

# Mutual Fund Liquidity Transformation and Reverse Flight to Liquidity\*

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## **Abstract**

We identify fixed-income mutual funds as an important contributor to the unusually high selling pressure in liquid asset markets during the Covid-19 crisis. We show that mutual funds experienced pronounced investor outflows amplified by their liquidity transformation. In meeting redemptions, funds followed a pecking order by first selling their liquid assets, including Treasuries and high-quality corporate bonds, which generated the most concentrated selling pressure in these markets. Overall, the estimated price impact of mutual funds was sizable at a third of the increase in Treasury yields and a quarter of the increase in corporate bond yields in the Covid-19 crisis. (*JEL E50 G01 G12 G23*)

Conventional wisdom suggests that high-quality liquid assets usually experience net *buying* pressures during crises, i.e., flight to liquidity (Longstaff, 2004, Vayanos, 2004). However, the Covid-19 crisis is characterized by a “reverse flight to liquidity” phenomenon, where high-quality liquid assets experienced net *selling* pressures.<sup>1</sup> In March 2020, pronounced liquidations emerged in both Treasuries and investment-grade corporate bonds, resulting in large asset price movements in these markets that cannot be explained by their economic fundamentals per se.

These puzzling behavior sparked a fast-growing body of research. Most existing work has focused on the dealer side, explaining why dealers did not more forcefully lean against the wind in Treasury markets (Duffie, 2020, He, Nagel, and Song, 2022) and corporate bond markets (Kargar et al., 2021, O’Hara and Zhou, 2021). At the same time, the origins of the selling pressure are equally important to understand. Why was there such pronounced selling pressure in liquid asset markets during a major episode of market distress like the Covid-19 crisis?

In this paper, we provide an explanation for the disruptions in liquid asset markets during the Covid-19 crisis by tracing the net selling pressure to fixed-income mutual funds. We find that fixed-income mutual funds suffered unprecedented outflows in response to the shock to economic fundamentals in March 2020 because their transformation of illiquid assets into demandable fund shares triggered and amplified investors’ incentives to withdraw. In meeting redemption requests, bond funds followed a pecking order of liquidation by first selling their most liquid assets before more illiquid ones. This is why the pronounced outflows generated concentrated selling pressure in liquid asset markets on days of market distress.

In aggregate, the open-end mutual fund sector sold \$236 billion in Treasuries in the first quarter of 2020 — the highest amongst financial institutions — and contributed about one-third of the total sales in Treasuries in that quarter.<sup>2</sup> Highly-rated corporate bonds also

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<sup>1</sup>Our notion of reverse flight to liquidity means that the usual net buying pressure in liquid assets during market distress is reversed to a net selling pressure. It does not speak to whether the level of illiquidity in traditionally liquid assets eventually exceeds that of traditionally illiquid assets during market distress.

<sup>2</sup>The largest sellers of Treasuries in 2020Q1 include foreign investors (\$287 billion), mutual funds (\$236 billion), and households/hedge funds (\$171 billion).

ranked high in the pecking order of liquidation and were sold off in larger volumes than high-yield ones. The estimated aggregate price impact of the mutual fund sector was sizable at a third of the overall increase in Treasury yields and a quarter of the overall increase in corporate bond yields.

The aggregate impact of mutual funds during the Covid-19 crisis arose in part because of the sector's explosive growth in the past decade. From 2007 to 2019, the assets under management of fixed-income mutual funds have more than tripled from less than \$1.5 trillion to \$4.5 trillion. By issuing demandable and liquid claims against illiquid corporate bonds, fixed-income mutual funds have also increasingly engaged in liquidity transformation (Ma, Xiao and Zeng, 2019). This trend is unlikely to reverse itself so that tracing out the behavior of fixed-income funds during the Covid-19 crisis is essential for understanding potential disruptions to liquid asset markets going forward. In fact, if funds deplete their liquidity buffers, disruptions may further spill over to illiquid asset markets and cause widespread distress in the financial system.

We use granular bond-fund-level data to identify the intricate relationship between mutual fund liquidity transformation and the disruptions in liquid asset markets during the Covid-19 crisis. First, we find that outflows were more pronounced at fixed-income funds that invest in more illiquid assets and engage in more liquidity transformation. Overall, funds specializing in more illiquid asset classes such as bank loan funds and high-yield corporate bond funds experienced larger outflows than investment-grade and government bond funds.<sup>3</sup>

Second, we verify that it was the most liquid assets in bond funds' portfolios that were more likely to be sold in meeting investor redemptions. We first estimate the liquidation-to-outflow sensitivity by regressing bond-fund level liquidations against outflows at their

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<sup>3</sup>Fund liquidity transformation could be correlated with other fund characteristics, such as differences in asset riskiness and volatility. To isolate the effect of fund liquidity transformation, we control for a range of fund characteristics and fund-type fixed effects to find that a one standard deviation increase in fund-level liquidity transformation before the Covid-19 crisis led to a 0.82% increase in fund outflows in March 2020. The economic impact of liquidity transformation on fund outflows is also amongst the highest across all other observable fund characteristics.

corresponding funds in March 2020. We find that Treasury securities were more likely to be liquidated than corporate bonds. Within Treasuries, on-the-run Treasuries have higher liquidation-to-outflow sensitivities than off-the-run Treasuries. Within corporate bonds, highly-rated corporate bonds have higher liquidation-to-outflow sensitivities than high-yield bonds. These findings are consistent with funds following a pecking order to meet redemption requests.

The pecking order of liquidation implies that the likelihood for a fund to sell a given bond not only depends on the liquidity of that bond but also on the relative liquidity of the fund's other assets. For example, an investment-grade bond held by a high-yield fund could be amongst the first assets to be sold, while the same bond held by an investment-grade fund may come much later in the pecking order. To more precisely capture the relative liquidity of a bond within a fund's portfolio, we define the liquidation rank for a bond in a fund's portfolio as the share of more liquid bonds held by the same fund. We find that a bond ranked at the bottom of the pecking order of actively managed funds has a liquidation-to-outflow sensitivity of 0.21, whereas the same bond at the top of the pecking order has a liquidation-to-outflow sensitivity of 0.59. This confirms that actively managed funds follow the pecking order. For bonds held by open-end passive funds, however, the difference in liquidation-to-outflow sensitivities between liquid and illiquid bonds is statistically insignificant, showing that their passive nature constrains the use of the pecking order. Note that our results are not driven by bond-specific differences because we identify the effect of liquidation rank by comparing the liquidation-to-outflow sensitivities of the same bond in different fund portfolios.

In the third step, we show that pronounced fund outflows contributed to the price pressure observed in fixed-income markets during the Covid-19 crisis. We first examine the effect of fund outflows on bond returns by regressing daily bond returns on imputed outflows for the same bond. We calculate daily imputed outflows as the weighted average of daily outflows at funds holding the bond as of 2019Q4 and remove time-varying common exposures at the issuer, rating, and maturity-bucket level. Our findings confirm that mutual fund outflows depressed returns for off-the-run Treasury bonds and corporate bonds.

