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

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Abstract

Bond mutual funds holding illiquid assets (e.g., corporate bonds) actively manage their Treasury positions to buffer redemption shocks. We argue that this liquidity management practice can transmit and concentrate non-fundamental demand shocks from fund flows onto the Treasuries the funds hold, leading to fragility in Treasury prices. We find that Treasuries held more by bond funds tend to exhibit high return comovement during downside markets, negatively skewed returns, and frequent liquidity co-jumps, compared with Treasuries with little fund ownership. We address endogeneity concerns by exploiting the 2003 mutual fund scandal as an shock to fund ownership. Such mechanism can help explain the COVID-19 Treasury market turmoil in March 2020.

Keywords: liquidity management; bond mutual fund; return comovement; 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 recent 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 most liquid market.

In this paper, we argue that the common practice of liquidity management contributes to the increased fragility in Treasury prices. Financial intermediaries performing liquidity transformation—holding illiquid assets but issuing liquid claims to investors—often face run risk arising from strategic complementarity among investors (e.g., Chen, Goldstein, and Jiang, 2010a). To mitigate the risk, financial intermediaries 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, 2017; Choi, Hoseinzade, Shin, and Tehranian, 2020). We argue that this can potentially transmit and concentrate the non-fundamental shocks driven by fund flows onto the Treasury prices the funds hold, generating fragility in the Treasury market.[3] In particular, such mechanism has been more relevant in recent years as the total size of open-end funds investing in illiquid assets has increased several folds.[4]

To test the asset pricing implications of liquidity management on Treasuries, we focus

[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 (2020), 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."

[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.

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 behavior. Third, we can precisely measure investors' demand of liquid claims by fund flows.

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 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. With 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 suggest that bond funds use Treasuries in liquidity management, and Treasury positions are subject to more flow-induced selling than its corporate bond holdings when bond funds are redeemed by investors.

Second, we examine if such flow-induced trading can have significant price impacts on Treasuries, which are arguably the most liquid assets around the world. Following Lou (2012), we aggregate bond funds' flow-induced purchases and sales onto the Treasury level and scale by the total amount of the Treasury security held by bond funds (denote as "Flow-induced Trading", or *FIT*). We find that a one standard deviation increase in *FIT* is associated with 4.8 basis points higher beta-adjusted returns of Treasuries in the contemporaneous month, which is reversed in the subsequent weeks. Also, the effect is stronger when funds experience outflows and are net selling. Such a price impact from *FIT* with subsequent reversal suggests that demand shocks arising from fund flows are largely non-fundamental.[5] While the price pressure induced by fund flows has been widely identified in stock markets (e.g., Lou, 2012; Coval and Stafford, 2007; Huang,

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

Song, and Xiang, 2020), we are the first, to our best knowledge, to document that bond mutual funds can transmit the non-fundamental demand shocks from fund flows into the Treasury market, and thus generate price fragility on Treasuries, which are considered as the most liquidity asset.

The previous two tests confirm that Treasuries are widely traded by bond funds as a liquidity buffer. In this sense, the price of Treasuries with high bond funds' ownership should exhibit systematic exposure to non-fundamental fund flow shocks. Such exposure becomes a defining force for Treasury prices as mutual funds are now one of the major players in the Treasury market.[6] The essential testable implication from this mechanism is whether bond funds' ownership induces fragility of Treasury prices. In our empirical tests, we primarily use excess return comovement of Treasury pairs as an indicator of price fragility. The total return variance of one particular asset class (i.e., Treasuries in our context), as a conventional measure of fragility, is largely affected by the return correlation among individual assets within this asset class. Thus, our study on 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 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). Furthermore, by focusing on cross-sectional tests, we can pin down the economic mechanism and rule out confounding effects in time-series. In addition, we use liquidity co-jumps and return skewness as alternative fragility measures.

The underlying mechanism for the association between bond funds' ownership and return comovement among Treasuries is not new in the literature: 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. While this mechanism naturally works on bond funds, our setting offers several unique predictions for Treasuries and corporate bonds. First, as discussed earlier, bond funds' trading in Treasuries is more sensitive to fund flows than that of corporate bonds, and the trading-to-flow sensitivity among Treasuries is more pronounced when funds are redeemed. As

[6] Liang (2020) estimates that the share of marketable Treasury securities held by long-term mutual funds increased from 3% in 2008 to 8% in 2019—slightly more than the amount held by banks and broker-dealers.

such, we hypothesize that Treasuries commonly held more by bond funds (termed as *common ownership* for brevity) should exhibit stronger excess return comovement.

Second, more importantly, we emphasize an asymmetric pattern, that is, the effect of common ownership on Treasury return comovement should be stronger in presence of fund outflows or during market downturns. Such excessive downside market comovement can be considered as an indicator of the fragility in Treasury prices. Besides downside return comovement, we also use the negative return skewness and common liquidity dry-ups as alternative fragility measures and find similar results.

Third, by comparison, 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 excess return comovement among Treasuries or corporate bonds to bond funds' ownership as follows. First, for each Treasury or corporate bond pair in each quarter, we calculate the correlation between the two securities' daily risk-adjusted returns to measure return comovement. 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 introducing the cross-sectional regression results, we look at the aggregate trends. Figure 1 plots the time series of average excess return comovement on Treasuries (solid blue line) and 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 fragility of the Treasury market (see, Powell, 2016). In sharp contrast, such 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

[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. Similar results can be obtained using the percentage change in VIX as the factor.

increased fragility of Treasury prices.

To control for confounding driving forces for the time trends, we run Fama and MacBeth (1973) 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% increase in the return correlation between two Treasury securities. For comparison, we examine corporate bonds but find a much smaller effect. A one standard deviation increase in common ownership is only associated with a 0.5% increase in the return correlation between two corporate bonds.

Second, we examine the asymmetry in the association between fund common ownership and return comovement during downside and upside markets. 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 aggregate Treasury market returns. We then calculate return comovement for each group and take the difference in return comovement between downside and upside markets. For brevity, we denote this difference as *Down-minus-up*. Note that this asymmetry measure has a unique advantage in eliminating potential similarities in unobservable bond characteristics that may drive return comovement. After that, we run Fama-MacBeth regressions of *Down-minus-up* on common ownership to examine the asymmetric effect of common ownership on Treasuries between downside and upside markets.

Our analysis uncovers an intriguing pattern on Treasuries. The association between fund common ownership and 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 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]

[8] As an alternative setting, we find that the association between fund 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

In addition, we consider two alternative fragility measures. First, we examine liquidity co-jump, measured with bid-ask spreads. This is motivated by the observation during recent market-wide events during which the most liquid market experienced sudden liquidity dry-ups, such as the "flash rally" in 2014 and the COVID19 turmoil in March 2020 (e.g., Adrian, Fleming, Stackman, and Vogt, 2015a; Fleming and Ruela, 2020). Second, we use the negative skewness of risk-adjusted returns, which is a widely used measure of the likelihood of price crashes in the literature (Chen, Hong, and Stein, 2001; Brunnermeier, Nagel, and Pedersen, 2008). We find consistent results that Treasuries owned more by bond funds tend to experience more liquidity co-jumps and left-skewed returns.

