanding, issuers, coupon rates, and maturity dates. Following prior studies on corporate bonds, in the Mergent-FISD, we identify corporate bonds by requiring bonds' FISD type codes to be CDEB, CLOC, CMTN, CMTZ, CP, CPAS, CPIK, or CS. By doing in this way, we drop callables, puttables, convertibles, asset-backed securities, and corporate bonds with warrants or with unusual/zero coupons. Considering potential liquidity issues with bonds that are close to maturity, we further exclude Treasuries or corporate bonds with a time-to-maturity of less than six months.[12] Our final sample contains 1,136 Treasuries and 2,804 corporate bonds.

[11] We are aware of the reporting errors in the TRACE and follow the procedure in Dick-Nielsen (2009) to address the errors.

[12] Our results are robust to alternative cutoffs, such as one year or three months.

## 2.3 Fund flows, trading, and common ownership

For each fund at each quarter, we calculate fund flows as follows:

$$Fund\ Flow_{f,q} = \frac{TNA_{f,q} - TNA_{f,q-1}(1 + Fund\ Return_{f,q})}{TNA_{f,q-1}}, \tag{1}$$

where $Fund\ Return_{f,q}$ is fund $f$'s gross return over quarter $q$, and $TNA_{f,q}$ is fund $f$'s total net assets at quarter $q$. We calculate the gross return before expenses by adding one-twelfth of the fund expense ratio to the net monthly return.

We next calculate how bond funds trade different asset classes (either Treasuries or corporate bonds). Specifically, for each asset class (e.g., Treasuries) at each quarter, we define $Net\ Buy$ as

$$Net\ Buy_{f,q} = \frac{\sum_i^N Share_{i,f,q} P_{i,q-1} - \sum_i^N Share_{i,f,q-1} P_{i,q-1}}{\sum_i^N Share_{i,f,q-1} P_{i,q-1}}, \tag{2}$$

where $Share_{i,f,q}$ is the amount of bond $i$ held by fund $f$ at quarter $q$, $P_{i,q-1}$ is the price of bond $i$ at quarter $q-1$, and $N$ is the total number of bonds in the asset class (either Treasuries or corporate bonds). By construction, $Net\ Buy$ measures the percentage change of a fund's total holdings in Treasuries or in corporate bonds, relative to its beginning-of-the-quarter holdings. Note that we fix and use the quarter-beginning prices (e.g., $P_{i,q-1}$) in Equation (2), and thus our measure, $Net\ Buy$, is purely driven by funds' trading on Treasuries or corporate bonds rather than changes in bond prices.

Following Lou (2012), we calculate the flow-induced trading (denote as $FIT$) across all bond funds for bond $i$ in each month as,

$$FIT_{i,t} = \frac{\sum_i^F Share_{i,f,q-1} * Fund\ Flow_{f,t}}{\sum_i^F Share_{i,f,q-1}}, \tag{3}$$

where $Share_{i,f,q-1}$ is the amount of bond $i$ held by fund $f$ at quarter $q-1$, $Fund\ Flow_{f,t}$ is the fund flows for fund $f$ in month $t$ of quarter $q$, and $F$ is the total number of bond funds. Based on this definition, we assume that funds adjust all of their holdings in a proportional manner when experiencing inflows and outflows, i.e., trading-to-flow sensitivity is one (more discussion on this in Section 3.1). $FIT_{i,t}$ captures the aggregate flow-induced trading on bond $i$ in month $t$ from all bond funds in our sample.

We construct fund ownership and common ownership as follows. First, for each bond at each quarter, we calculate bond funds' ownership as the ratio of the total market value held by all bond funds divided by the total market value outstanding. Then, we follow Anton and Polk (2014) and calculate bond funds' common ownership (denoted as *Common Ownership*) to measure the extent to which a pair of bonds is heavily held by the same funds (termed as "common funds"). Specifically, for a pair of bonds $i$ and $j$ at each quarter, *Common Ownership* is defined as:

$$Common\ Ownership_{i,j,q} = \frac{\sum_{f=1}^{F}(Shares_{i,f,q} \times P_{i,q} + Shares_{j,f,q} \times P_{j,q})}{SharesOutstanding_{i,q} \times P_{i,q} + SharesOutstanding_{j,q} \times P_{j,q}}, \quad (4)$$

where $Shares_{i,f,q}$ is the amount of bond $i$ held by fund $f$ in quarter $q$, $F$ is the number of funds holding both bonds $i$ and $j$, $SharesOutstanding_{i,q}$ is the total amount outstanding of bond $i$ at quarter $q$, and $P_{i,q}$ is the price of bond $i$ at quarter $q$. Because *Common Ownership* has a time trend, we standardize the variable within each quarter so that the coefficients of this variable estimated from Fama and MacBeth (1973) regressions are comparable across time. It is also worth noting that the results are robust if we use non-standardized *Common Ownership* or its rank-transformation.

## 2.4 Risk-adjusted returns and liquidity jumps

We measure the excess return comovement between two bonds as follows. First, we calculate daily bond returns by adjusting price changes with accrued interests ($AI$) and coupon payments ($C$). More precisely, the daily return for bond $i$ at day $d$ is calculated as:

$$Bond\ Return_{i,d} = \frac{P_{i,d} + AI_{i,d} + C_{i,d}}{P_{i,d-1} + AI_{i,d-1}} - 1. \quad (5)$$

For Treasuries, $P_{i,d}$ is the clean price (or the average of bid and ask, if the clean price is missing) at the day-end from the CRSP. For corporate bonds, we define $P_{i,d}$ as the trading-volume-weighted intraday price, following Bessembinder, Kahle, Maxwell, and Xu (2008), who find that the trading-volume-weighted intraday price is less noisy than the day-end price.

Second, for each bond, we compute daily risk-adjusted returns as the residuals from the following regression:

$$Bond\ RetRF_{i,d} = \alpha_i + \sum_{s=0}^{2} \beta_{i,d-s} TRY_{d-s} + \sum_{s=0}^{2} \gamma_{i,d-s} IG_{d-s} + \sum_{s=0}^{2} \theta_{i,d-s} HY_{d-s} + \varepsilon_{i,d}, \quad (6)$$

where $Bond\ RetRF_{i,d}$ is bond $i$'s daily return minus the risk-free rate at day $d$, and the risk-free rate is the daily rate of the one-month Treasury bill. On the right-hand side of Equation (6), we use the aggregate daily returns (in excess of the risk-free rate) of three major bond categories, i.e., Treasuries, investment-grade bonds, and junk bonds, as the return factors. We use the average daily returns across all Treasuries to proxy for the aggregate returns of the Treasury market; we use returns from The Bloomberg US Corporate Bond Index (Ticker: LUACTRUU) to proxy for the the aggregate returns from investment-grade bonds; we use returns from The Bloomberg US Corporate High Yield Bond Index (Ticker: LF98TRUU) to proxy for the aggregate returns from junk bonds. We denote these three factors as $TRY$, $IG$, and $HY$, respectively. In addition, we include two lags for each factor to take into account of non-synchronized trading. This is particularly important for corporate bonds, which potentially have days with no trading ("zero-trading days" here after).[13] As a robustness test, we include additional factors in Equation (6): $VIX$, $TERM$, and $DEF$. $VIX$ refers to the CBOE Volatility Index. Following Fama and French (1993), we define $TERM$ as the difference in daily returns between The Bloomberg US Long Treasury Index (Ticker: LUTLTRUU) and the one-month Treasury bill rate, and define $DEF$ as the difference in daily returns between The SPDR Bloomberg Barclays 10+ Year U.S. Corporate Bond Index (Ticker: LD07TRUU) and The Bloomberg US Long Treasury Index (Ticker: LUTLTRUU). We find similar results after including these additional factors in the model.

Then, for each pair of Treasuries $i$ and $j$ (or corporate bonds) in each quarter, we use daily risk-adjusted returns to calculate the pairwise correlation as the measure of excess return comovement, and label this correlation as $Corr_{i,j,q}$. To examine the asymmetry in the excess return comovement, within each quarter, we sort all trading days into two equal groups (downside markets and upside markets) based on the aggregate Treasury

[13]Within each quarter, we drop inactive bonds that have non-zero trading days for less than 30 days in the quarter.

market returns (i.e., $TRY$). We then calculate the excess return comovement among Treasuries (or corporate bonds) using daily risk-adjusted returns in each group and take the difference in the excess return comovement between downside and upside markets. We denote this difference as $Down\text{-}minus\text{-}up_{i,j,q}$.

In addition to *Down-minus-up*, we consider two alternative fragility measures: liquidity co-jump and the negative skewness of risk-adjusted returns. Liquidity co-jump is computed based on bid-ask spreads. Even though the Treasury market has been traditionally viewed as the most liquid market, both market participants and academia raise concern on the heightened liquidity risk in the Treasury market; some studies find that sudden spikes in illiquidity have become more common (Adrian et al., 2015a; Adrian, Fleming, Stackman, and Vogt, 2015b). To capture illiquidity spikes, for each Treasury at each quarter, we define liquidity dry-up events as the days when the Treasury's bid-ask spread exceeds the top quartile of its bid-ask spreads over the previous four quarters. To measure liquidity co-jump, we examine whether two Treasuries simultaneously experience liquidity dry-ups. Specifically, for each Treasury pair at each quarter, we define a dummy variable, *Common Dry-ups*, which equals one if these two Treasuries have experienced liquidity dry-up events on the same day.[14]

The second measure, *Skewness*, is computed as the third moment of daily risk-adjusted returns within a quarter. This is a widely used measure of the likelihood of price crashes in the literature (Chen et al., 2001; Brunnermeier et al., 2008). The more left-skewed the return distribution, the higher proneness of price crashes.

For the tests on flow-induced price impact, we compute beta-adjusted daily returns to make them tradeable. More specifically, for month $t$, we first run the regression of Eq.(6) using daily returns from months $t-3$ to $t-1$ and obtain the beta estimates (the coefficients of TRY, IG, HY, and their lags) for each Treasury $i$. Then, we use these beta estimates with daily returns of these factors in month $t$ to compute daily adjusted returns for Treasury $i$ in month $t$.

[14] Koch et al. (2016) examines liquidity commonality of individual stocks as the regression coefficient of the stock's liquidity on the aggregate portfolio's liquidity. Their measure does not suit for Treasuries, because during normal times, Treasuries' bid-ask spread is stable and exhibits little variations. Therefore, we focus on common jumps in illiquidity in our paper. Also, our results are robust to using alternative variable definitions; see Section 4.2 for detail.

### 2.5 Summary statistics

Table 1 reports summary statistics. As shown in Panel A, the market size of bond funds has expanded quickly over time. The number of bond funds increased from 935 in 2002 to 1,308 in 2019. The total AUM of all bond funds grew over five times, from 709.8 billion USD in 2002 to over 3.6 trillion USD in 2019. Panel B reports summary statistics of the variables for Treasuries and corporate bonds. The average excess return correlation is 6.2% for pairs of Treasuries; by comparison, the average return correlation is only 1.4% for corporate bonds. Interestingly, Treasuries also exhibit a relatively stronger downside market comovement: the average *Down-minus-up* of Treasuries is positive and equals 0.3%, whereas the average *Down-minus-up* of corporate bonds is zero. These findings are surprising, as one would expect the corporate bond market to exhibit a stronger fragility because they are far less liquid then Treasuries. As the evidence we document later suggests, this can be driven by liquidity management that limits flow-induced selling and price impact on corporate bonds.

[Table 1 here]

## 3 Main Result

This section presents our main results. First, we validate our premise that, in our sample, bond funds use Treasuries to manage their liquidity needs (Section 3.1). Second, we examine whether bond funds' flow-induced-trading can generate significant non-fundamental price impacts on Treasuries (Section 3.2). Then, we study the association between bond funds' common ownership and the excess return comovement in Section 3.3. In Section 3.4, we address the endogeneity concerns by exploiting the 2003 mutual fund scandal as a quasi-natural experiment. In Section 3.5, we discuss the implication of liquidity management for the Treasury market turmoil around the COVID-19 pandemic announcement.

### 3.1 Liquidity management with Treasuries

We first examine bond funds' liquidity management behaviors. Our analysis is in a spirit similar to prior studies on bond funds' liquidity management, e.g., Chernenko and

Sunderam (2016), Choi et al. (2020), and Jiang et al. (2021). While these studies examine the role of cash and other cash-like securities, we mainly focus on the role of Treasuries in liquidity management instead. As we will show later, using Treasuries as a tool of liquidity management has important and testable asset pricing implications.

Like banks, bond funds perform liquidity transformation and are subject to potential investor run. That is, while bond funds heavily invest in illiquid assets (e.g., corporate bonds), they issue liquid claims (fund shares) that investors can redeem at the net asset value ($NAV$).[15] This liquidity mismatch between fund shares and the underlying assets can generate strategic complementarities among fund investors, leading to financial fragility of funds (e.g., Chen, Goldstein, and Jiang 2010a). To mitigate the fragility, bond funds actively manage their liquidity. We argue that Treasuries play an important role in liquidity management because Treasuries are the most liquid assets and trading them incurs low price impacts. In fact, the practice of liquidity management is common not only among bond funds but also among other open-end funds holding illiquid assets (e.g., bank loan funds and real estate funds) and even commercial banks (e.g., Chen, Goldstein, Huang, and Vashishtha, 2021; Ma, Xiao, and Zeng, 2021).

To verify and quantify the role of Treasuries in liquidity management, we examine how bond funds trade Treasuries or corporate bonds in response to fund flows. We illustrate our test design with the following simplified example. Suppose that a fund has a TNA of \$100 at the beginning of the quarter and it allocates \$20 to Treasuries and \$80 to corporate bonds. Now there is a 10% outflow during the quarter. If the fund manager does not engage in liquidity management, she will proportionally liquidate the holdings in both Treasuries and corporate bonds. That is, the fund will sell \$2 of Treasuries and \$8 of corporate bonds. As a result, the positions in Treasuries and corporate bonds will both decrease by 10%. It is clear that the trading-to-flow sensitivity is one on both Treasuries and corporate bonds in this case. In contrast, if the fund wants to avoid large price impacts in trading corporate bonds, it will prioritize selling Treasuries in liquidity management and liquidate relatively more Treasuries than corporate bonds, say, selling \$9 of Treasuries and \$1 of corporate bonds. Therefore, the fund's total holding of Treasuries will decrease by more than 10% while that of corporate bonds will decrease by less than

[15] In our sample, bond funds on average allocate approximately 70% of their assets in corporate bonds.