We further develop a novel measure of liquidation-adjusted outflow (LAO) that incorporates the empirical pecking order of liquidations into imputed outflows. To calculate the LAO, we first multiply daily fund-level outflows by the estimated liquidation-to-outflow sensitivity corresponding to the liquidation rank of the bond and then average the adjusted outflows at the bond level. The LAO is more effective than imputed outflows at capturing price impact by bond funds because it captures how outflows are converted into actual liquidations through empirically estimated fund liquidation policies. Compared to corporate bonds with the same issuer, maturity, and rating, a 1% increase in LAO corresponds to a 4.57 basis point drop in daily returns, which is more than double that for a 1% increase in imputed outflows. Similarly, for off-the-run Treasury bonds within the same maturity bucket, a 1% increase in LAO corresponds to a 3.16 basis point drop in daily returns, which is more than three times that for a 1% increase in imputed outflows.

After showing that the outflow-induced liquidations follow a pecking order and affected asset prices, we proceed to quantify the importance of mutual funds in shaping the aggregate asset price movements during the Covid-19 crisis. In the first exercise, we project the counterfactual bond yields in the absence of mutual fund ownership by first running a daily regression of bond yields on pre-Covid-19 mutual fund ownership and then setting the mutual fund ownership to zero. Compared to the observed yields, we find that the median Treasury and investment-grade corporate bond yield would have been 26 and 42 basis points lower in the absence of mutual fund ownership. These magnitudes amount to one-third of the overall increase in Treasury yields and one-quarter of the overall increase in investment-grade corporate bond yields during the Covid-19 crisis.

In the second quantification exercise, we use the Granular Instrumental Variables (GIV) approach developed by [Gabaix and Koijen \(2020, 2021\)](#) to estimate the aggregate price impact of the mutual fund sector. Intuitively, the GIV isolates idiosyncratic shocks of large sectors to trace out how much aggregate market price move in response to a 1% outflow of the market. Applying the GIV to the Treasury bond market, which was particularly strained in March 2020, we find that a 1% outflow decreases the 20-year Treasury bond price

by 173 basis points at the aggregate level. Since mutual funds sold 2.6% of Treasury bonds in the 2020Q1, their overall price impact amounts to 22.6 basis points.<sup>4</sup> This magnitude is economically important at about one-third of the overall increase in Treasury bond yields during the Covid-19 crisis.<sup>5</sup>

Our findings bear important policy implications. As liquidity transformation is increasingly performed by non-bank financial intermediaries like bond mutual funds, liquid asset markets may become more subject to strains from the concentrated sale of non-bank intermediaries' liquid buffers. These strains could disrupt key functions that liquid asset markets provide for the financial system, such as serving as collateral in funding markets and providing a benchmark for pricing and hedging other fixed-income securities. Central bank interventions that target non-bank intermediaries may become essential for stabilizing liquid asset markets going forward.

**Related Literature.** We show that liquidity transformation by fixed-income mutual funds contributed to the aggregate selling pressure straining liquid asset markets during the Covid-19 crisis. A number of papers have identified debt market disruptions during the Covid-19 crisis, including [Fleming and Ruela \(2020\)](#) for Treasuries, [Haddad, Moreira, and Muir \(2021\)](#) for corporate bonds, [Chen, Liu, Sarkar and Song \(2020\)](#) for mortgage-backed securities, and [Li, O'Hara and Zhou \(2021\)](#) for municipal bonds. [Liang \(2020\)](#) and [Vissing-Jorgensen \(forthcoming\)](#) provide reviews on the debt market developments and their potential mechanisms. In explaining these disruptions, [Duffie \(2020\)](#) and [He, Nagel, and Song \(2022\)](#) show that dealers' balance sheet constraints limited their ability to absorb the heightened selling pressure in long-term Treasury bond markets. [Kargar et al. \(2021\)](#) and [O'Hara and Zhou \(2021\)](#) show that dealer balance sheet constraints and the resulting shift from principal to agency trading has contributed to corporate bond illiquidity. We analyze a complementary channel by identifying bond mutual funds as an important seller of both Treasuries and high-quality corporate bonds. Relatedly, [Schrimpf, Shin and Sushko \(2020\)](#)

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<sup>4</sup>This magnitude is obtained by converting the change in bond price of 173 basis points into yields, which is 8.7 basis points at the 20-year maturity. Then, the total price impact is calculated as  $2.6 \times 8.7 = 22.6$  basis points.

<sup>5</sup>The 20-year Treasury yield increased by 69 basis points from March 9, 2020 to March 19, 2020.

and [Kruttli, Monin, Petrasek and Watugala \(2021\)](#) point to hedge funds as another source of selling pressure in Treasury markets.

More generally, we contribute to the mutual fund literature by unveiling the implications of mutual fund liquidity transformation in the Covid-19 crisis, which marks the first systematic crisis episode since bond funds have become a major player in financial markets. In an earlier study, [Feroi, Kashyap, Schoenholtz and Shin \(2014\)](#) explore the financial stability implications of unlevered investors and find a feedback loop between open-end mutual fund outflows and declined asset prices. Regarding the economic mechanism, most closely related to ours is [Chernenko and Sunderam \(2017\)](#), who show that mutual funds deploy cash as a liquidity buffer in meeting redemptions during normal times. We generalize their message by showing that in a system-wide crisis, outflows from bond funds can further lead to concentrated liquidations of Treasuries and high-quality corporate bonds. The amplification effect of fund liquidity transformation on fund outflows during the Covid-19 crisis is also consistent with [Chen, Goldstein and Jiang \(2010\)](#) and [Goldstein, Jiang and Ng \(2017\)](#), who show that the flow-to-performance relationship is more concave at more illiquid funds in normal times. [Falato, Goldstein and Hortacsu \(2021\)](#) zoom in on the various sources of outflow fragilities in bond funds during the Covid-19 crisis. Our paper differs by focusing on the asset pricing implications of funds' liquidity transformation and liquidation policies. By providing new evidence during a system-wide crisis that funds sold more liquid assets before more illiquid ones, we also inform the debate on mutual funds' liquidation policies, in which [Chernenko and Sunderam \(2017\)](#) show that funds first use cash to meet redemptions, while [Jiang, Li and Wang \(2021\)](#) suggest that the order of liquidation varies with the degree of market uncertainty.<sup>6</sup> Further, our finding that mutual funds' price impact was concentrated in liquid assets during the Covid-19 crisis can be reconciled with [Choi, Hoseinzade, Shin](#)

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<sup>6</sup>Specifically, using a sample from 2002 to 2014, [Jiang, Li and Wang \(2021\)](#) find evidence in line with the pecking order when market uncertainty is low. When market uncertainty is high, as measured by a higher VIX index, they show that bond funds no longer following the pecking order and liquidate assets proportionally. Please refer to Section 3.1 for a discussion on the potential reasons for why the pecking order was followed during the market distress of the Covid-19 crisis. We further differ from their paper by jointly analyzing the determinants of fund flows and the price impacts on liquid assets such as Treasury and high-quality corporate bonds.

and [Tehrani \(2020\)](#), who find limited price impact by mutual funds on illiquid assets in normal times, [Jiang, Li, Sun, and Wang \(2022\)](#), who show that bonds held by mutual funds with more illiquid assets are more fragile, and [Huang, Jiang, Liu and Liu \(2021\)](#), who show that Treasury securities that are more commonly held by bond funds exhibit higher return comovement.