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 explanation is unlikely to reconcile with the asymmetric pattern on the return comovement among Treasuries, we nonetheless exploit the 2003 mutual fund scandal as a natural experiment. Treasuries heavily owned by the scandal funds experience significant sell off and reduction in fund ownership. Specifically, we follow Koch, Ruenzi, and Starks (2016) and conduct a difference-in-differences regression. We find that Treasuries held more by the scandal funds, resulting in lower fund common ownership during the scandal period, tend to exhibit lower *Down-minus-up*, less frequent liquidity co-jumps, and fewer negatively skewed returns during the scandal period, compared to the non-scandal period. This result is consistent with our main analysis and provides causal evidence to our hypothesis that fund common ownership can induce fragility in Treasury prices.

Finally, we document several observations during the recent Treasury market turmoil in March 2020 that are consistent with our proposed mechanism. As shown in Panel A of Figure 2, starting from the second week of March (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, (1) Treasuries had dramatic price declines, and the price decline is much more pronounced among Treasuries with high bond funds' ownership (see Panel B of Figure 2), and (2) Treasuries exhibit increased return

that there is no such asymmetric pattern on stocks, which further highlights the uniqueness of our finding on Treasuries.

comovement, and the increase was more significant among Treasury pairs held more by bond funds. Both patterns are consistent with our conjecture that when bond funds experience large outflows, they tend to liquidate Treasuries to meet investor redemption, exerting 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 complementaries among investors (for empirical evidence, see, Chen et al., 2010a; Falato, Goldstein, and Hortaçsu, 2020). To mitigate the financial fragility, mutual funds use cash or cash-like assets to manage their liquidity needs (see Chernenko and Sunderam, 2016; Aragon, Ergun, Getmansky Sherman, and Girardi, 2017; Jiang et al., 2017; Choi et al., 2020; Ma, Xiao, and Zeng, 2020). For example, Ma et al. (2020) 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 selling liquid assets—Treasuries. Jotikasthira, Lundblad, and Ramadorai (2012) show that emerging market funds prefer to trade holdings in more liquid markets when accommodating fund flow shocks. Greenwood and Vayanos (2010) present anecdotal evidence from the government bond markets during two events (the UK pension reform of 2004 and the US Treasury's buyback program of 2000-2001) that the term structure of interest rate can be affected by short-term price pressure. Our study complements the literature by systematically and directly investigating the impact of liquidity management on the prices of the buffer assets (i.e., Treasuries). Our findings in corporate bonds are also related to 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.

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) highlight the role of margin spirals. He, Nagel, and Song (2020) 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, specifically, that liquidity management could at least partially contribute to the Treasury market turmoil that occurred during the COVID-19 pandemic. Another important difference between our study and this strand of literature is that we use data over a long period and our data have rich information (e.g., detailed bond holding and fund characteristics). The data not only allow us to conduct cross-sectional tests to pin down the underlying mechanism (i.e., liquidity management), but also help demonstrate that the liquidity management practices together with the fast-growing bond fund sector have contributed to the increased fragility in the Treasury market over the past decade.

There are also a few papers examining the corporate bond market during the COVID-19 episode. For example, Haddad, Moreira, and Muir (2020) 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 funds 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 return correlation between stocks. Greenwood and Thesmar (2011) estimate the correlation between fund flows among mutual funds and link the correlated fund flows to stock return comovement. Huang et al. (2020) document that correlation between fund flows among mutual funds 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. 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 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. According to the report by the Investment Company Institute (2020), total assets under management of open-end mutual funds with primary investment 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 holding in Treasuries has also increased dramatically, becoming an important player in the Treasury market. Using the flow of funds data from Federal Reserve, we find in Figure 3 that the fraction of Treasury securities outstanding owned by U.S. mutual funds and money market funds raised from about 5% in 1990 to over 12% in 2019. This pattern is also confirmed by Liang (2020), who finds that the share of marketable Treasury securities held by long-term mutual funds exceeds the amount held by banks and broker-dealers in 2019.

Unlike other major investors in the Treasury market (e.g., insurance companies and sovereign wealth funds), who tend to be passive and hold to maturity, open-end mutual funds trade frequently in the Treasury market to accommodate fund flows, and such trade-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 (2018).

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 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 CUSIP, number of shares, and market value. The holding data is on quarterly frequency and is available from July 2002. To obtain fund characteristics, including fund return 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 CUSIP and ticker. Our final sample includes 2293 unique bond funds from 2002 to 2019.

We obtain data on Treasuries from the CRSP and obtain 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, total shares outstanding (i.e., shares held by the public), and the issuance terms. The TRACE provides detailed transaction information on corporate bond trades, including the transaction prices and volumes.[9] The Mergent-FISD provides bond characteristics, such as credit rating, total shares outstanding, issuer, coupon rate, and maturity date. 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. Then, 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.[10] Our final sample contains 1,136 Treasuries and 2,804 corporate bonds.

2.3 Fund flows, trading, and common ownership

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

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

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

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

where $Fund\ Return_{f,q}$ is fund f's gross return over quarter q, and $TNA_{f,q}$ is total net assets at quarter q. We calculate 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 holding in Treasuries or in corporate bonds, relative to its beginning-of-the-quarter holding. Note that we use the quarter-beginning prices in Equation (2) and thus our measure, $Net\ Buy$, is purely driven by funds' trading on Treasuries or corporate bonds.

Following Lou (2012), we calculate the flow-induced trading across all bond funds for each bond in each month, i.e., FIT, 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 fund flows 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 in- and out-flows, i.e., trading-to-flow sensitivity to be one (more discussion on this later). Intuitively, $FIT_{i,t}$ 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 quarter, we calculate bond funds' ownership as the ratio of the total market value held by all bond funds divided by the total amount 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 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 return and liquidity jump

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

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

For Treasuries, $P_{i,t}$ 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 $P_{i,t}$ as the trading-volume-weighted intraday price, following Bessembinder, Kahle, Maxwell, and Xu (2008), who find that this 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:

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

where $Bond\ RetRf_{i,t}$ is bond i's daily return minus the risk-free rate at day t, and the risk-free rate is the daily rate of the one-month Treasury bill. On the right-hand side of Equation (6), we consider the aggregate daily returns (in excess of the risk-free rate) of three major bond sub categories: Treasuries, investment-grade bonds, and junk bonds. We use the average daily returns across all Treasuries to proxy for the aggregate returns from the Treasury market. We use returns from two Barclays corporate bond market indices to proxy for the the aggregate returns from investment-grade bonds (LUACTRUU) and junk bonds (LF98TRUU). 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).[11] 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 a Barclays long-term government bond index (LUTLTRUU) and the one-month Treasury bill rate, and define DEF as the difference in daily returns between a Barclays long-term corporate bond index (LD07TRUU) and the long-term government bond index. We find similar results after including these additional factors in the model.