10%. In this case (with liquidity management), the trading-to-flow sensitivity is larger than one on Treasuries but is smaller than one on corporate bonds.

Motivated by the above simplified example, we conduct the following regression to formally examine how bond funds trade Treasuries and corporate bonds in response to fund flows:

$$\begin{aligned} Net\ Buy_{f,q} = \alpha + \beta_1 \cdot Fund\ Flow_{f,q} + \beta_2 \cdot Fund\ Flow_{f,q-1} + \\ \gamma_1 \cdot Fund\ Return_{f,q} + \gamma_2 \cdot Fund\ Return_{f,q-1} + \phi_f + \delta_q + \varepsilon_{f,q}, \end{aligned} \tag{7}$$

where $Net\ Buy_{f,q}$ is fund $f$'s trading on Treasuries or corporate bonds in quarter $q$, $Fund\ Flow_{f,q}$ is fund $f$'s net flows in quarter $q$, and $Fund\ Return_{f,q}$ is the gross return of the fund $f$ in quarter $q$. We include quarter fixed effects and fund fixed effects. Standard errors are double clustered by fund and quarter. $\beta_1$ measures the trading-to-flow sensitivity of either Treasuries or corporate bonds. As illustrated in the aforementioned example, if funds use Treasuries as the liquidity buffer, $\beta_1$ should be larger than one for Treasuries but should be smaller than one for corporate bonds.

[Table 2 here]

Table 2 reports the results. Columns (1)–(4) are for Treasuries, and columns (5)–(8) are for corporate bonds. We find that bond funds' trading on Treasuries is more sensitive to fund flows than trading on corporate bonds. Particularly, the trading-to-flow sensitivity is larger than one on Treasuries. For example, as shown in column (1), a 1% fund inflow is associated with a 1.38% ($t$-statistic = 23.5) increase in Treasury holdings. In contrast, for corporate bonds, the trading-to-flow sensitivity is smaller than one. As shown in column (5), a 1% fund inflow is associated with only a 0.86% increase in corporate bond holdings ($t$-statistic = 23.9). The comparison of trading-to-flow sensitivity ($\beta_1$) between Treasuries and corporate bonds is consistent with bond fund using Treasuries to actively manage liquidity.

In Table 2, we also find that bond funds trade Treasuries and corporate bonds in response to lagged fund flows. That is, the coefficient on lagged fund flow is −0.302 ($t$-statistic = −6.3) for Treasuries and is 0.214 ($t$-statistic = 7.2) for corporate bonds. This finding is again consistent with liquidity management. When funds experience outflows (inflows), they initially liquidate (purchase) excess Treasuries to avoid the price impacts in trading illiquid corporate bonds, which induces bond funds' asset allocation to deviate from their initial targets. In the long run, bond funds will revert the trading in Treasuries and keep trading in corporate bonds toward their initial asset allocation targets.

We further examine how bond funds trade Treasuries and corporate bonds in response to fund outflows and inflows, respectively. We conjecture that the trading-to-flow sensitivity on Treasuries should be stronger when a fund experiences outflows because it is more urgent to obtain liquidity to meet investor redemption (e.g., Goldstein et al. (2017)). To differentiate the effects of inflows and outflows, we define a dummy variable, $Out_{f,q}$, which equals one if $Fund\ Flow_{f,q}$ is negative, and zero otherwise. We include the interaction between $Out_{f,q}$ and $Fund\ Flow_{f,q}$ in the right-hand side of Equation (7). That is,

$$\begin{aligned} Net\ Buy_{f,q} = \alpha + \beta_1 \cdot Fund\ Flow_{f,q} + \theta_1 \cdot Fund\ Flow_{f,q} \times Out_{f,q} + \\ \beta_2 \cdot Fund\ Flow_{f,q-1} + \theta_2 \cdot Fund\ Flow_{f,q-1} \times Out_{f,q-1} + \\ \gamma_1 \cdot Fund\ Return_{f,q} + \gamma_2 \cdot Fund\ Return_{f,q-1} + \phi_f + \delta_q + \varepsilon_{f,q}. \end{aligned} \tag{8}$$

The coefficient of interest is $\theta_1$, which measures the difference of the trading-to-flow sensitivity between fund outflows and inflows. The results in columns (3)–(4) of Table 2 are consistent with our conjecture that the trading-to-flow sensitivity on Treasuries is stronger when a fund experiences outflows than the time when the fund has inflows. For example, as shown in column (3), the point estimate of $\theta_1$ is 0.564 ($t$-statistic = 4.2), suggesting a selling-to-outflow sensitivity of 1.76 on Treasury positions. By comparison, the trading-to-flow sensitivity on corporate bonds is smaller for outflows than for inflows, but not statistically significant (see columns (7)–(8)). This implies that redemption does not induce significant fire sales of corporate bonds. These results support our argument. That is, when funds experience outflows, they are more likely to subject to financial fragility (consistent with the finding in Goldstein et al. (2017)). Therefore, prioritizing liquidating Treasuries is urgent to mitigate financial fragility, which in turn reduces the impact of fund outflow on selling corporate bonds.[16]

[16]We also consider alternative measures of fund outflows for robustness. For example, in Appendix Table A2, we define $Out_{f,q}$ as a dummy variable that equals one when the fund flow is lower than the

To strengthen our argument, we further conduct additional cross-sectional tests. Specifically, we focus on the heterogeneity in funds' portfolio holdings. Chen, Goldstein, and Jiang (2010a) document that funds that heavily invest in illiquid assets are more subject to financial fragility. Therefore, these funds should manage their liquidity with Treasuries more aggressively. We indeed find supporting evidence in our data (see Appendix Table A3).

## 3.2 Flow-induced price impact

In this section, we examine whether the flow-induced trading from bond funds can generate significant price impacts on Treasuries. This empirical exercise can shed light on whether bond funds transmit non-fundamental demand shocks from fund flows into the Treasury market, which is arguably the most liquidity market around the world.

To test the price impact of flow-induced trading on Treasuries, we first follow Lou (2012) and calculate the flow-induced trading at the Treasury level. That is, at the end of each month, we aggregate bond funds' flow-induced purchases and sales onto the Treasury level and scale it by the total amount of the Treasury security held by bond funds (denoted as "Flow-induced Trading," or $FIT$, and defined in Eq.(3)). To differentiate the impact between inflows and outflows, we further decompose $FIT$ into two components: one computed from funds with positive flows, i.e., net buying ($FIT\_Positive$), and the other calculated from funds with negative flows, i.e., net selling ($FIT\_Negative$).

We study price impact in the context of either excess returns (raw return minus the risk-free rate) or beta-adjusted returns (see definition in Section 2.4). Specifically, we conduct the following Fama and MacBeth (1973) regressions to study how flow-induced trading affects Treasury returns:

$$Return_{i,t} = \alpha + \beta \cdot FIT_{i,t} + \theta \cdot X_{i,t} + \varepsilon_{i,t}, \tag{9}$$

where $Return_{i,t}$ is either the cumulative excess return or the cumulative beta-adjusted return (both in basis points) for Treasury $i$ in month $t$. $FIT_{i,t}$ is the aggregate flow-induced trading for Treasury $i$ in month $t$, and $X_{i,t}$ is a vector of control variables to

quarter-median, and zero otherwise, and we find similar results.

capture bond characteristics (e.g., *On-the-Run*, *Coupon Rate*, and *Time-to-maturity*) that are potentially correlated with Treasury returns. Specifically, among control variables, *On-the-Run* is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Coupon Rate* is the coupon rate from a Treasury. *Time-to-maturity* is the years to maturity. All independent variables (except for *On-the-Run*, which is a dummy variable) are standardized to have a mean of zero and a standard deviation of one for each month.[17]

[Table 3 here]

Table 3 shows the results. As shown in column (1), the coefficient of $FIT$ is 4.801 ($t$-statistic = 3.9). In column (2), we decompose $FIT$ into $FIT\_Positive$ and $FIT\_Negative$, and we find that the price impact is about twice stronger for outflows than for inflows. This result is consistent with the higher trading-to-flow sensitivity on Treasuries during outflows, which we have documented Section 3.1. Columns (3) and (4) show that results are similar using excess returns. In terms of economic magnitude, the estimation in column (2) implies that a one standard deviation shock of the outflow-induced $FIT$ is associated with a 7.76 basis point lower beta-adjusted return in the contemporaneous month, which is economically meaningful given that the interquartile of beta-adjusted returns of Treasuries is 57.1 basis points in the sample.

[Figure 4 here]

The effect of $FIT$ on Treasuries prices can also be visualized in Figure 4. Here, at the end of month $t$, we sort all Treasuries into two portfolios: one with negative $FIT$ and the other with positive $FIT$ during month $t$. We calculate the equal-weighted returns for the two portfolios over the formation month $t$ and in the subsequent two months $t+1$ and $t+2$. Figure 4 plots the daily difference in cumulative returns between the negative $FIT$ portfolio and the positive $FIT$ portfolio (the solid line), together with its 5% confidence intervals (the dashed lines). It shows a contemporaneous flow-induced price pressure during month $t$ and a price reversal in the subsequent weeks. Such a contemporaneous

[17] To make the coefficients on $FIT\_Positive$ and $FIT\_Negative$ comparable with the coefficient on $FIT$, we standardize $FIT\_Positive$ and $FIT\_Negative$ using the mean and the standard deviation of $FIT$, so that we have $FIT\_Positive + FIT\_Negative = FIT$.

price impact with a subsequent reversal around $FIT$ shocks suggests that the fund flow-induced demand shocks are non-fundamental. In other words, flow-induced trading of bond funds transmits non-fundamental demand shocks of fund flows into the Treasury market.

### 3.3 Common ownership and return comovement

We have established empirical evidence confirming that Treasuries are widely traded by bond funds as a liquidity buffer (see Section 3.1) and bond funds transmit non-fundamental demand shocks from fund flows into Treasuries (see Section 3.2). With the non-fundamental flow-induced trading, the prices of Treasuries that bond funds commonly hold tend to comove arising from systematic exposure to fund flow shocks. As mutual funds have become one of the major players in the Treasury market, such an exposure becomes an important driving force for Treasury prices. To test such mechanism empirically, we examine how bond funds' ownership affects the return correlation across Treasury pairs. Return correlations among individual assets within a particular asset class (i.e., Treasuries in our context) largely determines the total return variance of the asset class, a conventional measure of fragility. Thus, focusing on return comovement among Treasury pairs can help us understand whether and how the increasing bond funds' ownership leads to the increased fragility in the Treasury market. Moreover, we focus on the cross-sectional relation between bond funds' ownership and the return comovement as the cross-sectional tests could avoid confounding effects in time-series tests.

We admit that it is not new in the literature to argue and test that fund ownership can drives return comovement of the assets that funds hold, but there are some novel empirical predictions in the context of liquidity management of bond mutual funds. Greenwood and Thesmar (2011) and Anton and Polk (2014) study the association between equity mutual funds' ownership and stock return comovement. They find that stocks commonly held by mutual funds tend to comove in price due to correlated fund trading. The underlying mechanism for our paper is similar in spirit. However, different from these existing works, we focus on bond funds and have several unique predictions for Treasuries and corporate bonds. First, as discussed earlier, since bond funds trade Treasuries aggressively to accommodate fund flows, Treasuries with a high common ownership should exhibit a stronger excess return comovement. Second, this effect should be stronger in presence of fund outflows or during market downturns, since the trading-to-flow sensitivity among Treasuries is more pronounced when funds face outflows. Such excessive downside market comovement can be considered as an indicator of the increased systematic risk in Treasury prices during market downturns. Third, the association between fund ownership and the return comovement should be weaker for corporate bonds, as funds tend to avoid selling corporate bonds when meeting redemption demands.

To test our argument, we follow Anton and Polk (2014) and run Fama and MacBeth (1973) regressions to examine the effect of common ownership on the Treasury return comovement.[18] The regression specification is as follows:

$$Corr_{i,j,q} = \alpha + \beta \cdot Common\ Ownership_{i,j,q-1} + \theta \cdot X_{i,j,q-1} + \varepsilon_{i,j,q}, \tag{10}$$

where $Corr_{i,j,q}$ is the excess return comovement between bonds $i$ and $j$ in quarter $q$, and the key independent variable is $Common\ Ownership_{i,j,q-1}$, which measures the extent to which bonds $i$ and $j$ are held by the same bond funds. Because $Common\ Ownership$ has a time trend, we standardize the variable within each quarter so that the coefficients of this variable estimated from Fama and MacBeth (1973) regressions are comparable across time. Following Anton and Polk (2014), we control for the Treasury pair's similarities in bond characteristics ($X_{i,j,q-1}$): *On-the-run Difference* is the absolute difference in the on-the-run status, where the on-the-run status describes whether a Treasury is the most recently issued of a particular maturity; *Coupon Rate Difference* is the absolute difference between two Treasuries' coupon rates; and *Time-to-maturity Difference* is the absolute difference between two Treasuries' years-to-maturity. Control variables are also standardized within each quarter (except for *On-the-run Difference*, which is a dummy variable). We compute Newey and West (1987) standard errors corrected by serial dependence of three lags.

[Table 4 here]

[18] Alternatively, we could follow Greenwood and Thesmar (2011) to estimate how the flow-induced trading of mutual funds affects asset return comovement. The approach from Greenwood and Thesmar (2011) depends on the structure of fund flows (e.g., the variance-covariance matrix of fund flows among different funds). Our analysis, which follows Anton and Polk (2014), does not involve stylized assumptions on parameter values.

Table 4 reports the results and confirms our conjecture that common ownership positively forecasts comovement among Treasuries. For example, as shown in column (2), the coefficient of *Common Ownership* is 0.079 ($t$-statistic = 19.8) after including all control variables. This implies that a one standard deviation increase in *Common Ownership* is associated with a 7.9% increase in the average pairwise correlation between two Treasuries. The effect we document here is economically meaningful, considering that the average of the excess return comovement among Treasuries is 6.2% and the standard deviation is 42.1%.