Finally, our paper adds to the literature examining the price impact of mutual fund flow-driven trading ([Coval and Stafford, 2007](#), [Frazzini and Lamont, 2008](#), [Lou, 2012](#)). We develop a novel liquidation-adjusted outflow (LAO) measure, which incorporates the empirically observed liquidation policy of bond funds into the imputation of outflows. This methodological innovation allows us to pinpoint both the flow-driven and the liquidation-policy-driven aspect of bond funds' effect on asset prices and may be useful for future studies exploring the asset pricing implications of fixed-income mutual funds. More broadly, the price impact of the bond mutual fund sector relates to the recent literature on how asset demand decisions of financial institutions affect asset prices ([Koijen and Yogo, 2019](#), [Koijen, Richmond, and Yogo, 2020](#)).

The remainder of the paper is arranged as follows. [Section 1](#) describes the data we use and [Section 2](#) explores aggregate trends in asset prices and the behavior of bond funds in the Covid-19 pandemic. [Section 3](#) uses fund-bond-level variation to verify mutual funds' liquidation policy in meeting pronounced outflows and confirms their price impact. [Section 3](#) also provides a simple quantification of the aggregate price impact of the mutual fund sector on liquid asset markets. Finally, [Section 4](#) concludes.

## 1 Data

This section introduces the main datasets that we use in our analysis.

**Mutual fund data.** We use the CRSP Mutual Fund Database to create a sample of US open-end fixed-income mutual funds. For each fund, we observe its daily portfolio returns, monthly flows, and monthly securities holdings. We complement the CRSP database with

the daily fund flows and NAV information from the Morningstar database. Our sample contains 6,356 unique share classes and 1,942 funds.

The upper panel of Table 1 presents summary statistics of the bond fund sample as of March 2020. The average return in March is -5.8%. The average outflow is 2.55% with a large cross-sectional dispersion: outflows at the 90th percentile reached 12.7%. Outflows are also significantly larger at larger funds, with the weighted average of outflows reaching 4.8%.

**Security-level data.** We obtain daily security-level data on prices of Treasury and corporate bonds from the CRSP US Treasury Database and TRACE. We further use TRACE data to calculate the proportion of zero trading days for corporate bonds. We obtain characteristics of corporate bonds such as maturity and ratings from the Mergent-FISD Database. The lower panel of Table 1 presents the security-level summary statistics.

**Aggregate data.** We obtain quarterly sector-level asset holdings and flows from the Flow of Funds (FoF). Flows are differences in levels adjusted for valuation effects. We further obtain the outstanding amount and trading volume for different types of securities from the Securities Industry and Financial Markets Association (SIFMA). Regarding aggregate asset prices, we use interest swap rates, sovereign CDS spreads, and corporate CDS spreads retrieved from Bloomberg, zero-coupon Treasury yields constructed by [Grkaynak, Sack, and Wright \(2007\)](#), Moody’s Seasoned Aaa and Baa Corporate Bond Yields, and the ICE BofA US High Yield Index Effective Yield.

## 2 Aggregate Trends

We begin by looking at asset prices and the overall behavior of the fixed-income mutual fund sector in the first half of 2020, focusing on the developments in March and April.

## 2.1 Asset Market Disruptions

Generally, safe and liquid assets like US Treasuries are thought to be in demand during crisis periods that are marked by high market volatility. For example, during the 2008 financial crisis, Treasury yields dropped on days when market volatility surged (see Figure 1). In contrast, Treasury markets during the Covid-19 crisis experienced disruptions from a heightened pressure to sell rather than to buy. From the blue dots in the top panel of Figure 1, we see that the relationship between Treasury yields and VIX remains negative in January and February of 2020, which was before the widespread global spread of the pandemic. Starting in March and lasting through April, however, the relationship reversed (see also [He, Nagel, and Song \(2022\)](#)). Days on which market volatility was higher also had higher Treasury yields (red dots). This trend implies that worsening economic conditions and volatility coincided with a higher pressure to sell Treasuries, which depressed Treasury prices and led to a surge in Treasury yields.

To confirm that the observed phenomenon was driven by heightened selling pressure, we analyze the behavior of the CDS-adjusted Treasury swap spread. This spread is calculated by subtracting the Treasury yield from the sum of the interest swap rate and the US sovereign CDS rate of the same maturity. From the upper panel of Figure 2, we see that the CDS-adjusted Treasury swap spread dropped significantly in the first half of March, which means that Treasury yields spiked to levels beyond what interest rate risk and credit risk could explain with the onset of the Covid-19 crisis in the US. This trend is consistent with the presence of net selling pressure in Treasury markets. The pressure to sell Treasuries was so high that the volatility in 30-year Treasury bonds, which is an indicator for market strains, increased by 10% within the first half of March as shown in the lower panel of Figure 2. Other Treasury market indicators also revealed strains during this time, as shown by [Fleming and Ruela \(2020\)](#).

Corporate bond markets also experienced liquidity strains well beyond what fundamentals can explain. [Haddad, Moreira, and Muir \(2021\)](#) document strains in the corporate bond market during the Covid-19 crisis by showing that corporate bonds, particularly investment-

grade bonds, traded at a discount to their credit default swaps (CDS). Following their approach, we also plot the evolution of the CDS-bond basis in the upper panel of Figure 3. The CDS-bond basis, which is the difference between the CDS spread and the bond spread, plunged drastically from a stable -10 basis points to below -35 basis points for both high-yield and investment-grade bonds. The divergence between CDS and corporate bond spreads indicates that although corporate default risk increased, it cannot account for the overall increase in corporate bond spreads, which suggests that corporate bonds faced heightened selling pressure. In particular, Figure 3 shows the pronounced widening of the CDS-bond basis even for the more liquid investment-grade bonds, consistent with the findings in Haddad, Moreira, and Muir (2021).

Taken together, there was a net pressure to sell rather than to buy liquid assets during the Covid-19 crisis. As we will show, the selling pressure for Treasuries and high-quality corporate bonds were intricately related because both are held as liquid asset buffers by fixed-income mutual funds.