Then, for each pair of Treasuries (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 $Corr$. 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 market returns. We then calculate excess return comovement among Treasuries (or corporate bonds) using daily risk-adjusted returns in each group and take the difference in excess return comovement between downside and upside markets. We denote this difference as *Down-minus-up*.

For the tests on flow-induced price impact, we compute beta-adjusted daily returns. More specifically, in each month t, we run Eq.(6) using daily returns from the past three months ($t-3$ to $t-1$) and obtain the beta estimates. Then we use these beta estimates together with the daily factors in month t to compute daily risk-adjusted returns for

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

Treasuries in month t.

In addition, we consider two alternative fragility measures: liquidity co-jump and the negative skewness of excess returns. The first measure, 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. Opposed to general declines in liquidity levels, sudden spikes in illiquidity seem to have become more common (Adrian et al., 2015a; Adrian, Fleming, Stackman, and Vogt, 2015b). To capture such illiquidity spikes, for each Treasury at each quarter, we define liquidity dry-up events as the days with bid-ask spreads exceeding the top quartile of bid-ask spreads in 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-ups in the same day.[12]

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.

2.5 Summary statistics

Table 1 reports summary statistics. As shown in Panel A, the market size of bond funds has expanded quickly over the time. The number of bond funds increased from 935 in 2002 to 1308 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. As one can see, the average excess return correlation is 6.2% for pairs of Treasuries but is only 1.4% for corporate bonds.

[12]Our results are robust if we define *Common Dry-ups* as a dummy variable that equals one if two Treasuries have experienced liquidity dry-ups in the [-1,1] or [-3,3] window. We have also considered an alternative measure of *Common Dry-ups*. For each Treasury at each quarter, we obtain the top 3/5/10 daily bid-ask spreads within the quarter as liquidity dry-up events. Then, for a pair of Treasuries, *Common Dry-ups* is defined as the percentage of liquidity dry-up events that happen on the same day. Results are very similar to the ones reported in Table 10.

[Table 1 here]

3 Main Result

This section presents our main results. First, we validate that, in our sample, bond funds use Treasuries to manage their liquidity needs (Section 3.1). Second we examine if such flow-induced trading can generate significant non-fundamental price impacts on Treasuries (Section 3.2). Then, we study the relationship between bond funds' ownership and 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 natural experiment. In Section 3.5, we discuss the Treasury market turmoil around the COVID-19 pandemic announcement.

3.1 Liquidity management with Treasuries

We first examine bond funds' liquidity management behavior. This 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. (2017). These studies examine the role of cash and other cash-like securities, and we primarily focus on Treasury positions. We will show later that using Treasuries as a liquidity management tool has important asset pricing implications.

Similar to banks, bond funds perform liquidity transformation and are subject to potential run risk. 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) anytime.[13] This liquidity mismatch between fund shares and the underlying assets can generate strategic complementarity 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 it is widely believed that Treasuries are the most liquid assets and trading them incurs low price impacts. The practice of liquidity management is common not only among bond funds but also among other open-end funds holding

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

illiquid assets (such as bank loan funds and real estate funds) and even commercial banks (e.g., Chen, Goldstein, Huang, and Vashishtha, 2020; Ma, Xiao, and Zeng, 2020).

To verify and quantify liquidity management, we follow Lou (2012) and examine how funds trade Treasuries or corporate bonds in response to fund flows. To illustrate our test design, consider the following simplified example. Suppose that a fund has 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 $8 of corporate bonds and $2 of Treasuries. As a result, the positions in Treasuries and corporate bonds will both decrease by 10%. In other words, the trading-to-flow sensitivity is one on both Treasuries and corporate bonds. In contrast, if the fund wants to avoid large price impacts in liquidating corporate bonds, it will prioritize Treasuries selling in liquidity management and liquid relatively more Treasuries than corporate bonds, say, selling $9 of Treasuries and $1 of corporate bonds. As a result, total holdings of Treasuries will decrease by more than 10% while that of corporate bonds will decrease by less than 10%. In other words, the trading-to-flow sensitivity is larger than one on Treasuries but is smaller than one on corporate bonds.

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. β_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, β_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 supporting evidence that bond funds' trading on Treasuries is more sensitive to fund flows than trading on corporate bonds. On Treasuries, the trading-to-flow sensitivity is larger than one. 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 (β_1) between Treasuries and corporate bonds is consistent with bond funds 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 largely consistent with liquidity management. When funds experience outflows (inflows), they initially liquidate (purchase) excess Treasuries to mitigate the price impacts on illiquid corporate bonds. These trades make bond funds' asset allocation 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 when funds experience 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, Jiang, and Ng (2017)). To differentiate the effects of inflows versus outflows, we define a dummy variable, $Out_{f,q}$, which equals one if $Fund\ Flow_{f,q}$ is negative, and zero otherwise. We include $Out_{f,q}$, $Fund\ Flow_{f,q}$, and their interaction term 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 θ_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 θ_1 is 0.564 (t-statistic = 4.2) for Treasuries.

By comparison, the trading-to-outflow sensitivity on corporate bonds is smaller (see columns (7)–(8)). These results support our argument. That is, when funds experience outflows, they are subject to stronger financial fragility (consistent with the finding in Goldstein et al. (2017)), therefore prioritizing Treasuries in liquidation is urgent to stabilize fund value.[14]

We conduct additional cross-sectional tests to strengthen our argument. 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 more actively. We indeed find supporting evidence in our data (see Appendix Table A3).

In sum, results in this subsection are consistent with our argument that bond funds use Treasuries in liquidity management, and Treasury positions are subject to more flow-induced selling than its corporate bond holdings, especially when bond funds are redeemed by investors.

[14] In Appendix Table A2, we define $Out_{f,q}$ as a dummy variable that equals one when the fund flow is lower than the quarter-median, and zero otherwise, and we find similar results.

3.2 Flow-induced price impact

Based on the result from the previous section, we examine whether the flow-induced trading from bond funds can generate significant price impacts. Following Lou (2012), at the end of each month, we aggregate bond funds' flow-induced purchases and sales onto the Treasury level and scale by the total amount of the Treasury security held by bond funds (denoted as "Flow-induced Trading", or FIT).

To show the asymmetric 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 computed from funds with negative flows, i.e., net selling ($FIT\_Negative$). Given that the trading-to-flow sensitivity is larger for outflows, $FIT\_Negative$ should exhibit a stronger effect than $FIT\_Positive$.