Next, we turn to test the asymmetric pattern, i.e., the effect of common ownership on the Treasury return comovement should be stronger during market downturns. The prediction is motivated by the finding in Table 2 that the trading-to-flow sensitivity on Treasuries is stronger when funds experience fund outflows. Intuitively, when the Treasury market declines, bond funds experience fund outflows (see, Brooks, Katz, and Lustig, 2020), and liquidity management is more urgent, leading to a stronger association between common ownership and return comovement in Treasuries. This test is also related to the common observations that return co-variance plays a more important role in the total return variance of the asset class during market turmoils, compared to normal periods.

We measure this asymmetry in return comovement in the following steps. Within each quarter, we first sort all trading days into two equal groups (downside markets and upside markets) based on the daily aggregate Treasury market returns. Then, we calculate the return comovement for each group and take the difference. Specifically, we define *Down-minus-up*, which equals the return comovement in downside markets minus that in upside markets. Note that since *Down-minus-up* is based on the same pair of Treasuries, this asymmetry measure has a unique advantage in eliminating potential similarities in unobservable bond characteristics that may drive return comovement.

We then run Fama-MacBeth regressions of *Down-minus-up* on common ownership to examine the asymmetric effect of common ownership on Treasuries comovement between downside and upside markets:

$$Down\text{-}minus\text{-}up_{i,j,q} = \alpha + \beta \cdot Common\ Ownership_{i,j,q-1} + \theta \cdot X_{i,j,q-1} + \varepsilon_{i,j,q}. \quad (11)$$

Columns (3) and (4) of Table 4 confirm our conjecture. For example, as shown in column (4), a one standard deviation increase in *Common Ownership* is associated with a 0.8% ($t$-statistic = 2.9) increase in *Down-minus-up*. In other words, for two Treasuries with a high common ownership, their pairwise correlation becomes significantly higher during downside markets relative to upside markets. This result is also economically sizeable, given that the average *Down-minus-up* is 0.3% for Treasuries.

For comparison, we repeat the same exercises on corporate bonds, and Table 5 reports the results. We consider the following control variables for corporate bonds: *Liquidity Difference* is the absolute difference between two corporate bonds' fraction of zero-trading days; *Coupon Rate Difference* is the absolute difference in coupon rates; *Rating Difference* is the absolute difference between two corporate bonds' numeric-transformed credit rating; and *Time-to-maturity Difference* is the absolute difference between two corporate bonds' years-to-maturity. Control variables are also standardized within each quarter.

[Table 5 here]

We have two findings from Table 5. First, while *Common Ownership* can also significantly forecast the excess return comovement on corporate bonds, the economic magnitude is much smaller than that on Treasuries. For example, as shown in column (2), a one standard deviation increase in *Common Ownership* is associated with a 0.5% increase in the excess return correlation between two corporate bonds, or 3.1% of the standard deviation. Second, more importantly, columns (3) and (4) show that the asymmetric effect of *Common Ownership* on the return comovement between downside and upside markets for corporate bonds is insignificant. These patterns are consistent with the results in Table 2 that corporate bonds are less sensitive to flow shocks, as bond funds tend to avoid trading corporate bonds (e.g., due to high price impacts) to meet liquidity needs.

For robustness, we consider an alternative factor model to calculate risk-adjusted bond returns. Existing studies suggest that Treasury prices are exposed to other factors such as investors' flight-to-safety behavior, changes in the term structure, and shifts in default rates (e.g., Fama and French, 1993; Chen, Ferson, and Peters, 2010b; Adrian, Crump, and Vogt, 2019). To better control for these effects, we consider an augmented factor model that includes $VIX$, $TERM$, and $DEF$ as the additional factors. We obtain risk-adjusted bond returns from this model and re-run the analyses in Tables 4 and 5. Results in Table 6 show that the findings are barely changed using this augmented factor model.

[Table 6 here]

We further conduct two tests to corroborate our evidence. First, we find that our results are robust if we exclude bonds with a time to maturity of less than a year (see Appendix Table A4). Second, we address one potential concern that the distinct pattern between Treasuries and corporate bonds is due to the high heterogeneity among corporate bonds. Since Treasuries are more homogeneous than corporate bonds, the number of unique Treasury securities (based on the CUSIP) in a fund's portfolio is often smaller than the number of corporate bonds. Therefore, it is possible that in presence of outflows, bond funds only have a small set of unique Treasury securities and are likely to induce correlated trading among them, leading to high return comovement among Treasuries. In Appendix Table A5, we show that this is not the case: the common ownership from bond funds holding a large number of unique Treasury securities exhibits even stronger correlation with return comovement than that from bond funds holding a small number of unique Treasuries.

### 3.4 Natural experiment: The 2003 mutual fund scandal

We are aware of potential endogeneity issues related to our findings in the previous section. For example, Treasuries in the portfolio of a bond fund may have similar but unobservable characteristics and thus naturally comove in prices. While this explanation is unlikely to explain the asymmetric pattern in the return comovement between downside and upside markets, we nonetheless exploit the 2003 mutual fund trading scandal as a quasi-natural experiment to establish a causal link between common ownership and return comovement among Treasuries.[19] This mutual fund scandal happened in September 2003:

[19]Because our measure of the asymmetry in the return comovement, *Down-minus-up*, compares the excess return comovement of the same pair of Treasuries in downside and upside markets within the same quarter, this measure can effectively control for unobservable similarities in bond characteristics that may drive the level of return comovement.

25 fund families settled allegations of illegal trading that included market timing and late trading.

We choose this event because the mutual fund scandal had a negative, long-lasting impact on the affected funds' flows based on previous studies (McCabe, 2009; Anton and Polk, 2014; Koch et al., 2016), but the scandal was unlikely to be related to the fundamentals of bonds held by the affected funds. These outflows continued from the fourth quarter of 2003 until the end of 2006. As estimated by Kisin (2011), funds from implicated mutual fund families lose 14.1% of their capital within one year and 24.3% within two years. Therefore, we define the scandal period as the sample period from 2003Q4 to 2006Q4, during which Treasuries heavily owned by the implicated bond funds should experience a significant reduction in fund ownership.

To pin down the causal effect of common ownership on *Down-minus-up* , we follow Koch et al. (2016) and estimate the following difference-in-differences regression using observations from 2002Q3 to 2010Q4:[20]

$$\begin{aligned} \textit{Down-minus-up}_{i,j,q} =& \alpha + \beta \cdot Treat_{i,j} \times Event_q + \theta_1 \cdot Treat_{i,j} \\ &+ \theta_2 \cdot X_{i,j,q-1} + \textit{year-quarter dummies} + \varepsilon_{i,j,q}, \end{aligned} \tag{12}$$

where $Treat_{i,j}$ is a dummy variable that equals one if a Treasury pair has an above-top-quartile common scandal fund ratio at the beginning of the scandal (i.e., September 2003). Common scandal fund ratio is the ratio of the total market value held by common scandal funds over the total market value held by all common funds. A high common scandal fund ratio suggests that a large fraction of the pair's common ownership is from the scandal funds before the event, and thus is expected to sharply decrease after 2003Q4. $Event_q$ is a dummy variable that equals one for quarters during the scandal period (i.e., 2003Q4 to 2006Q4), and zero otherwise. We are interested in the coefficient of the interaction term between $Treat$ and $Event$, which is expected to be negative, as the treated pairs have a lower common ownership after the event, leading to weaker downside fragility. Control variables are the same as in Table 4, and year-quarter fixed effects are included.

[20] The choice of the sample period follows Koch et al. (2016), whose sample for the event study is from 2000Q3 to 2010Q4. We start from 2002Q3 instead, because our bond holding data is not available before that.

All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and a standard deviation of one.

[Table 7 here]

Table 7 reports the results. The coefficient estimates of $Treat \times Event$ are all significant and negative. This suggests that Treasuries held more by the scandal funds, resulting in lower fund common ownership during the scandal period (Kisin, 2011; Anton and Polk, 2014; Koch et al., 2016), tend to exhibit lower *Down-minus-up* during the scandal period. For example, column (4) shows that Treasury pairs heavily held by scandal funds experienced a 0.7% lower *Down-minus-up* during the event period, compared to other Treasury pairs. The economic magnitude reported here is comparable to about a one-standard-deviation decrease in *Common Ownership* reported in Table 4. Overall, the results in Table 7 are consistent with our main analysis and provides causal evidence that fund common ownership can induce downside fragility in Treasury prices.[21]

## 3.5 The COVID-19 Treasury market turmoil

In this subsection, we extend our study and examine whether our economic mechanism contributes to the Treasury market turmoil around the COVID-19 pandemic announcement. The outbreak of COVID-19 in the U.S. induced significant outflows from bond mutual funds, thus we expect Treasuries commonly owned by bond funds experienced selling pressure and thus increased price comovement.

On March 11, 2020, the WHO announced that COVID-19 had become a global pandemic.[22] As the outbreaks in the United States and other countries brought unprecedented uncertainty to the global economy, bond funds started to experience a large amount of outflows from the second week of March 2020. As shown in Panel A of Figure 2, the average daily flow decreased from about 0.12% in the first week of March to about −0.65% following the announcement. The aggregate capital outflow from the bond funds

[21] In untabulated results, we also follow Anton and Polk (2014) and use a 2-stage IV approach. The results are consistent with what we report here.

[22] "WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020," https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020.

in our sample between March 11 and the end of the month was about 4.97% of their pre-event TNA. This pattern is also documented in detail by Falato et al. (2021).

During the same period, March 11 to 31 of 2020, the Treasury market experienced unprecedented turmoil. In Panel B of Figure 2, we plot the cumulative returns of two portfolios of Treasuries, equally split by bond fund ownership (calculated at the end of 2019).[23] We make several observations. First, in the first week of March, both Treasury portfolios experienced similar price increases, plausibly due to the flight-to-safety effect as the COVID-19 broke out in Italy and Spain. Starting in the second week of March, however, Treasuries experienced dramatic price declines. More importantly, the price drops were larger among Treasuries heavily held by bond funds than Treasuries with low bond fund ownership. We also examine the cumulative returns of two corporate bond portfolios, equally split by bond fund ownership. As shown in Panel C of Figure 2, both corporate bond portfolios exhibit sharp price declines around the event, consistent with the finding in Haddad et al. (2021). But, unlike the pattern on Treasuries, the difference of price declines between the two corporate bond portfolios was much smaller and less significant.

To formally examine the association between fund common ownership and the excess return comovement of Treasuries around the pandemic announcement, we conduct a difference-in-differences analysis. We focus on the first quarter of 2020 and split the sample into two period by the announcement day, March 11, 2020. Then, we run the following regression:

$$Corr_{i,j,m} = \alpha + \beta \cdot Treat_{i,j} \times After_m + \theta_1 \cdot Treat_{i,j} + \theta_2 \cdot After_m + \theta_3 \cdot X_{i,j} + \varepsilon_{i,j,m}, \quad (13)$$

where $m = 0$ indicates the period before March 11, 2020, and $m = 1$ indicates the period on and after March 11 within the first quarter of 2020. Common ownership is calculated based on fund holding data at the end of 2019. $Treat_{i,j}$ is a dummy variable that equals one if the security pair $i$ and $j$ has common ownership above the median, and zero otherwise.[24] $After_m$ is a dummy variable that equals one if $Corr_{i,j,m}$ is computed on

[23]Since fund ownership varies across bonds' maturity, here we rank fund ownership within three different time-to-maturity groups separately: six months to three years, three to seven years, and above seven years.

[24]Results are robust to using the continuous variable of *Common Ownership* (see Appendix Table

and after March 11, 2020 (i.e., when $m = 1$), and zero otherwise. $X_{i,j}$ denotes the same set of control variables as in Table 4, all measured at the end of 2019. As we show in Panel A of Figure 2, after the global pandemic announcement, a large amount of capital flowed out from bond funds, bond funds had to aggressively liquidate Treasuries, leading to the excess return comovement among Treasuries. In the sense that the post-event period features persistent fund outflows and downside markets, we focus on the level of return comovement (*Corr*) and do not need to use *Down-minus-up* on the left-hand side of the regression. We expect $\beta$ in Equation (13) to be positive.

Table 8 reports the results. Panel A provides the summary statistics and shows that the average *Corr* of Treasury pairs was about 14.2% before the WHO's announcement but increased to 17.8% afterward, consistent with our conjecture. By comparison, the average *Corr* of corporate bond pairs remained virtually unchanged.

[Table 8 here]

Panel B of Table 8 reports the regression results for both Treasuries and corporate bonds. We have several findings. First, Treasuries with a high common ownership experienced a larger increase in the return comovement than those with a low common ownership. For example, as implied in column (2) of Panel B, the average excess return comovement between two Treasuries with a low common ownership increased by 1.5% ($t$-statistic = 5.7) after the pandemic announcement. At the same time, Treasuries with a high common ownership experienced a 5.7% increase in the return correlation. The difference in the increased return comovement between these two groups (i.e., 4.2%) is not only statistically significant ($t$-statistic = 10.7) but also economically sizable, given that the mean of *Corr* before the event was about 14.2%. Second, for corporate bonds, we observe that the return comovement on corporate bonds with a high common ownership barely changed after the pandemic announcement. The corporate bonds with a low common ownership even experienced a slight decrease in return comovement. The pattern of corporate bond prices is consistent with our previous full sample analysis showing that *Down-minus-up* does not increase with fund common ownership for corporate bonds.

Overall, the patterns documented above are consistent with our argument that the

A6).

liquidity management practice using Treasuries by bond funds contributed to the market turmoil during the COVID-19 pandemic in March 2020. Nonetheless, we do not intend to claim this is the only mechanism that drove the event; several concurrent studies propose other mechanisms that potentially cause this turmoil in the Treasury market (see, e.g., Duffie, 2020; Fleming and Ruela, 2020; He, Nagel, and Song, 2022; Schrimpf, Shin, and Sushko, 2020; Kruttli, Monin, Petrasek, and Watugala, 2021). These channels, including ours, are not exclusive, and more granular data is needed to quantify each channel's contribution to the Treasury market turmoil. On the other hand, our main focus lies in the cross-section of Treasuries over a longer period, rather than one particular event, which can help rule out other confounding effects.

# 4 Additional Tests and Discussion

In this section, we conduct several additional tests to corroborate our main argument. In Section 4.1, we explore alternative ways to identify the asymmetric price impacts between bond funds' inflows and outflows. In Section 4.2, we consider two alternative fragility measures: liquidity co-jumps and negative return skewness.