## 2.2 Mutual Fund Outflows and Liquidations

We argue that the fixed-income mutual fund sector contributed a large part to the concentrated sales in traditionally liquid asset markets during the Covid-19 crisis. This sector has experienced an explosive growth spurt over the past decades with the total asset size increasing from less than \$1 trillion in 2000 to more than \$4.5 trillion by the end of 2019 (Internet Appendix Figure IA.1). At the same time, fixed-income mutual funds have increasingly engaged in liquidity transformation (Ma, Xiao and Zeng, 2019). They have become one of the most important intermediaries investing in corporate bonds, holding more than 20% of all outstanding corporate bonds in 2019. In other words, fixed-income mutual funds had, for the first time, become a significant player in the US financial system at the onset of the Covid-19 recession.

At the same time, bond funds suffered unprecedented outflows during the Covid-19 crisis. In March 2020, they lost an unprecedented \$264 billion of assets under management (Figure 4). In comparison, equity funds, whose assets were also exposed to the worsening economic fundamentals but are more liquid than corporate bonds, were subject to much smaller outflows (Internet Appendix Figure IA.2). This is consistent with Pastor and Vorsatz (2020) who find that “the [active equity fund] outflows are faster than their long-term trends, but the difference is not dramatic.” The difference in outflows between equity and fixed-income funds is consistent with the transformation of illiquid assets into liquid fund shares being the amplifier of fund outflows.

The amplifying effect of asset illiquidity on outflows is also confirmed by the behavior of different types of fixed-income funds. Before intervention by the Federal Reserve, cumulative outflows increase in magnitude from government bond funds to corporate bond funds to loan funds. Quantitatively, cumulative outflows at investment-grade, high-yield, and loan funds averaged 1.6%, 5.6%, and 11.6% from January 1, 2020 to March 15, 2020 (Figure 5).

However, if funds had liquidated assets proportionately to meet redemptions, larger outflows at funds holding more-illiquid assets would suggest the sale of more illiquid assets. Rather, we find that fixed-income funds disproportionately sold the most liquid components of their portfolios to pay redeeming investors. Figure 6 plots the percentage change in holdings of different fixed-income securities sorted by rankings. We use ratings to proxy for the liquidity of corporate bonds, where higher-rated bonds are generally more liquid than lower-rated ones. As Figure 6 shows, holdings of Treasuries decreased by 11% in March 2020 while holdings of AAA and AA+ rated corporate bonds decreased by around 5%. The position changes in lower-rated bonds were smaller and generally decreasing in bond ratings, confirming that liquid assets in bond funds’ portfolios were disproportionately sold.

In aggregate, the volume of Treasuries sold by open-end mutual funds is economically significant at \$236 billion in the first quarter of 2020 (see Table 2). Compared to other financial institutions, the large sale of liquid assets appears unique to the mutual fund sector. Note that money market funds bought rather than sold Treasuries. This is consistent with

liquidity transformation playing an important role in amplifying mutual fund outflows and liquidations because money market funds invest in more liquid assets and conduct much less liquidity transformation than fixed-income mutual funds. Because money market funds can only buy securities with a maturity of less than one year, their purchase of Treasury securities could not alleviate the stress in longer-term Treasuries. Relative to Treasury liquidations by non-financial sectors, liquidations by mutual funds are only below that of the rest of the world (\$287 billion) in absolute terms. The proportion of Treasuries held by mutual funds also experienced the largest decline at 18% in 2020Q1.<sup>7</sup> Although mutual funds generally buy and sell bonds with dealer banks, Table 2 shows that the ultimate buyer of Treasuries in 2020Q1 was primarily the Federal Reserve.

Table 3 further decomposes mutual fund liquidations by bond type using CRSP data. In 2020Q1, mutual funds sold \$12.5 billion in Treasury bills, \$138.1 billion in Treasury notes, and \$61.4 billion in Treasury bonds. Relative to the daily trading volume of Treasury bills, notes, and bonds, mutual fund liquidations make up 1%, 3%, and 9%, respectively, assuming that liquidations occurred mainly on days of heightened outflows.<sup>8</sup> For corporate bonds, fixed-income mutual funds sold \$96.1 billion of investment-grade corporate bonds and \$60.5 billion of high-yield corporate bonds.

This subsection has provided preliminary evidence that pronounced outflows at fixed-income mutual funds ultimately led to a systematic sell-off of liquid assets. The magnitude of this phenomenon appeared to be unique to the mutual fund sector amongst other financial intermediaries. At the same time, funds with more illiquid portfolios were more exposed, which suggests an amplifying effect of mutual fund liquidity transformation on the risk of concentrated outflows and sell-offs in liquid asset markets.

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<sup>7</sup>Sector-level data are only available as of 2020Q1 from the Flow of Funds, which may already include the impact of some interventions by the Federal Reserve. The quoted Treasury sales volumes are therefore likely an underestimate of the peak sales that occurred during the Covid-19 crisis.

<sup>8</sup>Using SIFMA data, we find that the average daily trading volumes in 2020Q1 are \$128.3 billion for Treasury bills, \$461.9 billion for Treasury notes, and \$68.5 billion for Treasury bonds. Since mutual fund outflows and liquidations occurred within about ten days in mid-March 2020 (also shown in Figure 5 in Falato, Goldstein and Hortacsu (2021)), we divide our quarterly liquidation volume by ten to proxy for the daily liquidation volume.

## 2.3 Mutual Fund Ownership and Asset Prices

The unprecedented outflows and asset liquidations at bond funds had a sizable impact on overall asset prices during the Covid-19 crisis. To see this, we first calculate how much each bond is owned by fixed-income mutual funds as a proportion of its total outstanding amount in 2019Q4. Then, we divide Treasuries and corporate bonds into quartiles according to their proportion of mutual fund ownership. Finally, we residualize bond yields with rating-time fixed effects to control for credit risk and plot the residualized yields sorted by mutual fund ownership in Figure 7.

From Figure 7, we observe that Treasuries and corporate bonds owned more by mutual funds experienced larger increases in yields during Covid-19 relative to other bonds of the same rating. Magnitude wise, Treasuries in the first quartile of mutual fund ownership had a 50 basis point higher yield than Treasuries of the same maturity in the fourth quartile of mutual fund ownership at the height of the crisis on March 19, 2020.<sup>9</sup>

We further plot the yield spread between the first and fourth quartile of mutual fund ownership separately for investment-grade and high-yield corporate bonds with maturities above and below five years. The results are shown in Figure 8. We observe that the spreads for short- and long-maturity investment-grade bonds became positive in early March and reached 142 and 133 basis points on March 20, 2020. This is a sizeable effect compared to the overall yield increases for investment-grade bonds, which were between 176 and 186 bps based on Moody's Seasoned Aaa and Baa Corporate Bond Yields, respectively. The spreads for high yield bonds are noisier. The long-term high-yield spread based on the ICE BofA US High Yield Index Effective Yield reaches up to 124 basis points before mid-March, but it dissipates relatively quickly and is much smaller than the overall increase in high-yield bond yields of more than 600 basis points in this time frame.