We measure price impact using either excess returns (raw return over risk-free rate) or beta-adjusted returns returns (both in basis points). We conduct the following Fama and MacBeth (1973) regressions to explore the relation between flow-induced trading and Treasury prices:

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

where $Return_{i,t}$ is either the cumulative excess return or the cumulative beta-adjusted return for Treasury i in month t, $FIT_{i,t}$ is the aggregate flow-induced trading intensity for Treasury i in month t, and $X_{i,t}$ is a vector of control variables to capture bond characteristics that are potentially related to the cross-section of Treasury returns. Specifically, *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.

[Table 3 here]

Table 3 shows the results. As shown in column (1), the coefficient of FIT is 4.801 (t-statistic = 3.9). This implies that a one standard deviation increase in FIT is associated with a 4.8 basis point increase in the beta-adjusted return in the contemporaneous month.

We further examine the asymmetric price impacts between inflows and outflows. In column (2), after we decompose FIT into $FIT\_Positive$ and $FIT\_Negative$, we find that the price impact is about two times 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 in the previous subsection. Columns (3) and (4) show that results are similar using excess returns.

[Figure 4 here]

Figure 4 visualizes the effects on Treasuries prices. At the end of each month, we sort all Treasuries into two portfolios: one with negative FIT and the other with positive FIT during the month. We track equal-weighted returns for the two portfolios over the formation month, i.e., [-20, 0], and the subsequent two months, i.e., [1, 40], where $t = 0$ is the portfolio formation day (i.e., month-end). We compute the average 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). Figure 4 shows a contemporaneous flow-induced price pressure during the [-20, 0] window, and subsequent Treasury prices gradually revert back in the subsequent weeks. Such price overshooting pattern around FIT shocks suggests that the fund flow induced demand shocks are non-fundamental.

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 in Section 3.1. Due to such non-fundamental flow-induced trading, the price of Treasuries with high bond funds' ownership should exhibit systematic exposure to fund flow shocks. As mutual funds have become one of the major players in the Treasury market, such exposure becomes an important driving force for Treasury prices. To test such mechanism empirically, we examine whether bond funds' ownership affects return comovement across Treasury pairs. Since the total return variance in the Treasury market, a conventional measure of fragility, is largely affected by the return correlation among individual Treasuries, 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 return comovement, avoiding confounding effects in time-series tests.

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, by focusing on bond funds, our setting can offer unique predictions for Treasuries and corporate bonds. First, as discussed earlier, since bond funds trade Treasuries aggressively to accommodate fund flow shocks, Treasuries with high fund common ownership should exhibit 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 are redeemed. Such excessive downside market comovement can be considered as an indicator of the fragility in Treasury prices. Third, such effect should be weaker for corporate bonds, as funds tend to avoid selling corporate bonds when meeting redemption demands.

To test these hypotheses, we we follow Anton and Polk (2014) and run Fama and MacBeth (1973) regressions to examine the effect of fund common ownership on the Treasury return comovement. [15] The detailed 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

[15] 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), do not involve stylized assumptions on parameter values.

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; *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]

Table 4 reports the results and confirms our conjecture that common ownership positively forecasts comvement among Treasuries. For example, as shown in column (2), the coefficient estimate 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. This is economically meaningful, considering that the average of excess return comovement among Treasuries is 6.2%.

Next, we turn to test the asymmetric pattern, i.e., the effect of common ownership on 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 investor redemption. Intuitively, when the Treasury market declines, bond funds experience fund outflows (see, Brooks, Katz, and Lustig, 2018), and liquidity management is more urgent, leading to a stronger association between common ownership and return comovement in Treasuries.

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 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*. Note that this asymmetry measure has a unique advantage in eliminating 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 Treasuries between downside and upside markets:

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

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 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%.

In comparison, we repeat the same exercises of Table 4 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; *Time-to-maturity Difference* is the absolute difference between two corporate bonds' years-to-maturity. Control variables are also standardized within each quarter. We compute Newey and West (1987) standard errors corrected by serial dependence of three lags.

[Table 5 here]

We have two observations. First, while *Common Ownership* can also significantly forecast 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 excess return correlation between two corporate bonds. Second, more importantly, columns (3) and (4) show that there is no asymmetric effect of *Common Ownership* on return comovement between downside and upside markets for corporate bonds. 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.

Our results are also robust when we use an alternative factor model to calculate risk-adjusted bond returns. Existing studies suggest that Treasury prices are affected by 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 purge out the effects from such fundamental price fluctuations, we consider an extended factor model including 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 our results are robust to the inclusion of these additional factors.

[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 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. 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 predictability in Treasury 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 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 explanation is unlikely to reconcile with the asymmetric pattern on the return comovement among Treasuries, we nonetheless exploit the 2003 mutual fund scandal as a natural experiment to establish a causal link between common ownership and the asymmetric return comovement (*Down-minus-up*) among Treasuries.[16] We choose this setting because the scandal had a negative impact on affected funds' flows from 2003Q4 to 2006Q4 (McCabe, 2009; Anton and Polk, 2014; Koch et al., 2016) but was unlikely to be related to bond fundamentals. 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. These outflows continued from 2003Q4 through 2006Q4. Treasuries heavily owned by scandal funds experienced a significant reduction in fund ownership during the scandal period.

Specifically, we follow Koch et al. (2016) and estimate the following difference-in-differences regression using observations from 2002Q3 to 2010Q4:

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

where $Treat_{i,j}$ is a dummy variable that equals one if a Treasury pair has above-top-quartile common scandal fund ratio. Common scandal fund ratio is the ratio of the total value held by common scandal funds over the total value held by all common funds. $Event_q$ is a dummy variable that equals one for quarters during the scandal period, and zero otherwise. We are interested in the coefficient of the interaction term between $Treat$ and $Event$, which is expected to be negative. 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.

[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, tend to exhibit lower *Down-*

[16] Because our measure of the asymmetry in 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 return comovement.

minus-up during the scandal period.[17] For example, column (4) shows that Treasury pairs heavily held by scandal funds experienced 0.7% lower $Down - minus - up$ during the scandal 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 This result is consistent with our main analysis and provides causal evidence to our hypothesis that fund common ownership can induce fragility in Treasury prices.[18]

3.5 The COVID-19 Treasury market turmoil

In this subsection, we apply our hypothesis to explain 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 experience downward selling pressure and increased price comovement. We find the data are indeed consistent with our conjecture.

On March 11, 2020, the WHO announced that COVID-19 had become a global pandemic.[19] 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 total capital outflow from the bond funds in our sample between March 11 and the end of the month summed up to 4.97% of their pre-event TNA. This pattern is also documented in depth by Falato et al. (2020).