## 4.1 Alternative ways to identify the asymmetric impact from inflows and outflows

We provide further support for our argument by exploring the cross-sectional variations in bond fund flows. As we have shown in Section 3.1, bond funds prefer to liquidate Treasuries to meet redemption when they experience outflows, so the trading-to-flow sensitivity on Treasuries is higher for outflows than for inflows. Motivated by the results in Section 3.1, we use two alternative ways to measure bond funds' inflows and outflows, and then we examine the asymmetric impacts of fund common ownership on the return comovement. The first way is based on the fraction of common funds with outflows, and the other is based on the well-anticipated times when bond funds are subject to liquidity-driven redemption (e.g., month-ends)

First, based on our argument, given the same level of common ownership, Treasuries should comove more when more of their common funds experience outflows. To test this conjecture, we run the following regressions:

$$\begin{aligned} Corr_{i,j,q} = \alpha + \beta_1 \cdot Common\ Ownership_{i,j,q-1} + \\ \beta_2 \cdot Common\ Ownership_{i,j,q-1} \times Ratio\ of\ Outflow_{i,j,q} + \\ \beta_3 \cdot Ratio\ of\ Outflow_{i,j,q} + \theta \cdot X_{i,j,q-1} + \varepsilon_{i,j,q}, \end{aligned} \tag{14}$$

where for bonds $i$ and $j$ at quarter $q$, $Ratio\ of\ Outflow_{i,j,q}$ is the holding-weighted proportion of the security pair's common funds whose fund flow is negative. (i.e., $Out_{f,q} = 1$). A larger value of $Ratio\ of\ Outflow_{i,j,q}$ means that more common funds holding bonds $i$ and $j$ experience outflows. We expect $\beta_2$ to be positive for Treasury pairs.

[Table 9 here]

Table 9 reports the results and confirms our conjecture. As shown in columns (1) and (2), the coefficient estimates of $\beta_2$ are significant and positive, which suggest that the effect of fund common ownership on the Treasury return comovement is stronger when more common funds face fund outflows. Again, we do not observe such a pattern on corporate bonds (see columns (3) and (4)).

Although our results are consistent with the argument that the effect of common ownership on the excess return comovement among Treasuries is more pronounced when common funds experience outflows, there could be one potential alternative explanation. That is, fund investors may anticipate the decline in the Treasury market and thus are more likely to withdraw their investment from funds with more Treasury holdings. This possibility can also generate a strong association between common ownership and Treasuries' return comovement in presence of fund outflows. To address this concern, we follow prior studies (e.g., Ogden 1990; Etula, Rinne, Suominen, and Vaittinen 2020) and identify the well-anticipated times when bond funds are subject to liquidity driven redemption—month ends. Existing literature shows that because of the clearing of the monthly pre-scheduled payment, there is a strong seasonality in liquidity-motivated trading.

Taking advantage of the plausible exogenous seasonality in fund flows, we examine the excess return comovement among Treasuries preceding month ends when bond funds face outflows. To implement the test, we take the following steps. First, following Etula, Rinne, Suominen, and Vaittinen (2020), we define month ends as the five-trading-day window [$t$-8, $t$-4], and month beginnings as the five-trading-day window [$t$-1, $t$+3], where $t$ is the last trading day of each month. Presumably, assets held more by mutual funds tend to experience selling (buying) pressure at month ends (beginnings). In the second step, for each pair of bonds at each quarter, we calculate the excess return comovement for month ends and month beginnings, separately. To measure the asymmetry in the excess return comovement, we calculate the difference of the return comovement between month-ends and month-beginnings and denote this difference as *End-minus-beginning*. After that, we run the regressions in Tables 4 and 5 but replace the dependent variables with *End-minus-beginning*.

Table A7 reports the results. We find that common ownership positively forecasts the excess return comovement at month ends and at month beginnings on both the Treasury and corporate bond markets, while the effect is economically much smaller for corporate bonds. More importantly, common ownership positively forecasts the asymmetric price pattern (i.e., *End-minus-beginning*) on Treasuries, but, again, not on corporate bonds. Overall, these results are largely consistent with the asymmetric impact of fund common ownership on the return comovement on Treasuries.

## 4.2 Liquidity co-jump and return skewness

To further support our argument that bond fund ownership contributes to the Treasury fragility, we consider two alternative fragility measures of the Treasury market: liquidity co-jump and negative return skewness. We first examine liquidity co-jump, which indicates whether the bid-ask spreads of a pair of Treasuries spike simultaneously. This empirical exercise is motivated by the observation during several market-wide events where the most liquid market experienced sudden liquidity dry-ups, such as the "flash rally" in 2014 and the COVID-19 turmoil in March 2020 (e.g., Adrian, Fleming, Stackman, and Vogt, 2015a; Fleming and Ruela, 2020). We formally study whether fund common ownership can generate the commonality of liquidity dry-ups in Treasuries over a long period (from 2002 to 2019) by cross-sectional tests.

To carry out our tests, we measure liquidity based on bid-ask spreads and construct a dummy variable, *Common Dry-ups*, to indicate the presence of liquidity co-jumps, that is, both Treasuries $i$ and $j$ exhibit a bid-ask spread that is higher than the top quartile of its own daily bid-ask spreads over the previous four quarters on the same day (see Section 2.4 for detailed definitions).[25] Then, we run the Fama-MacBeth regressions of Equation (10) but replace the dependent variable with *Common Dry-ups*.

[Table 10 here]

The first two columns in Panel A of Table 10 report the results. We find that Treasury pairs with a high common ownership tend to experience common liquidity dry-ups. For example, as shown in column (4), a one standard deviation increase in *Common Ownership* is associated with a 0.027 ($t$-statistics = 3.6) increase in *Common Dry-ups*. For comparison, the mean of *Common Dry-ups* is 0.257.

The second alternative fragility measure is the negative skewness of daily risk-adjusted returns of individual Treasuries. The negative skewness is a widely used measure for the likelihood of price crashes in the literature (Chen et al., 2001; Brunnermeier et al., 2008). With our results that fund outflows have larger impacts on bond funds trading Treasuries (Section 3.1) and the outflow-induced trading has larger price impacts (Section 3.2), one natural implication is that fund ownership can negatively affect return skewness. To test this conjecture, we run Fama-MacBeth regressions where the key independent variable is bond funds' ownership (denoted as *Ownership*) and the dependent variable is the skewness of daily-adjusted returns of individual Treasuries in a quarter. We consider the following control variables in columns (3)-(4): *On-the-run* is a dummy variable that equals one if the Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Coupon Rate* is coupon rate expressed in percentage. *Time-to-maturity* is years to maturity. The last two columns in Panel A of Table 10 report the results. We find that fund ownership significantly and negatively forecasts return skewness. These results are aligned with our findings on return comovement and liquidity commonality.

[25] The reason why we measure liquidity cojumps is that Treasuries' bid-ask spreads barely change and only spike during some turmoils, which is our focus. It is also worth noting that our results are robust to alternative definitions: (1) define common dry-up in [-1,1] or [-3,3] windows, (2) define liquidity dry-up event as the top 3, 5, or 10 daily spreads in a quarter, and (3) define common dry-ups as the fraction of days with liquidity dry-up events happened on the same day.

We further use the same method as in Section 3.4 to identify the causal link between fund ownership and liquidity common dry-ups (skewness) and report the results in Panel B of Table 10. In columns (1)-(2), $Treat$ is a dummy variable that equals one if a Treasury pair has an above-top-quartile common scandal fund ratio. In columns (3)-(4), $Treat$ is a dummy variable that equals one if a Treasury has an above-top-quartile scandal fund ratio (the ratio of scandal fund ownership over bond fund ownership). $Event$ is a dummy variable that equals one during the scandal period, and zero otherwise. Control variables are the same as in Panel A. We find that Treasury pairs (individual Treasuries) heavily affected by the mutual fund scandal experienced a decrease (increase) in liquidity common dry-ups (skewness).[26] These results are consistent with our main argument and provide further causal evidence on the relation between bond funds' ownership and the fragility in Treasuries.

## 5 Conclusion

In recent years, the U.S. Treasury market—which is considered as the most liquid market in the world—has become more fragile, as was seen in the "flash rally" episode in 2014 and the turmoil during the outbreak of COVID-19. Given the importance of Treasuries in the global financial system, it is necessary to understand the underlying economic mechanism through which the fragility arises.

We argue and empirically test that liquidity management practice of open-end bond mutual funds can transmit non-fundamental demand shocks from fund flows into Treasuries and lead to the Treasury fragility. We have several empirical findings to support our argument. First, we document that bond funds aggressively trade Treasuries to manage their liquidity needs, and consequently, the trading-to-flow sensitivity is larger on Treasuries than that on corporate bonds. Meanwhile, the trading-to-flow sensitivity on Treasuries is stronger when funds experience outflows than when they experience inflows, which suggests that liquidity management using Treasuries is more urgent for bond funds in the presence of large redemption. Second, we find that flow-induced trading can have

[26]Note that our results on liquidity commonality here is in the same spirit of Koch et al. (2016) who document that stock pairs heavily affected by the mutual fund scandal experienced a decrease in liquidity commonality.

significant contemporaneous price impacts on Treasuries followed by subsequent reversals. This finding not only suggests that the demand shocks arising from fund flows are largely non-fundamental, but it also suggests that bond mutual funds transmit these non-fundamental shocks from fund flows onto Treasury prices. Third, bond fund ownership can lead to the increased fragility in Treasury prices. That is, Treasuries that are commonly held by bond funds tend to comove more in prices, and this pattern is stronger during downside markets. Our argument regarding bond funds' ownership and Treasury fragility is also evident when using alternative fragility measures, such as common liquidity dry-ups and negative return skewness. We use the 2003 mutual fund scandal to pin down the causal link between common ownership and Treasury return comovement. Finally, we extend our analyses and show that the economic mechanism using Treasuries in liquidity management at least partially contributes to several stylized facts during the recent Treasury market turmoil around the COVID-19 pandemic announcement.

While our sample only includes U.S. open-end bond mutual funds, given the widespread practice of liquidity management using Treasuries, the economic mechanism documented in our study can naturally apply to other financial intermediaries performing liquidity transformation. In this sense, we believe that our findings can shed some light on the discussion of possible causes for the increasing fragility in the world's most liquid asset market.

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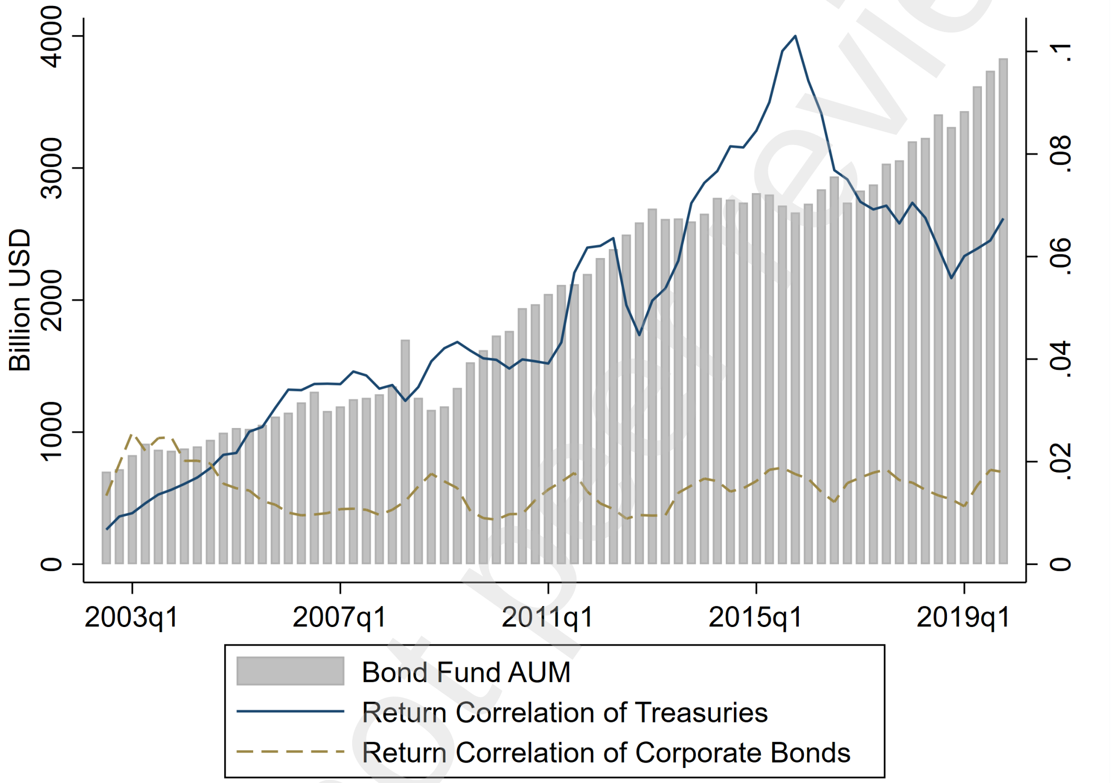
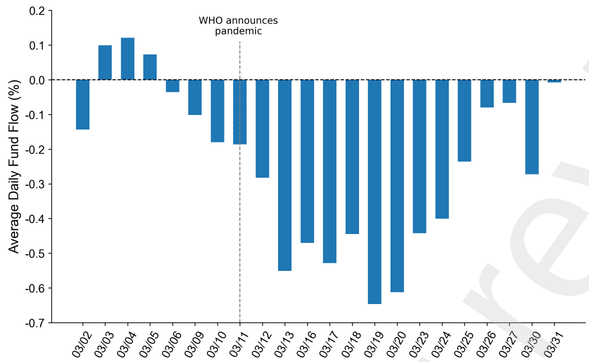
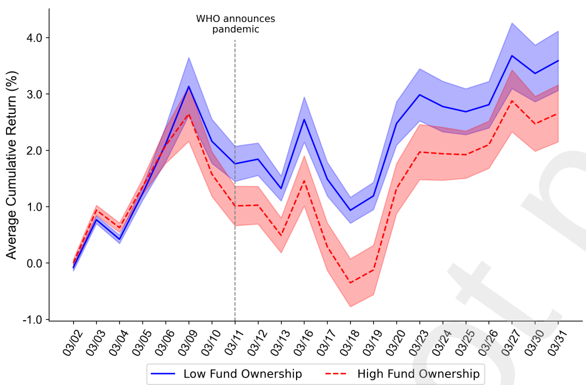



Figure 1. Return comovement in the Treasury and corporate bond markets

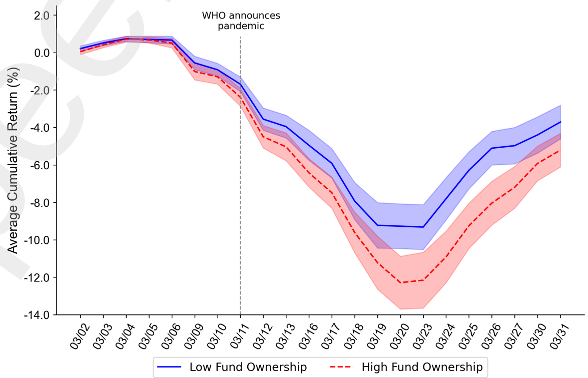
This figure plots the time-series average of excess return comovement among Treasuries (solid blue line) and corporate bonds (dashed yellow line) from 2002Q3 to 2019Q4, as well as the total assets under management (AUM) from all bond funds (in billion USD). The excess return comovement is calculated as the pairwise correlation of daily risk-adjusted returns between two securities. Daily risk adjusted returns are obtained as the residual from a regression of daily bond returns in excess of the risk-free rate on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags (as specified in Equation (6)).