Overall, our findings suggest that mutual funds ownership had an economically large impact on bond yields in the Covid-19 crisis. The fact that the impact of mutual fund

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<sup>9</sup>Figure IA.3 in the Internet Appendix confirms that the same relationship between yields and mutual fund ownership persists without residualizing with respect to rating-time fixed effects.

ownership was primarily on investment-grade bonds is also consistent with mutual funds disproportionately selling more liquid bonds in meeting fund outflows. In contrast, the extent of mutual fund ownership does not have a conclusive effect on high-yield bonds, which, as we will show, is because high-yield bonds were less likely sold to meet fund outflows. Rather, variations in credit risk may have played a bigger role in driving high-yield bond yields.

### 3 Empirical Analysis

Having presented the aggregate relationship between fund ownership and bond yields, we proceed to identify the underlying mechanism and quantify the overall price impact of mutual funds. We first show that funds displayed a pattern of first selling more liquid assets, including Treasuries and high-quality corporate bonds, in meeting their pronounced outflows during the Covid-19 crisis. Then, we confirm that fund-outflow-induced liquidations affected corporate bond and Treasury markets prices. Finally, we quantify the aggregate price impact of mutual funds.

#### 3.1 Fund Outflows and Liquidation Policy

As discussed in Section 2.2, bond mutual funds have become an important provider of liquidity transformation in the economy, which has contributed to their large outflows in March 2020. Intuitively, outflows are triggered by a deterioration in fundamentals and then further amplified by liquidity transformation. First, investors redeem shares when their prospects about the long-term economic fundamentals decline, as with the onset of the Covid-19 crisis. Then, for a given shock to economic fundamentals, investors' incentives to redeem are higher when mutual funds transform more illiquid assets into liquid shares because those who remain in the fund will have to bear a larger proportion of the liquidation costs. This intuition is consistent with earlier work that highlight the strategic complementarities between mutual fund shareholders' redemption decisions (e.g., [Chen, Goldstein and Jiang, 2010](#), [Feroli, Kashyap, Schoenholtz and Shin, 2014](#), [Goldstein, Jiang and Ng, 2017](#)).

Focusing on the Covid-19 crisis, [Falato, Goldstein and Hortacsu \(2021\)](#) provide a decomposition of the determinants of outflows for bond mutual funds and ETFs. Consistent with their findings, our analysis in Internet Appendix [IA.1](#) confirms liquidity transformation as an important contributor to fund outflows.<sup>10</sup> Controlling for a range of other fund characteristics, we find that a one standard deviation increase in fund liquidity transformation before the Covid-19 crisis corresponds to a  $0.816\% * 1.01 = 0.824\%$  larger outflow in March 2020. This magnitude is economically significant given that the cumulative outflows at investment-grade, high-yield, and loan funds were 1.6%, 5.6%, and 11.6% from January 1, 2020 to March 15, 2020.

Building on the above findings, we now examine how mutual funds liquidate their bond holdings in meeting investors' redemption requests. After all, pronounced outflows alone cannot explain why, during the Covid-19 crisis, selling pressure was concentrated in liquid asset markets. Funds' strategies on which assets to liquidate also played a vital role. This question is of particular relevance because the existing theoretical predictions are ambiguous. [Scholes \(2000\)](#) shows that the optimal liquidation policy is to follow a pecking order to sell more-liquid assets first, consistent with the view of minimizing overall price impact. However, when the option value of liquidity-hoarding is relatively high, funds may also strategically preserve their liquid asset buffer for future use (e.g., [Brown, Carlin and Lobo, 2010](#), [Morris, Shim and Shin, 2017](#)). Therefore, whether bond funds followed the pecking order of liquidation during the Covid-19 crisis remains an empirical question.

### 3.1.1 Liquidation-to-Outflow Sensitivity

We first examine how the sensitivity of liquidations for a given bond varies with respect to outflows at funds holding that bond. The pecking order of liquidations would suggest a higher sensitivity for more liquid securities. To check, we regress liquidations of bond  $i$  by fund  $j$  on the outflows at fund  $j$  for bonds of different liquidation groups  $g(i)$  as in equation [\(3.1\)](#). For each bond  $i$  that is held by fund  $j$  at the end of February 2020, we calculate the

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<sup>10</sup>See Internet Appendix Figure [IA.4](#) and Tables [IA.1](#) and [IA.2](#).

percentage change in its quantity in fund  $j$ 's portfolio from the end of February 2020 to the end of March 2020 to obtain  $Liquidations_{i,j}$ .<sup>11</sup> Similarly,  $Outflows_j$  denotes the percentage change in fund-level AUM from the end of February to the end of March. We also control for fund and bond level characteristics  $X_{i,j}$  including maturity, lag fund size, and fund returns, and fund objective fixed effects,  $\theta_{o(j)}$ . We plot the coefficients on the main explanatory variable, fund outflows, in Figure 9. The capped bars represent the 95% confidence interval.

$$Liquidation_{i,j} = \beta_{g(i)}Outflows_j + \gamma_{g(i)}X_{i,j} + \theta_{o(j)} + \epsilon_{i,j}. \quad (3.1)$$

From Figure 9, we observe larger liquidations to outflow sensitivities for corporate bonds with higher ratings, which also tend to be more liquid. Within the investment-grade segment, an AAA-rated bond is five times more likely to be liquidated in meeting outflows than an A-rated bond. This trend implies that more liquid corporate bonds are sold off by a larger extent following fund outflows, which is consistent with a pecking order of liquidations in which more liquid assets are sold first. At the same time, the trend rules out that only a credit-risk channel was at play, which would suggest a larger tendency to sell riskier bonds from funds' portfolios. Within the high-yield segment, credit risk likely played a larger role as the liquidation sensitivity is more volatile. Nevertheless, highly-rated investment-grade bonds have the highest liquidation sensitivity of all, which points to their use as liquid buffers across fund types.<sup>12</sup>

Figure 9 also shows that the liquidation-to-outflow sensitivity for Treasuries is higher than that of almost all corporate bonds, which suggests that Treasuries are ranked high in

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<sup>11</sup>Given our focus on funds' liquidation policy during March 2020, our sample only includes bonds that were held by funds at time  $t - 1$ , that is, February 2020. In other words, we do not include new positions added in March 2020 that were not already owned in February 2020.