During the same period, March 11 to 31, 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.[20] We make several observations. First,

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[17] In an untabulated test, we show that scandal fund ratio does negatively predicts fund common ownership during the scandal period. This is consistent with the finding in Anton and Polk (2014).

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

[19] "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.

[20] 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.

in the first week of March, both Treasury portfolios experienced similar price increases, plausibly due to the flight-to-safety effect as COVID-19 broke out in Italy and Spain. Starting in the second week of March, 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 before the event. 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, compared to the patterns on Treasuries, the difference of price declines between the two corporate bond portfolios was less significant.

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

$$Corr_{i,j,m} = \alpha + \beta \cdot Treat_{i,j} \times After_m + \theta_1 \cdot Treat_{i,j} + \theta_2 \cdot After_m + \theta_3 \cdot X_{i,j,2019} + \varepsilon_{i,j,m}, \quad (13)$$

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.[21] $After_m$ is a dummy variable that equals one if $Corr_{i,j,m}$ is computed on and after March 11, 2020 (i.e., when $m = 1$), and zero otherwise. $X_{i,j,2019}$ denotes the same set of control variables as in Table 3 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 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 β in Equation (13) to be positive.

Table 8 reports the results. Panel A provides summary statistics, and Panel B reports

[21]Results are robust to using the continuous variable of *Common Ownership* (see Appendix Table A6).

the regressions results of the diff-in-diff analysis. The statistics in Panel A are largely consistent with our conjecture. Specifically, the average *Corr* of Treasury pairs was about 14.2% before the WHO's announcement and increased to 17.8% afterward. By comparison, the average *Corr* of corporate bond pairs remained virtually unchanged.

[Table 8 here]

Panel B of Table 8 reports the results of the diff-in-diff regressions for both Treasuries and corporate bonds. We have several findings. First, Treasuries with high common ownership experienced a larger increase in return comovement than those with low common ownership. For example, as implied in column (2) of Panel B, the average excess return comovement between two Treasuries with low common ownership increased by 1.5% (t-statistic = 5.7) after the pandemic announcement. At the same time, Treasuries with high common ownership experienced a 5.7% increase in return correlation. The difference in increased return comovement between these two groups (i.e., 4.2%) is not only statistically significant (t-statistic = 10.7), but also economically sizable, considering 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 high common ownership barely changed after the pandemic announcement. The corporate bonds with low common ownership experienced a slight decrease in return comovement.

Overall, the patterns documented above are consistent with our hypothesis that the liquidity management practice using Treasuries by bond fund 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 casue this turmoil in the Treasury market (see, Duffie, 2020; Fleming and Ruela, 2020; He, Nagel, and Song, 2020; Schrimpf, Shin, and Sushko, 2020; Kruttli, Monin, Petrasek, and Watugala, 2021). These channels include ours are not exclusive, and more granular data is needed to pin down each channel's contribution to the event. On the other hand, our primary focus lies in the cross section of Treasuries over a longer period, rather than one event, which can help rule out other confounding effects.

4 Further 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 measure inflows and outflows, and examine the their asymmetric price impacts. In Section 4.2, we consider two alternative fragility measures: liquidity co-jumps and skewness.

4.1 Alternative ways to measure inflows and outflows

We provide further support for our argument by exploring the cross-sectional variations in bond funds' flows. As we have shown in Section 3.1, bond funds prefer to liquidate Treasuries to meet redemption when they experience outflows, and thus the trading-to-flow sensitivity on Treasuries is higher for outflows than for inflows. In this section, we use two alternative ways to measure bond funds' inflows and outflows, and examine their asymmetric price impact. The first way is based on the fraction of common funds with fund outflows, and the second is based on well-anticipated times when bond funds are subject to liquidity-related trading (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 β_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 β_2 are significant and positive, which suggest that the effect of fund common ownership on Treasury return comovement is stronger when more common funds experience redemption. On the contrary, we do not observe such a pattern for corporate bonds (see columns (3) and (4)).

Even though our results suggest 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-related trading, that is, month ends. Existing literature shows that there is a strong seasonality in liquidity-motivated trading because of a systematic pre-scheduled event—the clearing of the monthly payment cycle.

Taking advantage of the plausible exogenous seasonality in fund flows, we examine the excess return comovement among Treasuries at 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-day window [t-8, t-4], and month begins as the five-day window [t-1, t+3], where t is the last trading day of each month. For each pair of bonds at each quarter, we calculate the excess return comovement for month ends and month begins, separately. To measure the asymmetry in excess return comovement, we calculate the difference of return comovement between month-ends and month-begins and denote this difference as *End-minus-begin.* After that, we run regressions similar to those in Tables 4 and 5.

Table A7 reports the results. We find that common ownership positively forecasts excess return comovement at month ends and month begins on both the Treasury and corporate bond markets, and the effect is much smaller for corporate bonds. More importantly, common ownership positively forecasts *End-minus-begin* only on Treasuries.

4.2 Liquidity co-jump and return skewness

we consider two alternative fragility measures: liquidity co-jump and return skewness. We first examine liquidity co-jump and measure Treasury securities' liquidity with bid-ask spreads. This is motivated by the observation during recent market-wide events where the most liquid market experienced sudden liquidity dry-ups, such as the "flash rally" in 2014 and the COVID19 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 liquidity commonality in Treasuries over a long period (from 2002 to 2019) and conduct 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-cojumps (see Section 2.4 for detailed definitions). 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 high common ownership tend to experience liquidity dry-ups together. 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 for individual Treasuries. The negative skewness is a widely used measure of the likelihood of price crashes in the literature (Chen et al., 2001; Brunnermeier et al., 2008). Our argument implies that fund ownership can negatively affect return skewness. To test this conjecture, we run Fama-MacBeth regressions where the key independent variable is bond fund ownership (denoted as *Ownership*). 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 reports 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.

We use a similar method as in Section 3.4 to identify the causal relation 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 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 (the ratio of scandal fund ownership of 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). These results are consistent with our main argument and provide further causal evidence on the relation between bond fund ownership and the fragility in Treasury prices.

5 Conclusion

In recent years, the U.S. Treasury market—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 whether the liquidity management practices can transmit the non-fundamental demand shocks from fund flows into Treasuries and lead to fragility. We have several empirical findings to support our argument. First, we document that bond funds actively trade Treasuries to manage their liquidity needs, as 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 in the presence of large redemption. Second, flow-induced trading can have significant contemporaneous price impacts on Treasuries followed by subsequent reversal, suggesting that the demand shocks arising from fund flows are largely non-fundamental. Third, bond fund ownership can lead to the increased fragility in Treasury prices. That is, Treasuries that are commonly owned by bond funds tend to comove more in prices, and this pattern is stronger during downside markets. The results are robust to 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 relationship between common ownership and Treasury return comovement. Finally, we extend our analyses to help explain the recent Treasury market turmoil around the COVID-19 pandemic announcement.