(a) Bond fund flow




(b) Treasury return




(c) Corporate bond return

Figure 2. Bond fund flows and cumulative returns for Treasuries and corporate bonds in March 2020

This figure plots (a) the averages of daily bond fund flows (%), (b) the cumulative returns (%) from two Treasury portfolios sorted by bond fund ownership, and (c) the cumulative returns (%) from two corporate bond portfolios sorted by bond fund ownership. The sample period is March 2020. The colored areas indicate 95% confidence intervals. The vertical line represents the WHO pandemic announcement date, March 11, 2020. Bond fund ownership is the ratio of the total market value held by all bond funds divided by the total amount outstanding, and is calculated at the end of 2019. Bond portfolios are sorted on fund ownership within each of three time-to-maturity groups (i.e., six months to three years, three to seven years, and above seven years).

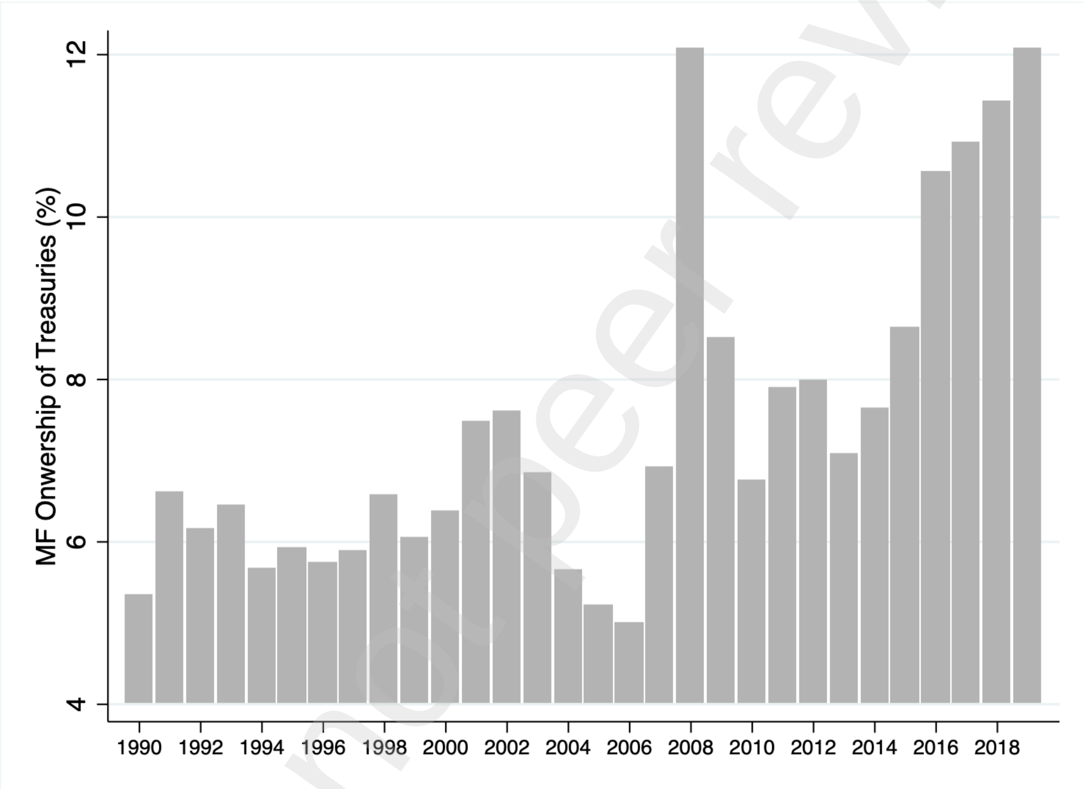



Figure 3. Mutual Fund Total Ownership of Treasuries

This figure plots the time-series of the fraction of Treasury securities outstanding owned by U.S. mutual funds and money market funds (%) between 1990 and 2019. The data is from Federal Reserve Flow of Funds.

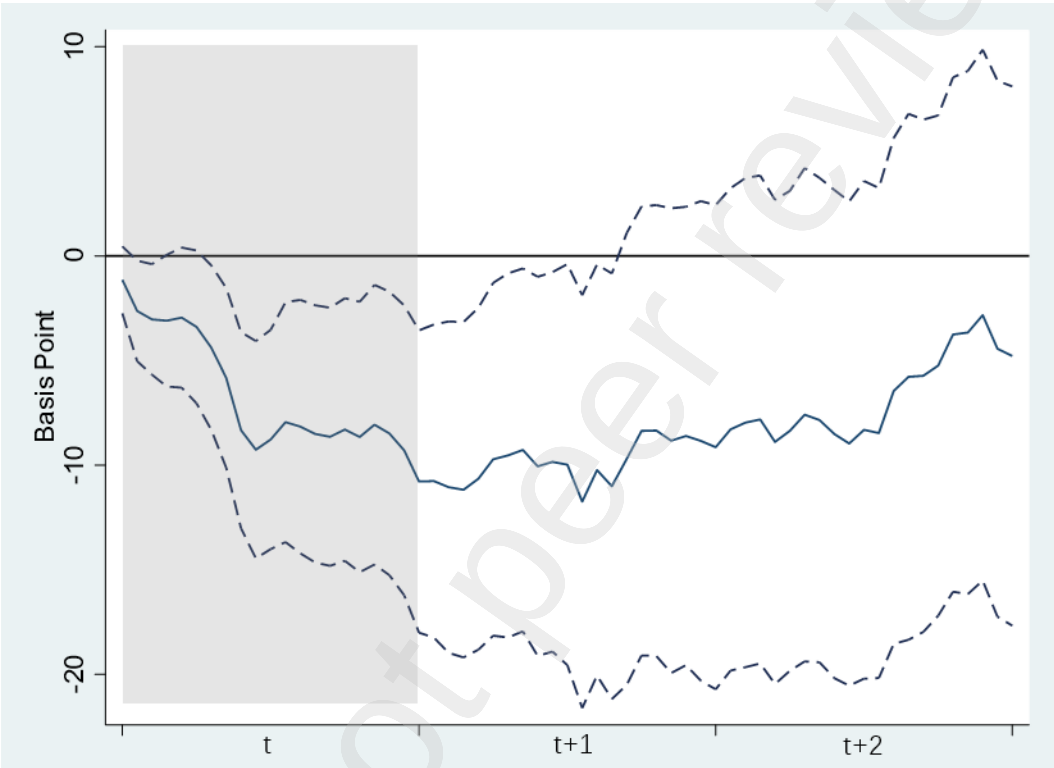



Figure 4. Flow-induced Trading Impact on Treasury Prices

This figure shows the flow-induced trading impact on treasury returns (in basis points). At the end of month $t$, Treasuries are sorted into two portfolios: one with negative $FIT$ and the other with positive $FIT$. $FIT$ is bond funds' flow-induced purchases and sales in aggregate onto the Treasury level and scale by the total amount of the Treasury security held by bond funds. Equal-weighted returns for these two portfolios are computed over the contemporaneous month $t$ and the subsequent two months $t+1$ and $t+2$. The figure plots the difference of daily cumulative returns between the negative $FIT$ portfolio and the positive $FIT$ portfolio (the solid line), together with its 5% confidence intervals (the dashed lines). The sample period is from 2002Q3 to 2019Q4.

Table 1. Summary Statistics

This table reports descriptive statistics. Panel A reports the summary statistics of bond funds, while Panel B reports the summary statistics for Treasury and corporate bond variables, respectively. *Corr* is the excess return correlation between two securities in a quarter. The excess return correlation is computed as the pairwise correlation of daily risk-adjusted returns for a pair of securities. Daily risk adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. All trading days in a quarter are sorted into two equal groups (downside and upside market days) based on the aggregate Treasury market returns, *Down-minus-up* equals the difference of *Corr* between downside and upside market days. *# of Common Funds* is the number of funds holding the pair of securities (termed as common funds). *Common Ownership* is the proportion of total market value of a security pair held by all common funds. *On-the-run* is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *On-the-Run Difference* is the absolute difference in the on-the-run status for a pair of Treasuries. *Coupon Rate* is the coupon rate for a security. *Coupon Rate Difference* is the absolute difference between two securities' coupon rates. *Time-to-maturity* is the years-to-maturity for a security. *Time-to-maturity Difference* is the absolute difference between two securities' years-to-maturity. *Common Dry-ups* is a dummy variable that equals one if two Treasuries have experienced liquidity dry-ups events on the same day, where liquidity dry-up events are defined as the days when a Treasury's bid-ask spread exceeds the top quartile of its bid-ask spreads over the previous four quarters. *Excess return* is the monthly Treasury return in excess of risk-free rate, quoted in basis points. *Beta-adjusted return* is constructed as follows. In each month $t$, we first run a regression using daily excess returns from months $t-3$ to $t-1$ on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. We obtain the beta estimates and use these beta estimates with daily returns of the factors in month $t$ to compute daily adjusted returns for each Treasury in month $t$. Then we aggregate this daily measure to the monthly level. *FIT* is the monthly aggregate flow-induced trading across all bond funds for each Treasury. *FIT* is further decomposed into *FIT_Positive* and *FIT_Negative* based on inflows and outflows, respectively. *Skewness* is the third moment of daily risk-adjusted returns within a quarter for each Treasury. *Liquidity Difference* is the absolute difference between two corporate bonds' fraction of zero-trading days. *Rating Difference* is the absolute difference between two corporate bonds' numeric-transformed credit rating. The sample period is from 2002Q3 to 2019Q4.

| Panel A: Summary Statistics for Bond Funds | | | | |
|---|---|---|---|---|
| Year | # of bond funds | Average fund TNA ($M) | Median fund TNA ($M) | Total AUM ($B) |
| 2002 | 935 | 759.7 | 217.5 | 709.8 |
| 2003 | 1017 | 851.9 | 233.0 | 866.0 |
| 2004 | 1030 | 899.2 | 231.6 | 926.5 |
| 2005 | 1047 | 1010.0 | 244.3 | 1057.2 |
| 2006 | 1080 | 1120.2 | 235.3 | 1209.8 |
| 2007 | 1105 | 1129.1 | 245.3 | 1247.5 |
| 2008 | 1106 | 1236.6 | 246.7 | 1368.7 |
| 2009 | 1092 | 1300.5 | 283.2 | 1419.7 |
| 2010 | 1090 | 1697.8 | 365.2 | 1851.1 |
| 2011 | 1151 | 1842.3 | 368.3 | 2119.7 |
| 2012 | 1165 | 2102.5 | 406.7 | 2446.9 |
| 2013 | 1184 | 2222.9 | 409.4 | 2629.7 |
| 2014 | 1255 | 2176.8 | 363.9 | 2731.7 |
| 2015 | 1303 | 2108.4 | 344.7 | 2746.8 |
| 2016 | 1322 | 2125.4 | 340.5 | 2810.6 |
| 2017 | 1310 | 2250.6 | 364.3 | 2949.0 |
| 2018 | 1311 | 2506.8 | 385.7 | 3286.5 |
| 2019 | 1308 | 2793.4 | 383.7 | 3654.0 |
| Average | 1156 | 1674.1 | 315.0 | 2001.7 |

Table 1. Continued

| Panel B: Summary Statistics for Treasuries and Corporate Bonds | | | | | | |
|---|---|---|---|---|---|---|
| | mean | std | p25 | p50 | p75 | *N* |
| (a) Treasuries | | | | | | |
| *Corr* | 0.062 | 0.421 | -0.218 | 0.027 | 0.316 | 2,185,735 |
| *Down-minus-up* | 0.003 | 0.322 | -0.199 | -0.004 | 0.204 | 2,185,735 |
| *# of Common Funds* | 7.452 | 7.417 | 2.000 | 6.000 | 11.000 | 2,185,735 |
| *Common Ownership* | 0.014 | 0.018 | 0.001 | 0.009 | 0.021 | 2,185,735 |
| *On-the-run Difference* | 0.200 | 0.400 | 0.000 | 0.000 | 0.000 | 2,185,735 |
| *Coupon Rate Difference* | 2.229 | 2.093 | 0.625 | 1.500 | 3.125 | 2,185,735 |
| *Time-to-maturity Difference* | 7.354 | 7.837 | 1.581 | 3.962 | 10.721 | 2,185,735 |
| *Common Dry-ups* | 0.257 | 0.482 | 0.000 | 0.000 | 1.000 | 2,185,735 |
| *Excess return* (in *bp*) | 34.839 | 170.849 | -13.661 | 3.478 | 69.434 | 57,521 |
| *Beta-adjusted return* (in *bp*) | -0.680 | 106.082 | -32.335 | -0.727 | 24.812 | 57,521 |
| *FIT* | 0.005 | 0.022 | -0.003 | 0.005 | 0.013 | 57,521 |
| *FIT_Positive* | 0.013 | 0.017 | 0.005 | 0.010 | 0.016 | 57,521 |
| *FIT_Negative* | -0.008 | 0.012 | -0.010 | -0.004 | -0.002 | 57,521 |
| *On-the-run* | 0.177 | 0.382 | 0.000 | 0.000 | 0.000 | 57,521 |
| *Coupon Rate* | 3.099 | 2.618 | 1.250 | 2.375 | 4.375 | 57,521 |
| *Time-to-maturity* | 6.266 | 7.408 | 1.329 | 3.540 | 7.627 | 57,521 |
| *Skewness* | 1.101 | 2.281 | -0.357 | 0.133 | 2.356 | 16,477 |
| (b) Corporate Bonds | | | | | | |
| *Corr* | 0.014 | 0.159 | -0.087 | 0.009 | 0.107 | 11,528,871 |
| *Down-minus-up* | 0.000 | 0.256 | -0.170 | 0.000 | 0.169 | 11,528,871 |
| *# of Common Funds* | 1.960 | 3.055 | 0.000 | 1.000 | 3.000 | 11,528,871 |
| *Common Ownership* | 0.010 | 0.021 | 0.000 | 0.000 | 0.013 | 11,528,871 |
| *Liquidity Difference* | 0.187 | 0.174 | 0.048 | 0.143 | 0.281 | 11,528,871 |
| *Coupon Rate Difference* | 2.043 | 1.598 | 0.750 | 1.680 | 3.000 | 11,528,871 |
| *Rating Difference* | 3.678 | 3.463 | 1.000 | 3.000 | 5.000 | 11,528,871 |
| *Time-to-maturity Difference* | 6.069 | 8.019 | 1.293 | 3.219 | 7.419 | 11,528,871 |