<sup>12</sup>In Internet Appendix Table IA.3, we further examine how the liquidation-to-outflow sensitivity of corporate bonds varies with the bond's remaining maturity, maturity at issuance, and age. We find that remaining and issuing maturity do not have a clear impact on the liquidation-to-outflow sensitivity. The age of the bond seems to matter in a monotone way, where younger bonds are more likely to be liquidated than older ones. The result on bond age is consistent with the idea that corporate bond liquidity deteriorates with bond age and the on-the-run versus off-the-run results for Treasuries. The variation in liquidation-to-outflow sensitivities by age, however, is much smaller than that by rating.

mutual funds' liquidation strategies.<sup>13</sup> To better understand the variation in liquidation-to-outflow sensitivities within Treasuries, we repeat specification (3.1) for different types of Treasury securities. In particular, we differentiate between on-the-run and off-the-run Treasuries because a large literature has shown that on-the-run Treasuries are more liquid than their off-the-run counterparts (e.g., [Warga, 1992](#), [Krishnamurthy, 2002](#), [Vayanos and Weill, 2008](#), [Pasquariello and Vega, 2009](#)).

Table 4 shows the estimation results. Overall, the magnitude of the liquidation-to-outflow sensitivities for Treasury notes and bonds are well above those of the highest-rated corporate bonds in Figure 9, which confirms the high ranking of Treasury securities in the pecking order. Within Treasuries, the most salient trend is that funds are much more likely to sell on-the-run Treasuries in meeting redemption requests compared with off-the-run Treasuries of the same type. For a given outflow, on-the-run Treasury notes and bonds are  $1.008/0.629=1.60$  and  $1.509/1.193=1.26$  times more likely to be sold than their off-the-run counterparts. This result is consistent with the pecking order of liquidations because on-the-run Treasuries are more liquid.<sup>14</sup> In Internet Appendix Table IA.4, we show that our findings are not driven by differences in outflows at funds holding on-the-run versus off-the-run Treasuries. We further break down Treasuries into finer maturity buckets and confirm that on-the-run Treasuries are always sold off by more in meeting outflows within each bucket in Table IA.5 in the Internet Appendix. For Treasury bills, the coefficient is not significant. This may be because Treasury bills make up a very small fraction of fixed-income mutual funds' holdings in our data and the sample size is thus very small.

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<sup>13</sup>The point estimate for AAA-rated corporate bonds is higher than that of Treasuries, but the statistical significance of the difference is limited as suggested by the wide confidence interval for AAA-rated corporate bonds.

<sup>14</sup>Table 4 also shows that the coefficients for Treasury bonds are larger than those for Treasury notes. The interpretation of this finding may be affected by the heterogeneity in liquidity within Treasury notes, where some issues like the 7-year note are particularly illiquid. For example, [Diaz and Escribano \(2017\)](#) show that the daily trading volume of the 7-year note from 1996 to 2000 was 22.7 thousand dollars, while those of the 10-year and 30-year Treasuries are much higher at 371.1 and 100.0 thousand dollars. Using a more recent sample until 2017, [Adrian, Fleming and Vogt \(2017\)](#) also show considerable variation in market depth and price impact between 2-year, 5-year, and 10-year Treasuries.

One implication of our results is that future disruptions by the mutual fund sector may not necessarily be confined to the most liquid assets. Instead, it is a continuous phenomenon whereby as fundamentals deteriorate, the relatively more liquid securities in the portfolio are sold before the less liquid ones. By the same token, more liquid tranches of the portfolio experience heightened selling pressure before relatively less liquid tranches. During the Covid-19 crisis, bond funds' concentrated sale of Treasuries and highly-rated corporate debt only marked the beginning stages of a more general market distress event. If fundamentals were allowed to deteriorate further, e.g., if the Federal Reserve did not intervene, investors' redemption requests would have likely continued and led to the sale of increasingly illiquid assets from funds' portfolios. In that case, heightened selling pressure and strains may have spilled over to markets trading more illiquid debt securities as well.

### **3.1.2 Fund-level Relative Liquidation Rank**

So far, we have estimated the propensity of liquidation based on the absolute level of liquidity of a given bond. In reality, the likelihood of liquidating a bond at a given fund not only varies with the liquidity of the bond itself but also with the relative liquidity of the fund's other assets. For example, an investment-grade bond held by a high-yield fund could be part of the first assets to be sold, while the same investment-grade bond held by a fund with predominantly investment-grade assets may come much later in the pecking order.

To more precisely capture the relative liquidation sensitivity of bonds within a fund's portfolio, we define a liquidation rank at the bond-fund level following equation (3.2) below. Specifically, the liquidation rank of a bond in a given fund's portfolio is the share of other bonds held by the same fund that are less liquid. Since bond-level liquidation discounts are difficult to measure accurately at the bond level, we sort bonds by liquidation groups and let bonds in the same group be equally liquid. Treasuries are ranked before corporate bonds in decreasing ratings. That is, Treasuries are in group one, AAA-rated corporate bonds are in

group two, AA+ rated corporate bonds are in group three, etc.<sup>15</sup> Of course, corporate bond ratings and thus their liquidation groups may correlate with credit risk. However, credit risk concerns would most likely lead to lower-rated bonds being sold first, which would go against us finding any results for the pecking order. Also, as we will show, our specifications control for bond and issuer-time fixed effects to remove potential confounding by credit risk shocks.

Further, since liquidation groups are discrete, we include the last term in equation (3.2) to reflect our assumption that bonds in the same group are equally liquid. For example, if a fund holds 20% of Treasuries, 20% of AAA-rated corporate bonds, and 60% of other corporate bonds with lower ratings, the liquidation rank for each of the Treasuries would be 0.9 and the liquidation rank for each of the AAA-rated corporate bonds would be 0.7. Formally, we define the liquidation rank of bond  $i$  in fund  $j$  that belongs to liquidity group  $g(i)$  as

$$\text{Liquidation Rank}_{i,j} \doteq \sum_{g(i')} \text{Share}_{g(i'),j} \times \mathbb{1} [\text{Liq. Group}_{g(i)} > \text{Liq. Group}_{g(i')}] + \frac{1}{2} \text{Share}_{g(i),j}, \quad (3.2)$$

where  $\text{Share}_{g(i'),j}$  is the share of bonds  $i'$  in the liquidity group  $g(i')$  in fund  $j$ 's portfolio.

Then, we consider how the liquidation rank affects bonds' liquidation-to-outflow sensitivity. For each bond  $i$  that is held by fund  $j$  at the end of February 2020, we regress bond-fund level liquidations against fund-level outflows interacted with its liquidation rank in fund  $j$ 's portfolio at the end of February (see equation (3.3)). As before, we calculate  $Liquidations_{i,j}$  as the percentage change in bond  $i$ 's quantity in fund  $j$ 's portfolio from the end of February 2020 to the end of March 2020. Similarly,  $Outflows_j$  denotes the percentage change in fund-level AUM from the end of February to the end of March. We run separate specifications for active open-end funds and passive open-end funds because the investment mandate of the latter may interact with the pecking order. We also include fixed effects for fund objective

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<sup>15</sup>We confirm that standard measures of bond illiquidity in the literature, including Amihud, Roll, and Imputed Round-trip Costs (IRC), are increasing in our ratings-based liquidity-group measure (see Figure IA.5 in the Internet Appendix). We use ratings as a proxy for corporate bond liquidity because Amihud, Roll, and IRC can only be constructed for bonds with a certain number of transactions.