We are well aware that the economic magnitude we document in this study could not perfectly match what happened in the "flash rally" and the COVID-19 crisis. This is because our sample only includes U.S. open-end bond mutual funds. However, 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. Thus, 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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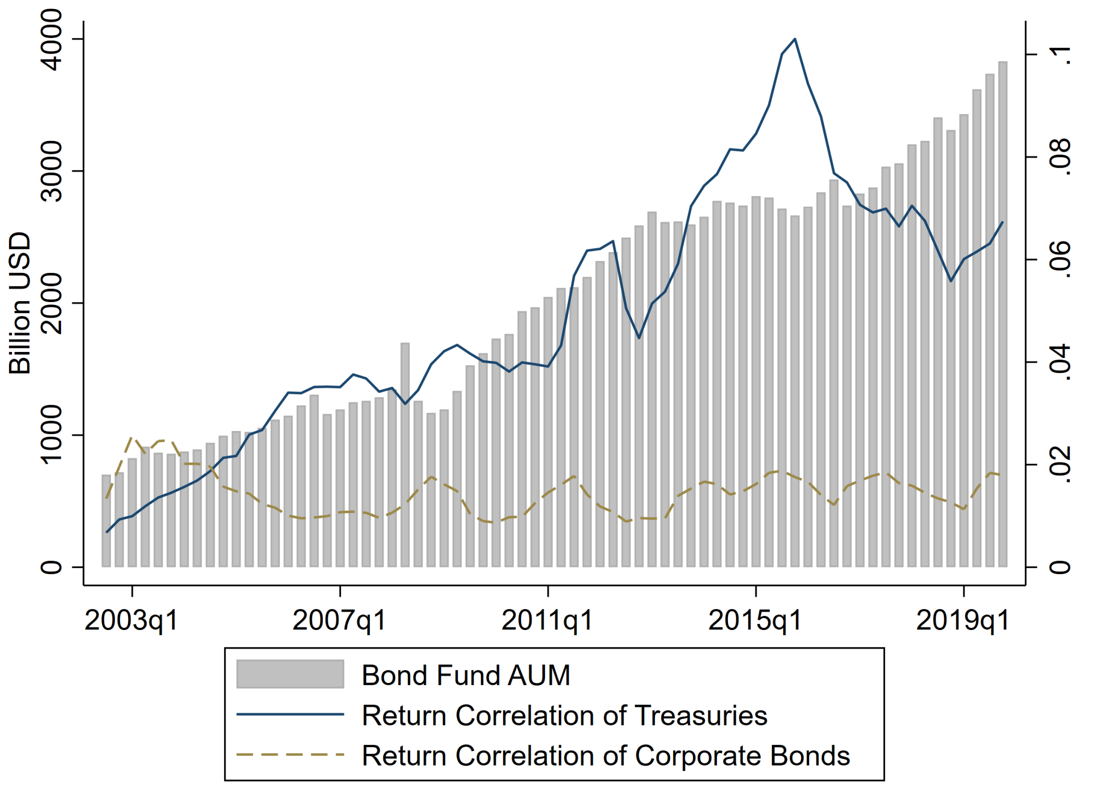
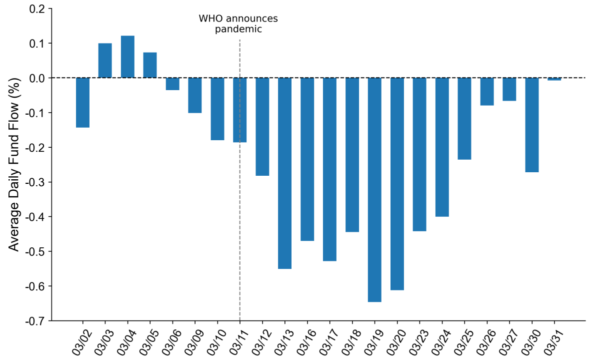
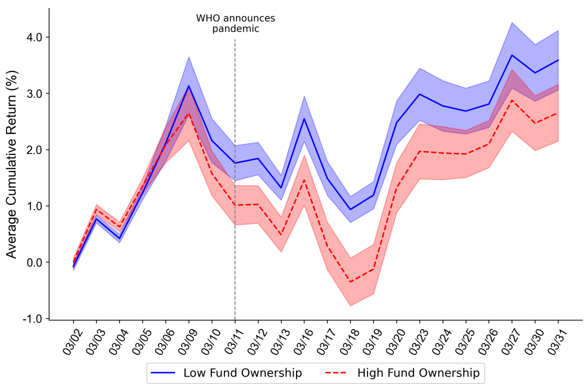


Figure 1. Return comovement in the Treasury and corporate bond markets

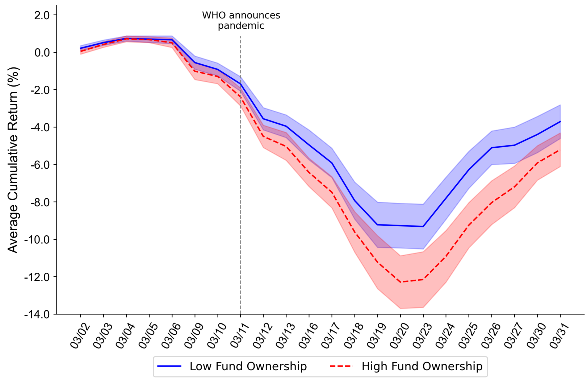
This figure plots the time-series average of excess return correlations among Treasuries (solid blue line) and corporate bonds (dashed yellow line) from 2002Q3 to 2019Q4, as well as the total assets under management from all bond funds (bar, in billion USD). Daily risk-adjusted returns are computed as the residuals from a regression model that includes daily average returns on all Treasuries, investment-grade corporate bonds, junk bonds, and their two lags.



(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 (%) of Treasury portfolios sorted by bond fund ownership, and (c) the cumulative returns (%) of corporate bond portfolios sorted by bond fund ownership in March 2020. The vertical line represents the WHO pandemic announcement date, March 11, 2020. Bond fund ownership equals the fraction of bond shares owned by bond funds and is calculated at the end of 2019. Since fund ownership varies across bonds' maturity, 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.