Table 2. Fund Trading and Fund Flows

This table reports the regression results of fund trading on fund flows for Treasuries and corporate bonds. $Net\ Buy_{f,q}$ is calculated as the percentage change of fund $f$'s total holdings in Treasuries or corporate bonds in quarter $q$, relative to its beginning-of-the-quarter holdings. $Fund\ Flow_{f,q}$ and $Fund\ Return_{f,q}$ represent quarterly fund flows and fund return for fund $f$ in quarter $q$, respectively. $Out_{f,q}$ is a dummy variable that equals one if the fund flow for fund $f$ in quarter $q$ is negative and zero otherwise. Variables are winsorized by quarter at the $5^{th}$ and $95^{th}$ percentiles. Standard errors are clustered by fund and quarter, and the $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample period is from 2002Q3 to 2019Q4

| DepVar: | $Net\ Buy_{f,q}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Treasuries | | | | Corporate Bonds | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Fund\ Flow_{f,q}$ | 1.382*** | 1.417*** | 1.197*** | 1.249*** | 0.864*** | 0.859*** | 0.882*** | 0.876*** |
| | (23.5) | (22.5) | (15.5) | (15.6) | (23.9) | (23.3) | (16.0) | (16.0) |
| $Fund\ Flow_{f,q} \times Out_{f,q}$ | | | 0.564*** | 0.509*** | | | -0.055 | -0.052 |
| | | | (4.2) | (4.0) | | | (-0.7) | (-0.7) |
| $Fund\ Flow_{f,q-1}$ | -0.302*** | -0.259*** | -0.226*** | -0.164*** | 0.214*** | 0.206*** | 0.225*** | 0.212*** |
| | (-6.3) | (-5.8) | (-3.7) | (-3.2) | (7.2) | (7.0) | (5.4) | (5.1) |
| $Fund\ Flow_{f,q-1} \times Out_{f,q-1}$ | | | -0.234* | -0.313*** | | | -0.044 | -0.025 |
| | | | (-2.0) | (-3.1) | | | (-0.5) | (-0.3) |
| $Fund\ Return_{f,q}$ | -0.760*** | -0.585* | -0.789*** | -0.608** | -0.001 | -0.185 | 0.003 | -0.183 |
| | (-3.2) | (-2.0) | (-3.3) | (-2.1) | (-0.0) | (-0.8) | (0.0) | (-0.8) |
| $Fund\ Return_{f,q-1}$ | 0.163 | 0.326 | 0.145 | 0.317 | -0.552*** | -0.693*** | -0.547*** | -0.689*** |
| | (0.6) | (1.0) | (0.5) | (1.0) | (-3.3) | (-3.9) | (-3.2) | (-3.8) |
| Fund Fixed Effects | No | Yes | No | Yes | No | Yes | No | Yes |
| Quarter Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| # of Obs | 34,008 | 34,008 | 34,008 | 34,008 | 34,008 | 34,008 | 34,008 | 34,008 |
| Adj $R^2$ | 0.070 | 0.190 | 0.071 | 0.191 | 0.097 | 0.159 | 0.097 | 0.159 |

Table 3. Funds' Flow-induced Trading Impact on Treasury Prices

This table reports the results from Fama-MacBeth regressions of bond funds' flow-induced trading in month $t$ on Treasury returns (in basis points) in the same month. *FIT* is the monthly aggregate flow-induced trading across all bond funds for each Treasury. *FIT* is further decomposed into *FIT_Positive* and *FIT_Negative* based on inflows and outflows, respectively. *Excess return* is the monthly Treasury return in excess of risk-free rate, quoted in basis points. *Beta-adjusted return* is constructed as follows. In each month $t$, we first run a regression using daily excess returns from months $t-3$ to $t-1$ on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. We obtain the beta estimates and use these beta estimates with daily returns of the factors in month $t$ to compute daily adjusted returns for each Treasury in month $t$. Then we aggregate this daily measure to the monthly level. *On-the-Run* is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Coupon Rate* is the coupon rate from a Treasury. *Time-to-maturity* is the years-to-maturity. All independent variables (except for *On-the-Run*) are standardized to have a mean of zero and standard deviation of one in each month. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample period is from July 2002 to December 2019.

| DepVar: | Beta-adjusted Return | | Excess Return | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *FIT* | 4.801*** | | 2.833*** | |
| | (3.9) | | (3.0) | |
| *FIT_Positive* | | 3.618** | | 0.955 |
| | | (2.3) | | (0.8) |
| *FIT_Negative* | | 7.755*** | | 6.544*** |
| | | (3.0) | | (3.5) |
| *On-the-run* | | | 3.717 | 3.904 |
| | | | (1.5) | (1.6) |
| *Coupon Rate* | | | 21.307*** | 20.987*** |
| | | | (9.1) | (9.0) |
| *Time-to-maturity* | | | 12.247 | 12.410* |
| | | | (1.6) | (1.7) |
| # of Obs | 57,521 | 57,521 | 57,521 | 57,521 |

Table 4. Common Ownership and Treasury Return Comovement

This table reports the results from Fama-MacBeth regressions of Treasury pairs' return comovement in quarter $q$ on their common ownership in quarter $q-1$. *Corr* is the excess return correlation between a pair of Treasuries in a quarter. The excess return correlation is computed as the pairwise correlation of daily risk-adjusted returns for a pair of Treasuries. Daily risk-adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. All trading days in a quarter are sorted into two equal groups (downside and upside market days) based on the aggregate Treasury market returns, *Down-minus-up* equals the difference of *Corr* between downside and upside market days. *Common Ownership* is the proportion of total market value of a Treasury pair held by all bond funds that hold both of them in a quarter. *On-the-Run Difference* is the absolute difference in on-the-run status, where on-the-run status is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Coupon Rate Difference* is the absolute difference between two Treasuries' coupon rates. *Time-to-maturity Difference* is the absolute difference between two Treasuries' years-to-maturity. All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and standard deviation of one by quarter. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample period is from 2002Q3 to 2019Q4.

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Ownership* | 0.103*** | 0.079*** | 0.011*** | 0.008*** |
| | (36.8) | (19.8) | (5.3) | (2.9) |
| *On-the-run Difference* | | 0.016*** | | -0.012*** |
| | | (4.3) | | (-5.2) |
| *Coupon Rate Difference* | | -0.056*** | | 0.008 |
| | | (-20.7) | | (1.5) |
| *Time-to-maturity Difference* | | -0.176*** | | -0.065*** |
| | | (-21.6) | | (-7.5) |
| # of Obs | 2,185,735 | 2,185,735 | 2,185,735 | 2,185,735 |

Table 5. Common Ownership and Corporate Bond Return Comovement

This table reports the results from Fama-MacBeth regressions of corporate bond pairs' return comovement in quarter $q$ on their common ownership in quarter $q-1$. *Corr* is the excess return correlation between a pair of corporate bonds in a quarter. The excess return correlation is computed as the pairwise correlation of daily risk-adjusted returns for a pair of corporate bonds. Daily risk adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. All trading days in a quarter are sorted into two equal groups (downside and upside market days) based on the aggregate Treasury market returns, *Down-minus-up* equals the difference of *Corr* between downside and upside market days. *Common Ownership* is the proportion of total market value of a corporate bond pair held by all bond funds that hold both of them in a quarter. *Liquidity Difference* is the absolute difference between two corporate bonds' fraction of zero-trading days. *Coupon Rate Difference* is the absolute difference between two corporate bonds' coupon rates. *Rating Difference* is the absolute difference between two corporate bonds' numeric-transformed credit rating. *Time-to-maturity Difference* is the absolute difference between two corporate bonds' years-to-maturity. All independent variables are standardized to have a mean of zero and standard deviation of one in each quarter. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample period is from 2002Q3 to 2019Q4.

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Ownership* | 0.007*** | 0.005*** | 0.0005 | 0.0004 |
| | (9.9) | (9.1) | (1.3) | (1.3) |
| *Liquidity Difference* | | -0.004*** | | -0.0000 |
| | | (-13.4) | | (-0.1) |
| *Coupon Rate Difference* | | -0.002*** | | 0.0000 |
| | | (-4.3) | | (0.0) |
| *Rating Difference* | | -0.003*** | | -0.0004 |
| | | (-7.5) | | (-1.1) |
| *Time-to-maturity Difference* | | -0.003*** | | 0.0006 |
| | | (-7.3) | | (1.2) |
| # of Obs | 11,528,871 | 11,528,871 | 11,528,871 | 11,528,871 |

Table 6. Common Ownership and Return Comovement: Controlling for Additional Factors

This table reports the results from Fama-MacBeth regressions of a security pair's excess return comovement in quarter $q$ on their common ownership in quarter $q-1$. *TERM* is the difference in daily returns between a long-term government bond index and the one-month Treasury bill rate. *DEF* is the difference in daily returns between a long-term corporate bond index and the long-term corporate bond index. *Corr* is the excess return correlation between a pair of securities in a quarter. The excess return correlation is computed as the pairwise correlation of daily risk-adjusted returns for a pair of securities. Daily risk adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, *VIX*, *TERM*, and *DEF*, and their two lags. *VIX* refers to the VIX index level. *TERM* is the difference in daily returns between a long-term government bond index and the one-month Treasury bill rate. *DEF* is the difference in daily returns between a long-term corporate bond index and the long-term corporate bond index. All trading days in a quarter are sorted into two equal groups (downside and upside market days) based on the aggregate Treasury market returns, *Down-minus-up* equals the difference of *Corr* between downside and upside market days. *Common Ownership* is the proportion of total market value of a security pair held by all bond funds that hold both of them in a quarter. All control variables are the same as the ones in Tables 4 and 5. All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and standard deviation of one in each quarter. Panel A reports the results for Treasuries, and Panel B reports the results for corporate bonds. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.The sample period is from 2002Q3 to 2019Q4.

Panel A: Treasuries

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Onwership* | 0.099*** | 0.085*** | 0.006*** | 0.005** |
| | (31.4) | (19.7) | (2.7) | (2.3) |
| *On-the-run Difference* | | 0.013*** | | -0.009*** |
| | | (4.1) | | (-5.7) |
| *Coupon Rate Difference* | | -0.050*** | | 0.006** |
| | | (-24.9) | | (2.2) |
| *Time-to-maturity Difference* | | -0.078*** | | -0.023*** |
| | | (-15.2) | | (-5.9) |
| # of Obs | 2,185,735 | 2,185,735 | 2,185,735 | 2,185,735 |

Panel B: Corproate Bonds

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Ownership* | 0.005*** | 0.004*** | 0.0005 | 0.0005 |
| | (11.3) | (9.8) | (1.6) | (1.6) |
| *Liquidity Difference* | | -0.004*** | | -0.0001 |
| | | (-11.9) | | (-0.2) |
| *Coupon Rate Difference* | | -0.001*** | | -0.0002 |
| | | (-5.0) | | (-0.9) |
| *Rating Difference* | | -0.002*** | | -0.0005 |
| | | (-7.0) | | (-1.3) |
| *Time-to-maturity Difference* | | -0.000 | | 0.0002 |
| | | (-0.5) | | (0.7) |
| # of Obs | 11,528,871 | 11,528,871 | 11,528,871 | 11,528,871 |

Table 7. Quasi-Natural Experiment: 2003 Mutual Fund Trading Scandal

This table reports the results from difference-in-differences regressions based on the 2003 mutual fund trading scandal. For each pair of Treasuries, common scandal fund ratio is calculated as the ratio of the total value held by common scandal funds of a security pair over the total value held by all common funds in September 2003. The dummy variable, $Treat$, equals one if a Treasury pair has above-top-quartile common scandal fund ratio at the beginning of the scandal. *Event* is a dummy variable that equals one for quarters during the scandal period (i.e., 2003Q4 to 2006Q4), and zero otherwise. The excess return correlation is computed as the pairwise correlation of daily risk-adjusted returns for a pair of securities. Daily risk adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. All trading days in a quarter are sorted into two equal groups (downside and upside market days) based on the aggregate Treasury market returns, *Down-minus-up* equals the difference of $Corr$ between downside and upside market days. Control variables are the same as in Table 4, and year-quarter fixed effects are included. All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and standard deviation of one. The sample period is from 2002Q3 to 2010Q4. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

| DepVar: | Down-minus-up | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Treat* × *Event* | -0.005* | -0.005* | -0.005** | -0.007*** |
| | (-1.8) | (-1.8) | (-2.0) | (-2.6) |
| *Treat* | 0.005** | 0.005** | 0.003 | -0.002 |
| | (2.3) | (2.4) | (1.5) | (-0.8) |
| *On-the-run Difference* | | -0.012*** | -0.012*** | -0.006 |
| | | (-3.7) | (-3.6) | (-0.8) |
| *Coupon Rate Difference* | | | -0.007*** | -0.007*** |
| | | | (-11.4) | (-11.9) |
| *Time-to-maturity Difference* | | | | -0.051*** |
| | | | | (-89.6) |
| # of Obs | 128,818 | 128,818 | 128,818 | 128,818 |