$\theta_{o(j)}$  and bond-level fixed effects  $\delta_i$  to ensure that our results are not driven by bond-specific or fund-type specific differences. Table 5 details the results.

$$\text{Liquidation}_{i,j} = b_0 \text{Outflows}_j + b_1 \text{Outflows}_j \times \text{Liquidation Rank}_{i,j} + \theta_{o(j)} + \delta_i + \epsilon_{i,j}. \quad (3.3)$$

From the results in Table 5, we see that the coefficient on the interaction between outflows and rank is statistically significant for actively managed bond funds. This implies that when the same bond is ranked higher in the pecking order of one fund relative to another fund, it also has a higher tendency to be sold when there are outflows, consistent with the pecking order of liquidations. Note that this effect is not driven by credit risk or other unobserved features at the bond level because we are comparing liquidation-to-outflow sensitivities using within-bond variation. The magnitude is economically important. The estimates in column 2 suggest that the same bond ranked at the bottom of the pecking order with a liquidation rank of 0 is liquidated by 0.21% for a 1% outflow while the same bond at the top of the pecking order with a liquidation rank of 1 would have been liquidated by 0.59% for the same 1% outflow.<sup>16</sup> Our findings are qualitatively robust with similar magnitudes when investment-grade and high-yield funds are analyzed separately (see Internet Appendix Table IA.6).

In contrast, the coefficient on the interaction term for open-end passive funds in column 3 of Table 5 is not significant. This suggests that for open-end passive bond funds, the liquidation rank of bonds does not affect their liquidation-to-outflow sensitivity in a statistically significant way.<sup>17</sup> Moreover, the economic magnitude of the point estimate is much smaller than that for actively managed bond funds. These findings suggest that open-end

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<sup>16</sup>One reason for why the estimated liquidation-to-outflow sensitivities are below 1 across liquidation ranks is because we do not observe cash holdings, which are the most liquid asset that should have the highest liquidation sensitivity, for the majority of funds. Another factor is that our data aggregates outflows and portfolio changes at the monthly level, which may introduce noise to the pecking order magnitude if funds experience inflows and asset purchases on certain days.

<sup>17</sup>Relatedly, [Dannhauser and Hoseinzade \(forthcoming\)](#) compare the bond trading behavior of bond mutual funds and ETFs, focusing on the Taper Tantrum period. Our notion of passive funds does not include ETFs.

passive bond funds appear to liquidate their portfolios proportionally instead of following the pecking order of liquidation, consistent with their mandate to track bond indices.

Our results in this section indicate that bond funds liquidated more-liquid assets first to meet redemption requests during the Covid-19 crisis when not constrained by their investment mandate. Our finding is consistent with [Chernenko and Sunderam \(2017\)](#), who show that mutual funds use cash to meet redemption requests during normal times. [Jiang, Li and Wang \(2021\)](#) do not find evidence for the pecking order when market uncertainty, as proxied by the VIX index, is high. During the Covid-19 crisis, the VIX index was generally elevated but the impact on financial markets was largely perceived as unexpected and acute from the outset. As a result, there was likely a higher benefit of following the pecking order compared to the option value of liquidity-hoarding so that the incentive to avoid selling illiquid corporate bonds at the height of market illiquidity prevailed. [Jiang, Li, Sun, and Wang \(2022\)](#) further show that bonds held by more illiquid funds are more likely to suffer from flow-induced sales. Our analysis jointly considers outflows and the order by which mutual funds liquidate their assets to meet these outflows. We show that the likelihood for a bond being sold depends on its relative liquidity within the fund portfolio and that this liquidation policy is important for understanding the large price disruptions observed in Treasury and high-quality corporate bond markets during the Covid-19 crisis.

## 3.2 Mutual Fund Liquidations and Asset Prices

Section 2 has shown that fixed-income mutual funds' outflows and asset sales occur around the same time as liquid asset prices fell during the Covid-19 crisis. Nevertheless, it remains to be shown whether funds' outflows and liquidation policies indeed contributed to the asset price movements. In this section, we examine how bond returns vary with fund outflows and bonds' liquidations ranks in their funds' portfolios to identify the presence of price impact by mutual funds. A quantification of the price impact will be provided in Section 3.3.

### 3.2.1 Relative Liquidation Rank and Asset Prices

We begin by showing that bonds with higher liquidation ranks in funds' portfolios experienced larger drops in prices during the Covid-19 crisis. We first define and calculate a bond-level liquidation rank by averaging across the bond-fund level liquidation ranks at all funds  $j$  that held bond  $i$  in 2019Q4 weighted by the size of holdings:

$$\text{Liquidation Rank}_i \doteq \sum_j \text{Liquidation Rank}_{i,j} \times \frac{\text{Holding}_{i,j,2019Q4}}{\sum_k \text{Holding}_{i,k,2019Q4}}, \quad (3.4)$$

where  $\text{Liquidation Rank}_{i,j}$  is given by equation (3.2).

Then, we group bonds by quartiles of their liquidation rank, controlling for rating-date fixed effects to remove potential confounding due to credit risks. We plot the demeaned yields by liquidation rank quartiles in Figure 10. For easier comparison, the yields at the beginning of February 2020 are normalized to zero.

Figure 10 shows that for bonds of the same rating, higher-ranked ones in the pecking order of funds' portfolios experienced larger price drops and larger yield increases than those lower in the pecking order during the Covid-19 crisis. This variation suggests that the higher selling pressure for bonds higher up in the pecking order trickled down to impact overall asset prices. Notice also that the divergence in yields across the liquidation rank quartiles starts at the beginning of March 2020 and widens until the end of March. In our framework, this is because the notion of liquidation rank only materializes into actual liquidations when there are actual outflows. Recall from Figure 5 that bond fund outflows were indeed most pronounced during this period.