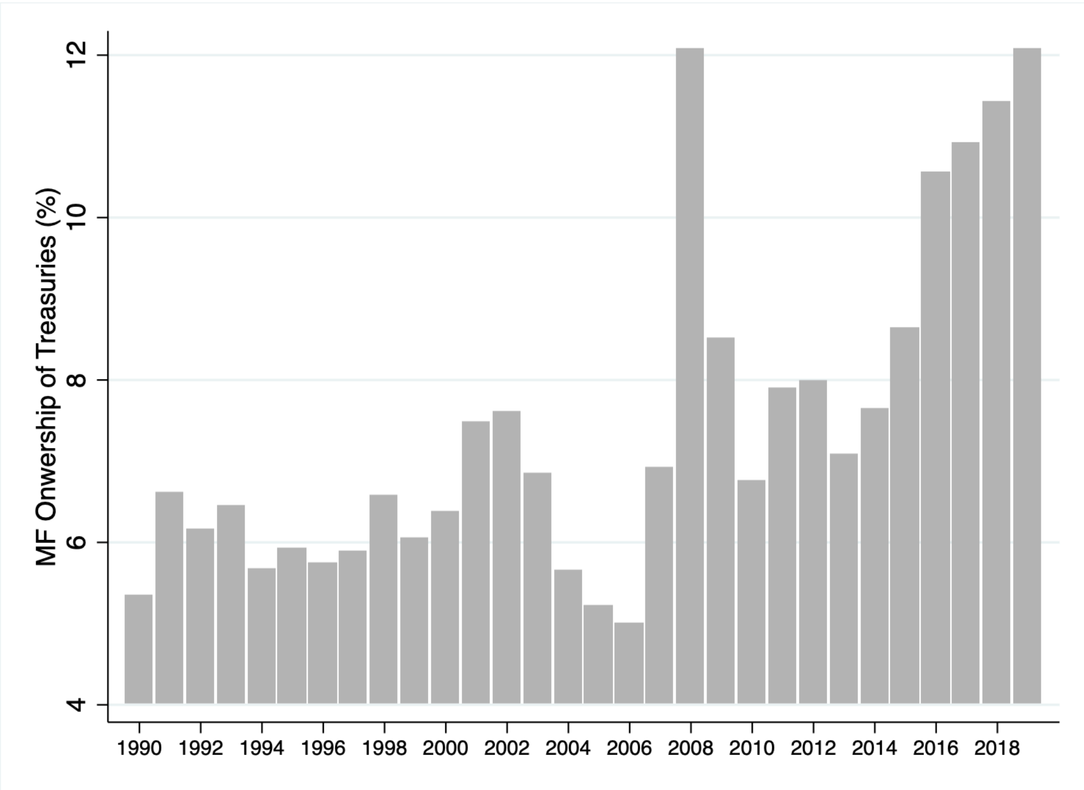


Figure 3. Mutual Fund Total Ownership of Treasuries

This figure plots the time-series of total ownership of Treasuries (in %) from all mutual funds and money market funds between 1990 and 2019. Data is from Federal Reserve Flow of Funds (Z1).