Table 8. Common Ownership and Return Comovement During COVID-19

This table reports the results based on the COVID-19 outbreak in the first quarter of 2020. Panel A reports the summary statistics. *Corr* is the excess return correlation of a pair of securities, computed separately for periods before and after March 11, 2020 within the first quarter of 2020. The excess return correlation is computed as the pairwise correlation of daily risk-adjusted returns for a pair of securities. Daily risk adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. Panel A represents summary statistics. Panel B reports the results from difference-in-differences regressions. *Treat* is a dummy variable that equals one if the common ownership of a security pair is above median, and zero otherwise. Common ownership is the proportion of total market value of a security pair held by all bond funds that hold both of them by the end of 2019. *After* is a dummy variable that equals one if *Corr* is computed using the sample period after March 11, 2020, and zero otherwise. All control variables are the same as the ones in Tables 4 and 5. Robust $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Panel A: Summary Statistics for *Corr*

| | Mean | sd | p10 | p25 | p50 | p75 | p90 | $N$ |
|---|---|---|---|---|---|---|---|---|
| *Treasuries* | | | | | | | | |
| Before March 11 | 0.142 | 0.497 | -0.575 | -0.278 | 0.176 | 0.530 | 0.826 | 48503 |
| After March 11 | 0.178 | 0.438 | -0.427 | -0.151 | 0.200 | 0.517 | 0.765 | 48503 |
| *Corporate Bonds* | | | | | | | | |
| Before March 11 | 0.030 | 0.244 | -0.276 | -0.125 | 0.024 | 0.182 | 0.348 | 63093 |
| After March 11 | 0.026 | 0.373 | -0.475 | -0.250 | 0.028 | 0.306 | 0.527 | 63093 |

Panel B: Diff-in-diff Regressions

| DepVar: | Corr | | | |
|---|---|---|---|---|
| | Treasuries | | Corporate Bonds | |
| | (1) | (2) | (3) | (4) |
| *Treat* × *After* | 0.042*** | 0.042*** | 0.009*** | 0.009*** |
| | (7.2) | (10.7) | (2.6) | (2.6) |
| *Treat* | 0.210*** | 0.134*** | 0.017*** | 0.010*** |
| | (47.6) | (48.0) | (8.8) | (4.7) |
| *After* | 0.015*** | 0.015*** | -0.009*** | -0.009*** |
| | (4.0) | (5.7) | (-3.5) | (-3.5) |
| Controls | No | Yes | No | Yes |
| # of Obs | 97,006 | 97,006 | 126,186 | 126,186 |
| Adj $R^2$ | 0.063 | 0.567 | 0.001 | 0.003 |

Table 9. Common ownership and Return Comovement: Outflow Funds versus Inflow Funds

This table reports the results from Fama-MacBeth regressions of return comovement on common ownership, $Ratio\ of\ Outflow$, and their interaction for Treasuries and corporate bonds. $Corr$ is the excess return correlation between a pair of securities. The excess return correlation is computed as the pairwise correlation of daily risk-adjusted returns for a pair of securities. Daily risk adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. *Common Ownership* is the proportion of total market value of a security pair held by all bond funds that hold both of them in a quarter. $Ratio\ of\ Outflow$ is the holding-weighted proportion of the security pair's common funds whose fund flow is negative. Control variables are the same as in Tables 4 and 5. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at %, 5% and 10%, respectively. The sample period is from 2002Q3 to 2019Q4.

| DepVar: | Corr | | | |
|---|---|---|---|---|
| | Treasuries | | Corporate Bonds | |
| | (1) | (2) | (3) | (4) |
| *Common Ownership* | 0.075*** | 0.075*** | 0.004*** | 0.004*** |
| | (10.5) | (10.6) | (4.5) | (4.6) |
| *Common Ownership* × *Ratio of Outflow* | 0.039** | 0.038** | -0.000 | -0.000 |
| | (2.3) | (2.3) | (-0.2) | (-0.0) |
| *Ratio of Outflow* | 0.015 | 0.015 | -0.002* | -0.002* |
| | (1.3) | (1.3) | (-1.7) | (-1.8) |
| Control | Yes | Yes | Yes | Yes |
| Control × *Ratio of Outflow* | No | Yes | No | Yes |
| # of Obs | 1,836,161 | 1,836,161 | 5,820,845 | 5,820,845 |

Table 10. Liquidity Commonality and Return Skewness of Treasuries

This table reports the results on Treasury pairs' liquidity commonality and individual Treasuries' skewness. In Panel A, we conduct Fama-MacBeth regressions from 2002Q3 to 2019Q4. In columns (1)-(2), *Common Dry-ups* is a dummy variable, which equals one if these two Treasuries have experienced liquidity dry-up events in the same day. For each Treasury at each quarter, liquidity dry-up events are defined as the days with bid-ask spreads exceeding the top quartile of bid-ask spreads in the previous four quarters. *Common Ownership* is the proportion of total market value of a Treasury pair held by all bond funds that hold both of them in a quarter. Control variables in columns (1)-(2) are the same as in Tables 4. In columns (3)-(4), *Skewness* is the skewness of the daily risk-adjusted returns of a Treasury in a quarter. *Ownership* is the proportion of total market value of a Treasury held by all bond funds in a quarter. Control variables in columns (3)-(4) include: *On-the-run* is a dummy variable that equals one if the Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise; *Coupon Rate* is coupon rate expressed in percentage; and *Time-to-maturity* is years-to-maturity. In Panel B, we conduct difference-in-differences regressions similar to Table 7. In columns (1)-(2), *Treat* is a dummy variable that equals one if a Treasury pair has above-top-quartile common scandal fund ratio. In columns (3)-(4), *Treat* is a dummy variable that equals one if a Treasury has above-top-quartile scandal fund ratio. *Event* is a dummy variable that equals one during the scandal period, and zero otherwise. The sample period is from 2002Q3 to 2010Q4. All independent variables (except for *On-the-Run Difference* and *On-the-Run*) are standardized to have a mean of zero and standard deviation of one by quarter. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

| Panel A: Full Sample | | | | |
|---|---|---|---|---|
| DepVar: | Common Dry-ups | | Skewness | |
| | (1) | (2) | (3) | (4) |
| *Common Ownership* | 0.025*** | 0.027*** | | |
| | (3.6) | (3.6) | | |
| *Ownership* | | | -0.587*** | -0.441*** |
| | | | (-9.9) | (-10.9) |
| Controls | No | Yes | No | Yes |
| # of Obs | 2,185,735 | 2,185,735 | 16,477 | 16,477 |

| Panel B: Mutual Fund Scandal | | | | |
|---|---|---|---|---|
| DepVar: | Common Dry-ups | | Skewness | |
| | (1) | (2) | (3) | (4) |
| *Treat × Event* | -0.002*** | -0.002*** | 0.238** | 0.269** |
| | (-3.3) | (-3.2) | (2.0) | (2.2) |
| *Treat* | 0.002*** | 0.002*** | -0.184** | -0.260*** |
| | (4.1) | (3.3) | (-2.0) | (-2.7) |
| Controls | No | Yes | No | Yes |
| # Obs | 128,818 | 128,818 | 3,082 | 3,082 |

# A Appendix

Table A1. Variable Definition

| *Variable* | Definition |
|---|---|
| *Corr* | The realized pairwise correlation of the daily risk-adjusted returns between securities $i$ and $j$ in quarter $q$. Daily risk adjusted returns are obtained as the residual from a regression of daily bond excess return on returns from the aggregate Treasury market, investment-grade bonds, junk bonds, and their two lags. |
| *Down-minus-up* | To measure the asymmetry in return comovement during downside and upside markets, in each quarter, we sort all trading days into two equal groups (downside and upside markets) based on the aggregate Treasury market returns. We then calculate return comovement for each group and take the difference in return comovement between downside and upside markets. We denote this difference as *Down-minus-up*. |
| *Common Ownership* | The market value held by all funds commonly holding a pair of bonds over the sum of the total market value of the two bonds |
| *Time-to-maturity* | The years between the quarter-end and maturity date. |
| *Time-to-maturity Difference* | The absolute difference in *Time-to-maturity* between two securities |
| *Coupon Rate* | Coupon rate expressed in percentage |
| *Coupon Rate Difference* | The absolute difference in *Coupon Rate* between two securities |
| *On-the-run* | A dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise |
| *On-the-run Difference* | The absolute difference of *On-the-run* between two Treasuries |
| *Liquidity Difference* | The absolute difference in the fraction of zero-trading days between two corporate bonds |
| *Rating Difference* | The absolute difference in the numeric-transformed credit rating between two corporate bonds. The main rating information of corporate bonds is from Moody's. If there is no rating from Moody's then the rating is from S&P, and if there is no rating from either Moody's or S&P, the rating is from Fitch. An Aaa rating is translated as 1 and a C rating is translated as 21. The other ratings are assigned accordingly. |
| *Net Buy* | The percentage change of a fund's total holding in Treasuries or corporate bonds, relative to its beginning-of-the-quarter holding |
| *Fund Flow* | Quarterly fund flows |
| *Out* | A dummy variable that equals one if *Fund Flow* is negative, and zero otherwise. An alternative *Out* used in the Appendix Tables A2 is defined as a dummy variable that equals one if *Fund Flow* is lower than the quarter median, and zero otherwise. |
| *Fund Return* | Quarterly fund gross returns. We calculate gross return before expenses by adding one-twelfth of the fund expense ratio to the net monthly return. |
| *Ratio of Outflow* | The holding-weighted proportion of the security pair's common funds whose fund flow is negative. Common funds for a security pair are the bond funds that hold both of the securities in the pair |
| *FIT* | Following Lou (2012), *FIT* is the monthly aggregate flow-induced trading across all bond funds for each Treasury using holding details from the most recent quarter. |
| *FIT_Positive* | The monthly aggregate flow-induced trading across all bond funds with positive fund inflows for each Treasury. |
| *FIT_Negative* | The monthly aggregate flow-induced trading across all bond funds with negative fund inflows for each Treasury. |
| *Common Dry-ups* | We measure liquidity commonality for each Treasury pair in the following steps. First, for each Treasury at each quarter, liquidity dry-up events are defined as the days with bid-ask spreads exceeding the top quartile of bid-ask spreads in the previous four quarters. To measure liquidity commonality, we examine whether two Treasuries simultaneously experience liquidity dry-ups. Specifically, for each Treasury pair at each quarter, we define a dummy variable, *Common Dry-ups*, which equals one if these two Treasuries have experienced liquidity dry-ups in the same day. |
| *Skewness* | The skewness of the daily risk-adjusted returns of a Treasury in a quarter |

Table A2. Fund Flows and Liquidity Management: Alternative Definition for *Out*.

This table reports the regression results of fund trading on fund flows for Treasuries and corporate bonds. $Net\ Buy_{f,q}$ is calculated as the percentage change of fund $f$'s total holdings in Treasuries or corporate bonds in quarter $q$, relative to its beginning-of-the-quarter holdings. $Fund\ Flow_{f,q}$ and $Fund\ Return_{f,q}$ represent quarterly fund flows and fund return for fund $f$ in quarter $q$. $Out_{f,q}$ is a dummy variable that equals one if the fund flow for fund $f$ in quarter $q$ is lower than the quarter median, and zero otherwise. Variables are winsorized by quarter at the $5^{th}$ and $95^{th}$ percentiles. Standard errors are clustered by fund and quarter, and the $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample period is from 2002Q3 to 2019Q4.

| DepVar: | $Net\ Buy_{f,q}$ | | | |
|---|---|---|---|---|
| | Treasuries | | Corporate Bonds | |
| | (1) | (2) | (3) | (4) |
| $Fund\ Flow_{f,q}$ | 1.205*** | 1.258*** | 0.883*** | 0.878*** |
| | (15.9) | (15.9) | (16.4) | (16.3) |
| $Fund\ Flow_{f,q} \times Out_{f,q}$ | 0.539*** | 0.481*** | -0.059 | -0.058 |
| | (4.3) | (4.0) | (-0.8) | (-0.8) |
| $Fund\ Flow_{f,q-1}$ | -0.229*** | -0.169*** | 0.223*** | 0.211*** |
| | (-3.7) | (-3.3) | (5.5) | (5.2) |
| $Fund\ Flow_{f,q-1} \times Out_{f,q-1}$ | -0.223* | -0.299*** | -0.036 | -0.019 |
| | (-1.9) | (-2.9) | (-0.5) | (-0.2) |
| $Fund\ Return_{f,q}$ | -0.787*** | -0.606** | 0.003 | -0.183 |
| | (-3.3) | (-2.1) | (0.0) | (-0.8) |
| $Fund\ Return_{f,q-1}$ | 0.143 | 0.315 | -0.547*** | -0.689*** |
| | (0.5) | (1.0) | (-3.2) | (-3.8) |
| Fund Fixed Effects | No | Yes | No | Yes |
| Quarter Fixed Effects | Yes | Yes | Yes | Yes |
| # of Obs | 34,008 | 34,008 | 34,008 | 34,008 |
| Adj $R^2$ | 0.070 | 0.195 | 0.098 | 0.159 |

Table A3. Fund Flows and Liquidity Management: Illiquid Funds versus Liquid Funds

This table reports the regression results of fund trading on fund flows for illiquid funds (columns (1)–(2)) and liquid funds (columns (3)–(4)). In each quarter, we define illiquid funds as the ones whose portfolio weights on corporate bonds is higher than the quarter median; the rest of the funds are defined as liquid funds. $Net\ Buy_{f,q}$ is calculated as the percentage change of fund $f$'s total holdings in Treasuries or corporate bonds in quarter $q$, relative to its beginning-of-the-quarter holdings. $Fund\ Flow_{f,q}$ and $Fund\ Return_{f,q}$ represent quarterly fund flows and fund return for fund $f$ in quarter $q$. $Out_{f,q}$ is a dummy variable that equals one if the fund flow for fund $f$ is negative in quarter $q$, and zero otherwise. Variables are winsorized by quarter at the $5^{th}$ and $95^{th}$ percentiles. Standard errors are clustered by fund and quarter, and the $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample is from 2002Q3 to 2019Q4.

| DepVar: | $Net\ Buy_{f,q}$ | | | |
|---|---|---|---|---|
| | Iliquid Funds | | Liquid Funds | |
| | Treasuries | Corporate Bonds | Treasuries | Corporate Bonds |
| | (1) | (2) | (3) | (4) |
| $Fund\ Flow_{f,q}$ | 1.205*** | 0.882*** | 1.345*** | 0.657*** |
| | (11.4) | (14.0) | (14.5) | (11.1) |
| $Fund\ Flow_{f,q} \times Out_{f,q}$ | 0.885*** | 0.063 | 0.173 | 0.059 |
| | (5.3) | (0.6) | (0.9) | (0.6) |
| $Fund\ Flow_{f,q-1}$ | -0.248*** | 0.117*** | -0.104 | 0.234*** |
| | (-3.6) | (2.9) | (-1.6) | (4.7) |
| $Fund\ Flow_{f,q-1} \times Out_{f,q-1}$ | -0.299* | 0.023 | -0.284** | -0.064 |
| | (-1.9) | (0.2) | (-2.1) | (-0.7) |
| $Fund\ Return_{f,q}$ | -0.545 | -0.116 | -0.178 | -0.206 |
| | (-1.3) | (-0.5) | (-0.3) | (-0.7) |
| $Fund\ Return_{f,q-1}$ | -0.212 | -0.461*** | 0.817 | -0.929*** |
| | (-0.6) | (-2.8) | (1.2) | (-4.0) |
| Fund Fixed effects | Yes | Yes | Yes | Yes |
| Quarter Fixed Effects | Yes | Yes | Yes | Yes |
| # of Obs | 15,695 | 15,695 | 17,829 | 17,829 |
| Adj $R^2$ | 0.199 | 0.222 | 0.236 | 0.170 |

Table A4. Common ownership and Return Comovement: Alternative Sample Selection on Time-to-Maturity

This table reports the results from Fama-MacBeth regressions of a security pair's excess return comovement in quarter $q$ on their common ownership in quarter $q-1$. Securities with a time-to-maturity of less than one-year are excluded from the sample. *Corr* is the excess return correlation between a pair of securities in a quarter. All trading days in a quarter are sorted into two equal groups (downside and upside markets) based on the aggregate Treasury market returns, *Down-minus-up* equals the difference of *Corr* between downside and upside market days. *Common Ownership* is the proportion of total market value of a security pair held by all bond funds that hold both of them in a quarter. *On-the-Run Difference* is the absolute difference in on-the-run status, where on-the-run status is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Liquidity Difference* is the absolute difference between two corporate bonds' fraction of zero-trading days. *Rating Difference* is the absolute difference between two corporate bonds' numeric-transformed credit rating. *Coupon Rate Difference* is the absolute difference between two securities' coupon rates. *Time-to-maturity Difference* is the absolute difference between two securities' years-to-maturity. All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and standard deviation of one in each quarter. Panel A reports the results for Treasuries and Panel B reports the results for corporate bonds. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.The sample period is from 2002Q3 to 2019Q4.

Panel A: Treasuries

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Onwership* | 0.111*** | 0.079*** | 0.014*** | 0.008*** |
| | (35.2) | (19.3) | (5.4) | (2.7) |
| *On-the-run Difference* | | 0.014*** | | -0.011*** |
| | | (3.4) | | (-4.4) |
| *Coupon Rate Difference* | | -0.066*** | | 0.007 |
| | | (-21.0) | | (1.2) |
| *Time-to-maturity Difference* | | -0.193*** | | -0.072*** |
| | | (-20.0) | | (-7.8) |
| # of Obs | 1,810,220 | 1,810,220 | 1,810,220 | 1,810,220 |

Panel B: Corporate Bonds

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Ownership* | 0.007*** | 0.004*** | 0.0005 | 0.0003 |
| | (10.3) | (9.4) | (1.3) | (1.0) |
| *Liquidity Difference* | | -0.005*** | | -0.0002 |
| | | (-14.1) | | (-0.5) |
| *Coupon Rate Difference* | | -0.002*** | | -0.0001 |
| | | (-4.1) | | (-0.4) |
| *Rating Difference* | | -0.003*** | | -0.0005 |
| | | (-8.3) | | (-1.1) |
| *Time-to-maturity Difference* | | -0.004*** | | 0.0005 |
| | | (-7.3) | | (1.1) |
| # of Obs | 9,641,024 | 9,641,024 | 9,641,024 | 9,641,024 |

Table A5. Common ownership and Return Comovement: The Number of Unique Securities

This table reports the results from Fama-Macbeth regressions of a security pair's excess return comomvement in quarter $q$ on their common ownership in quarter $q-1$. *Common Ownership* (*more TRY*) (*Common Ownership* (*more CB*)) is the *Common Ownership* from common funds holding an above-median number of unique Treasury (corporate bond) securities, while *Common Ownership* (*less TRY*) (*Common Ownership* (*less CB*)) is the *Common Ownership* from common funds holding a below-median number of unique Treasury (corporate bond) securities. *Corr* is the excess return correlation between a pair of securities in a quarter. All trading days in a quarter are sorted into two equal groups (downside and upside markets) based on the aggregate Treasury market returns, *Down-minus-up* equals the difference of *Corr* between downside and upside market days. *On-the-Run Difference* is the absolute difference in on-the-run status, where on-the-run status is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Liquidity Difference* is the absolute difference between two corporate bonds' fraction of zero-trading days. *Rating Difference* is the absolute difference between two corporate bonds' numeric-transformed credit rating. *Coupon Rate Difference* is the absolute difference between two securities' coupon rates. *Time-to-maturity Difference* is the absolute difference between two securities' years-to-maturity. All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and standard deviation of one in each quarter. Panel A reports the results for Treasuries and Panel B reports the results for corporate bonds. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample is from 2002Q3 to 2019Q4.

Panel A: Treasuries

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Onwership (more TRY)* | 0.082*** | 0.067*** | 0.006*** | 0.004** |
| | (24.8) | (21.2) | (3.2) | (2.0) |
| *Common Onwership (less TRY)* | 0.008*** | 0.004*** | 0.001** | 0.000 |
| | (6.6) | (4.7) | (2.0) | (0.8) |
| *On-the-run Difference* | | 0.017*** | | -0.012*** |
| | | (4.5) | | (-5.2) |
| *Coupon Rate Difference* | | -0.055*** | | 0.008 |
| | | (-20.4) | | (1.5) |
| *Time-to-maturity Difference* | | -0.176*** | | -0.065*** |
| | | (-21.7) | | (-7.5) |
| # of Obs | 2,185,735 | 2,185,735 | 2,185,735 | 2,185,735 |

Panel B: Corporate Bonds

| DepVar: | Corr | | Down-minus-up | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Common Ownership (more CB)* | 0.006*** | 0.004*** | 0.0004 | 0.0004 |
| | (7.8) | (7.3) | (1.3) | (1.4) |
| *Common Ownership (less CB)* | 0.001*** | 0.000*** | 0.0000 | 0.0000 |
| | (4.4) | (3.9) | (0.2) | (0.2) |
| *Liquidity Difference* | | -0.004*** | | -0.0000 |
| | | (-13.4) | | (-0.1) |
| *Coupon Rate Difference* | | -0.002*** | | -0.0000 |
| | | (-4.3) | | (-0.0) |
| *Rating Difference* | | -0.003*** | | -0.0005 |
| | | (-7.7) | | (-1.2) |
| *Time-to-maturity Difference* | | -0.004*** | | 0.0006 |
| | | (-7.4) | | (1.2) |
| # of Obs | 11,528,871 | 11,528,871 | 11,528,871 | 11,528,871 |

Table A6. Common Ownership and Return Comovement During COVID-19

This table reports the OLS regression results based on the COVID-19 outbreak in the first quarter of 2020, for Treasuries (Panel A) and corporate bonds (Panel B). *Corr* is the excess return correlation between a pair of securities. In columns (1)–(2), *Corr* is computed before March 11th. In columns (3)–(4), *Corr* is computed after March 11. *After-minus-before* is the difference of *Corr* between the post- and pre-announcement period. *Common Ownership* is the proportion of total market value of a security pair held by all bond funds that hold both of them in a quarter. *On-the-Run Difference* is the absolute difference in on-the-run status, where on-the-run status is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Liquidity Difference* is the absolute difference between two corporate bonds' fraction of zero-trading days. *Rating Difference* is the absolute difference between two corporate bonds' numeric-transformed credit rating. *Coupon Rate Difference* is the absolute difference between two securities' coupon rates. *Time-to-maturity Difference* is the absolute difference between two securities' years-to-maturity. All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and standard deviation of one. Panel A reports the results for Treasuries and Panel B reports the results for corporate bonds. Robust $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample is from 2002Q3 to 2019Q4.

Panel A: Treasuries

| DepVar: | Corr | | | | After-minus-before | |
|---|---|---|---|---|---|---|
| Timing: | Before March 11 | | After March 11 | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Common Onwership* | 0.150*** | 0.086*** | 0.178*** | 0.149*** | 0.028*** | 0.062*** |
| | (76.5) | (60.9) | (97.4) | (97.5) | (16.7) | (37.2) |
| *On-the-run Difference* | | 0.060*** | | 0.051*** | | -0.009 |
| | | (8.7) | | (7.3) | | (-1.1) |
| *Coupon Rate Difference* | | -0.054*** | | 0.031*** | | 0.086*** |
| | | (-33.0) | | (23.9) | | (47.0) |
| *Time-to-maturity Difference* | | -0.378*** | | -0.278*** | | 0.100*** |
| | | (-292.6) | | (-198.1) | | (66.5) |
| # of Obs | 48,503 | 48,503 | 48,503 | 48,503 | 48,503 | 48,503 |
| Adj $R^2$ | 0.082 | 0.665 | 0.148 | 0.548 | 0.005 | 0.127 |

Panel B: Corporate Bonds

| DepVar: | Corr | | | | After-minus-before | |
|---|---|---|---|---|---|---|
| Timing: | Before March 11 | | After March 11 | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Common Ownership* | 0.010*** | 0.006*** | 0.018*** | 0.013*** | 0.008*** | 0.007*** |
| | (9.5) | (5.6) | (11.3) | (8.0) | (5.2) | (4.5) |
| *Liquidity Difference* | | -0.007*** | | -0.001 | | 0.005*** |
| | | (-6.7) | | (-0.8) | | (3.7) |
| *Coupon Rate Difference* | | -0.003*** | | -0.003** | | -0.000 |
| | | (-3.0) | | (-2.2) | | (-0.3) |
| *Rating Difference* | | -0.004*** | | -0.008*** | | -0.004** |
| | | (-4.0) | | (-5.2) | | (-2.6) |
| *Time-to-maturity Difference* | | -0.008*** | | -0.007*** | | 0.001 |
| | | (-7.1) | | (-4.0) | | (0.3) |
| # of Obs | 63,093 | 63,093 | 63,093 | 63,093 | 63,093 | 63,093 |
| Adj $R^2$ | 0.001 | 0.003 | 0.002 | 0.003 | 0.000 | 0.001 |

Table A7. Common ownership and Return Comovement: Month End versus Month Beginning

This table reports the results from Fama-Macbeth regressions of a security pair's excess return comovement on common ownership during month ends and month beginnings, for Treasuries (Panel A) and corporate bonds (Panel B). Following Etula, Rinne, Suominen, and Vaittinen (2020), we define month end as the five-trading-day window [$t$-8,$t$-4], and month beginning as the five-trading-day window [$t$-1,$t$+3], where $t$ is the last trading day of each month. *Corr* is the excess return correlation between a pair of securities. In columns (1)–(2), *Corr* is computed at month-ends in a quarter. In columns (3)–(4), *Corr* is computed at month-beginnings in a quarter. *End-minus-beginning* is the difference in *Corr* between month ends and month beginnings. *Common Ownership* is the proportion of total market value of a security pair held by all bond funds that hold both of them in a quarter. *On-the-Run Difference* is the absolute difference in on-the-run status, where on-the-run status is a dummy variable that equals one if a Treasury is the most recently issued Treasury of a particular maturity, and zero otherwise. *Liquidity Difference* is the absolute difference between two corporate bonds' fraction of zero-trading days. *Rating Difference* is the absolute difference between two corporate bonds' numeric-transformed credit rating. *Coupon Rate Difference* is the absolute difference between two securities' coupon rates. *Time-to-maturity Difference* is the absolute difference between two securities' years-to-maturity. All independent variables (except for *On-the-Run Difference*) are standardized to have a mean of zero and standard deviation of one in each quarter. Heteroscedasticity and auto-correlation-consistent Newey-West (1987) $t$-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample is from 2002Q3 to 2019Q4.

Panel A: Treasuries

| DepVar: | Corr | | | | End-minus-beginning | |
|---|---|---|---|---|---|---|
| Timing: | Month end | | Month beginning | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Common Onwership* | 0.117*** | 0.089*** | 0.100*** | 0.080*** | 0.016*** | 0.010*** |
| | (26.9) | (17.5) | (31.2) | (18.1) | (4.4) | (3.0) |
| *On-the-run Difference* | | 0.021*** | | -0.000 | | 0.021*** |
| | | (4.2) | | (-0.0) | | (5.3) |
| *Coupon Rate Difference* | | -0.064*** | | -0.041*** | | -0.023*** |
| | | (-16.4) | | (-8.8) | | (-5.8) |
| *Time-to-maturity Difference* | | -0.213*** | | -0.176*** | | -0.037*** |
| | | (-18.5) | | (-19.7) | | (-3.3) |
| # of Obs | 2,185,735 | 2,185,735 | 2,185,735 | 2,185,735 | 2,185,735 | 2,185,735 |

Panel B: Corporate Bonds

| DepVar: | Corr | | | | End-minus-beginning | |
|---|---|---|---|---|---|---|
| Timing: | Month end | | Month beginning | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Common Ownership* | 0.008*** | 0.006*** | 0.009*** | 0.007*** | -0.001 | -0.001 |
| | (9.5) | (8.6) | (8.3) | (8.3) | (-1.6) | (-1.3) |
| *Liquidity Difference* | | -0.004*** | | -0.005*** | | 0.001 |
| | | (-10.1) | | (-9.0) | | (0.9) |
| *Coupon Rate Difference* | | -0.001*** | | -0.002*** | | 0.001 |
| | | (-3.9) | | (-4.0) | | (1.4) |
| *Rating Difference* | | -0.004*** | | -0.003*** | | -0.000 |
| | | (-8.0) | | (-6.1) | | (-1.0) |
| *Time-to-maturity Difference* | | -0.004*** | | -0.005*** | | 0.001 |
| | | (-5.2) | | (-4.8) | | (0.8) |
| # of Obs | 11,528,871 | 11,528,871 | 11,528,871 | 11,528,871 | 11,528,871 | 11,528,871 |