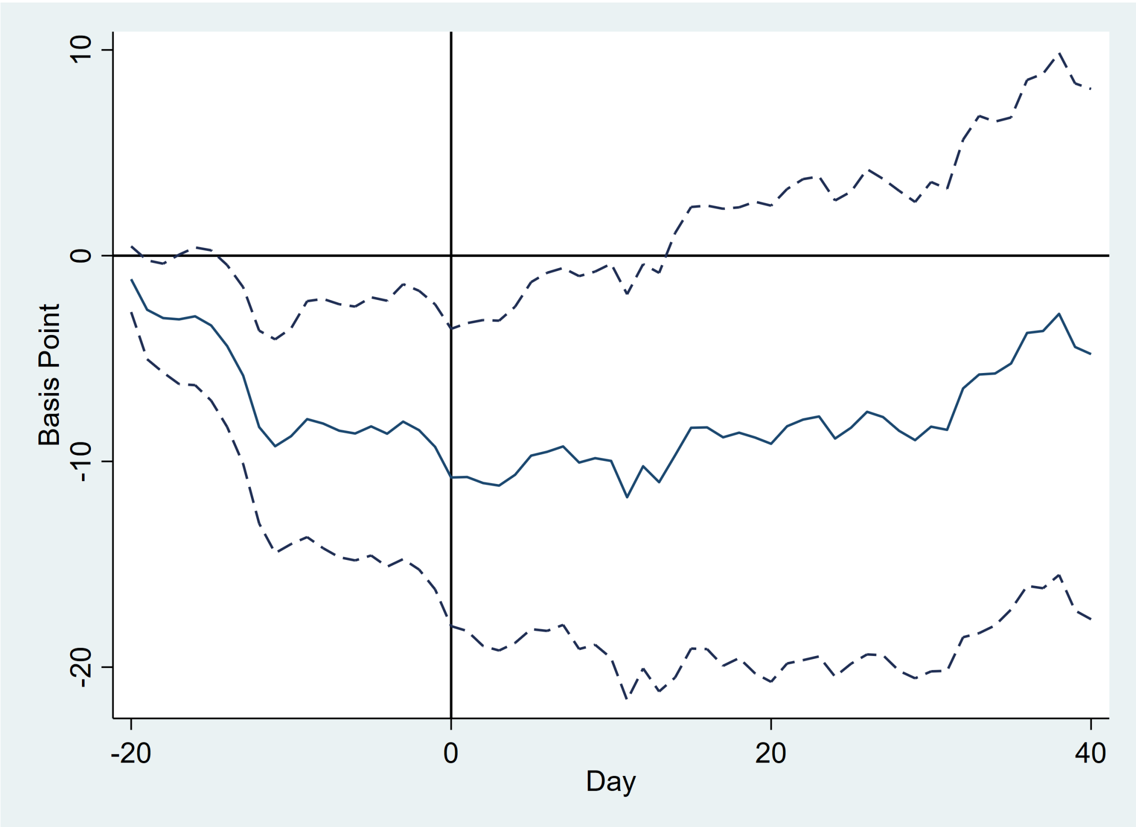


Figure 4. Funds' Flow-induced Trading Impact on Treasury Prices

This figure plots bond funds' aggregate flow-induced trading impact on treasury returns (in basis points). At the end of each month, we compute an aggregate measure of flow-induced trading (FIT) across all mutual funds for each Treasury using holding details from the most recent quarter. Then we sort all Treasuries into two portfolios: one with negative FIT and the other with positive FIT. We compute equal-weighted returns for these two portfolios over the [-20, 40] window, where t=0 is the portfolio formation day (i.e., month-end). We plot the average difference in the cumulative returns between these two portfolios (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 of our sample. Panel A reports the summary statistics of bond funds, while Panel B reports the summary statistics for Treasuries and corporate bonds, respectively. *Corr* is the excess return correlation between two securities in a quarter. To measure the asymmetry in return comovement during downside and upside markets, 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*. *# of Common Funds* is the number of funds holding a pair of securities. These funds are 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 on-the-run status. *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 in the same day. *Excess return* is the monthly Treasury return in excess of risk-free rate, quoted in basis points. *Beta-adjusted return* is the residual Treasury monthly return obtained from the factor model, also quoted in basis points. *FIT* is the monthly aggregate flow-induced trading across all bond funds for each Treasury. We further decompose *FIT* into *FIT_Positive* and *FIT_Negative* based on inflows and outflows. *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	p10	p25	p50	p75	p90	N
(a) Treasuries								
Corr	0.062	0.421	-0.481	-0.218	0.027	0.316	0.703	2,185,735
Down-minus-up	0.003	0.322	-0.407	-0.199	-0.004	0.204	0.418	2,185,735
# of Common Funds	7.452	7.417	0.000	2.000	6.000	11.000	16.000	2,185,735
Common Ownership	0.014	0.018	0.000	0.001	0.009	0.021	0.033	2,185,735
On-the-run Difference	0.200	0.400	0.000	0.000	0.000	0.000	1.000	2,185,735
Coupon Rate Difference	2.229	2.093	0.250	0.625	1.500	3.125	5.500	2,185,735
Time-to-maturity Difference	7.354	7.837	0.581	1.581	3.962	10.721	21.521	2,185,735
Common Dry-ups	0.257	0.482	0.000	0.000	0.000	1.000	1.000	2,185,735
Excess return (in *bp*)	34.839	170.849	-90.459	-13.661	3.478	69.434	208.198	57,521
Beta-adjusted return (in *bp*)	-0.680	106.082	-98.977	-32.335	-0.727	24.812	102.125	57,521
FIT	0.005	0.022	-0.013	-0.003	0.005	0.013	0.022	57,521
FIT_pos	0.013	0.017	0.002	0.005	0.010	0.016	0.025	57,521
FIT_neg	-0.008	0.012	-0.018	-0.010	-0.004	-0.002	-0.001	57,521
On-the-run	0.177	0.382	0.000	0.000	0.000	0.000	1.000	57,521
Coupon Rate	3.099	2.618	0.125	1.250	2.375	4.375	6.875	57,521
Time-to-maturity	6.266	7.408	0.414	1.329	3.540	7.627	18.890	57,521
Skewness	1.101	2.281	-0.830	-0.357	0.133	2.356	5.105	16,477
(b) Corporate Bonds								
Corr	0.014	0.159	-0.178	-0.087	0.009	0.107	0.206	11,528,871
Down-minus-up	0.000	0.256	-0.325	-0.170	0.000	0.169	0.324	11,528,871
# of Common Funds	1.960	3.055	0.000	0.000	1.000	3.000	6.000	11,528,871
Common Ownership	0.010	0.021	0.000	0.000	0.000	0.013	0.032	11,528,871
Liquidity Difference	0.187	0.174	0.016	0.048	0.143	0.281	0.422	11,528,871
Coupon Rate Difference	2.043	1.598	0.275	0.750	1.680	3.000	4.350	11,528,871
Rating Difference	3.678	3.463	0.000	1.000	3.000	5.000	8.000	11,528,871
Time-to-maturity Difference	6.069	8.019	0.471	1.293	3.219	7.419	16.827	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. $Out_{f,q}$ 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. At the end of each month, we compute an aggregate measure of flow-induced trading (*FIT*) across all mutual funds for each Treasury using holding details from the most recent quarter. We further decompose *FIT* into two components: one computed from funds with positive flows (*FIT_Positive*), and the other computed from funds with negative flows (*FIT_Negative*). Beta-adjusted returns in month t are adjusted returns using beta estimated from a factor model in the past three months, which includes returns from the Treasury market, investment-grade bonds, and junk bonds. *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 2002Q3 to 2019Q4.

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. To measure the asymmetry in return comovement during downside and upside markets, 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* 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 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	0.103***	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. To measure the asymmetry in return comovement during downside and upside markets, 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* 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 $q-1$. We consider the following additional factors when computing risk-adjusted returns: *VIX*, *TERM*, and *DEF*. *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. To measure the asymmetry in return comovement during downside and upside markets, 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* 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. Natural Experiment: Mutual Fund Scandal

This table reports the results from difference-in-differences regressions based on the 2003 mutual fund scandal. First, for each pair of Treasuries, we compute common scandal fund ratio 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. We define a dummy variable, $Treat$, that equals one if a Treasury pair has above-top-quartile common scandal fund ratio. *Event* is a dummy variable that equals one during the scandal period, and zero otherwise. Control variables are the same as in Table 4. We control for year-quarter dummies in the regressions. 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 both before and after March 11, 2020 within the first quarter of 2020. Panel B reports the results from difference-in-difference 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 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. We define common funds for a security pair as the bond funds that hold both of the securities in the pair. *Common Ownership* is the proportion of total market value of a security pair held by all common funds 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 among Treasuries and Skewness for Individual 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), 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. $Common\ Ownership$ 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. 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. 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 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.

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
Down-minus-up	To measure the asymmetry in return comovement during downside and upside markets, 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 mutual funds for each Treasury using holding details from the most recent quarter.
FIT_Positive	The monthly aggregate flow-induced trading across all mutual funds with positive fund inflows for each Treasury.
FIT_Negative	The monthly aggregate flow-induced trading across all mutual 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 for 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 when 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 adjusted for heteroscedasticity and clustered by fund and quarter. t-statistics are reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively. The sample is from 2002Q3 to 2019Q4.

DepVar:	$Net\ Buy_{f,q}$			
	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 and liquid funds. 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. Columns (1)–(2) report the results for illiquid funds, while columns (3)–(4) report the results for 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 when 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 adjusted for heteroscedasticity and clustered by fund and quarter. 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. To measure the asymmetry in return comovement during downside and upside markets, 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* 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. To measure the asymmetry in return comovement during downside and upside markets, 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*. *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 ordinary least squares results based on the COVID-19 outbreak in 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), the excess return correlation for a pair of securities is computed before March 11th in the first quarter of 2020. In columns (3)–(4), the excess return correlation for a pair of securities is computed after March 11 in the first quarter of 2020. To examine the asymmetry in return comovement, for each pair of securities, we take the difference in the excess return correlations after and before the pandemic announcement. We denote this difference as *After-minus-before. 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 Begin.

This table reports the results from Fama-Macbeth regressions of a security pair's excess return comovement on common ownership during month end and month begin, for Treasuries (Panel A) and corporate bonds (Panel B). Following Etula, Rinne, Suominen, and Vaittinen (2020), we define month end as the five-day window [t-8,t-4], and month begin as the five-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), the excess return correlation of a pair of securities is computed at month-ends in a quarter. In columns (3)–(4), the excess return correlation of a pair of securities is computed at month-begins in a quarter. To examine the asymmetry in return comovement, for each pair of securities, we take the difference in the excess return correlations between month ends and month begins. We denote this difference as *End-minus-begin*. *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-begin	
Timing:	Month end		Month begin			
	(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-begin	
Timing:	Month end		Month begin			
	(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