### 3.2.2 Imputed Outflows and Asset Prices

We proceed with examining the effect of fund outflows on the returns of the bonds in their portfolio. If fixed-income mutual funds affected asset prices, we would expect that bonds held by funds with larger outflows also suffered larger drops in returns because they are

more likely to be sold relative to bonds at funds with less pronounced outflows. Because daily holdings data are unavailable for mutual funds, it has been a standard practice since [Coval and Stafford \(2007\)](#) and [Lou \(2012\)](#) to use imputed flows to study how flow-induced fund trading affects daily asset returns. We construct a similar imputed outflow measure by calculating for each bond  $i$ , a weighted average of outflows at funds  $j$  that held this bond at the end of 2019Q4, where weights are defined by the volume of funds' holdings of bond  $i$ . Formally, the imputed outflow of bond  $i$  at date  $t$  is given by

$$\text{Imputed outflow}_{i,t} \doteq \sum_j \text{Fund outflow}_{j,t} \times \frac{\text{Holding}_{i,j,2019Q4}}{\sum_k \text{Holding}_{i,k,2019Q4}}.$$

Then, we regress daily bond-level returns against their daily imputed outflows from Jan 1, 2020 to March 31, 2020, as in equation (3.5) below.

$$\text{Return}_{i,t} = \beta \text{Imputed Outflow}_{i,t} + \gamma X_{i,t} + \delta_i + \kappa_{f(i),t} + \tau_{m(i),t} + \omega_{r(i),t} + \epsilon_{i,t}. \quad (3.5)$$

Both bond returns and fund outflows could be driven by fundamental news. For instance, an increase in default risk will drive down bond returns and prompt investor outflows. To ensure that the coefficient  $\beta$  can be interpreted as the price impact of mutual fund outflows, we include a set of fixed effects including issuer-time  $\kappa_{f(i),t}$ , rating-time  $\omega_{r(i),t}$ , and maturity-time  $\tau_{m(i),t}$ , where maturity is defined as yearly buckets of the bond's remaining maturity. Intuitively, our identification is obtained by comparing two almost identical bonds with the same maturity, rating, and issuer, with one being held by funds that suffered larger outflows than the funds holding the other. We also include bond fixed effects to remove any time-invariant bond characteristics such as the total volume of bonds outstanding.

Our granular within-bond-type analysis also helps to alleviate the concern that other investors' actions are confounding our results. For example, if a hedge fund is forced to liquidate corporate bonds of a given maturity and rating by an exposed issuer, the resulting price pressure would have been absorbed by the maturity-time and issuer-time fixed effects. The behavior of other investors would only affect our results if they differed within bonds of

the same issuer, maturity, and rating, and also happen to be correlated outflows at mutual funds. To this end, we control for outflows at fixed-income ETFs, which also invest in bond markets and are observable in the data. Finally, we control for the proportion of zero trading days for each corporate bond to ensure that our results are not driven by a lack in trading. Our results are similar with and without these controls, implying that there is little common variation within each granular bond-type.<sup>18</sup>

We first estimate equation (3.5) for different types of Treasury securities and show the results in Table 6a. Recall that the goal of equation (3.5) is to cleanly isolate the presence of price impact of fund outflows. However, by comparing bonds of the same maturity for a given issuer, any price impact common to bonds of a given issuer and maturity will be absorbed. Hence, the estimates are a lower bound of the overall price impact of mutual fund outflows. Despite the restrictive specification, the coefficient on off-the-run Treasury bonds is negative and statistically significant, which means that funds with larger outflows also suffered larger drops in returns compared to other off-the-run Treasury bonds of the same maturity. For shorter maturity and on-the-run Treasuries, the differential price impact controlling for maturity-time and bond fixed effects are not significant.<sup>19</sup> Overall, our results confirm the finding by He, Nagel, and Song (2022) and Fleming and Ruela (2020) that off-the-run longer-maturity Treasury markets were especially strained during the Covid-19 crisis.

We then estimate equation (3.5) for corporate bond issuers and present the results in Table 7a. The coefficient on imputed outflows is negative and statistically significant at the 5% level across all four specifications.<sup>20</sup> In the most restrictive specification in column (4), a 1% increase in imputed outflows is linked to a 2.00 basis point decrease in daily returns compared with other bonds issued by the same issuer and of the same rating and maturity

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<sup>18</sup>See Tables IA.7 and IA.8 in the Internet Appendix for the results.

<sup>19</sup>There may be several reasons for this result. First, by using only variation from one issuer, we difference out any aggregate effects on returns for Treasuries of the same type and maturity. That is, if the sale of a given Treasury security affects the overall price of Treasuries within the same bucket, the spillover price impact will be differenced out. At the same time, the market for Treasury bills and on-the-run Treasuries are also generally more liquid than those of longer-term off-the-run Treasuries.

<sup>20</sup>Internet Appendix Table IA.9 shows that the price impact of mutual fund liquidation is statistically significant for off-the-run corporate bonds but not for on-the-run corporate bonds, similar to the results for Treasuries.

bucket. The inclusion of issuer-time fixed effects helps address the concern that both returns and flows may be affected by news on the issuer’s default risk. Hence, this result establishes that for bonds with identical issuers, ratings, and maturities, those that are held by funds with greater outflows experienced more negative returns. Nevertheless, as in the case of Treasuries, the economic magnitude is likely an underestimate of the overall price impact because common shocks are conditioned on.

### 3.2.3 Liquidation-Adjusted Outflows and Asset Prices

So far, we have shown the extent to which imputed outflows trickle down to affect bond returns. However, we have not yet factored in the effect of funds’ liquidation policies on asset prices. Recall from Section 3.1 that bonds ranked higher in the order of liquidations are disproportionately sold following fund outflows at active funds, i.e., the pecking order of liquidation applies. At the same time, Figure 10 implies that bonds with higher liquidation ranks experienced larger price drops in March 2020. These results suggest that incorporating the empirical liquidation policy into imputed outflows could be a more accurate way to capture the price impact of fixed-income mutual funds, especially given the absence of daily portfolio data for mutual funds.

To this end, we propose the Liquidation-Adjusted Outflow (LAO) as a novel measure that incorporates the empirical pecking order within funds’ portfolios.<sup>21</sup> Rather than just taking the weighted average over fund-level outflows at funds, the LAO takes the weighted average over bond-fund level adjusted outflows that incorporate the funds’ empirical liquidation policy. Specifically, we define LAO for bond  $i$  at time  $t$  as

$$\begin{aligned} & \text{Liquidation-adjusted outflow (LAO)}_{i,t} \\ & \doteq \sum_j \text{Fund outflow}_{j,t} \times (\hat{b}_0 + \hat{b}_1 \text{Liquidation Rank}_{i,j}) \times \frac{\text{Holding}_{i,j,2019Q4}}{\sum_k \text{Holding}_{i,k,2019Q4}}, \end{aligned} \quad (3.6)$$

where  $\hat{b}_0$  and  $\hat{b}_1$  are the estimated coefficients in equation (3.3) reported in Table 5.

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<sup>21</sup>We thank Stefan Nagel for a helpful suggestion that inspired the construction of the LAO.

The benefit of the LAO is to better isolate mutual funds' outflow-induced price impact by accounting for the differential selling pressure of outflows on bonds according to their relative liquidation rank. For example, two bonds held by the same fund will have the same imputed outflows, but their LAOs will vary with their liquidation rank within the fund. If liquidations are induced by outflows and if bonds higher up in the pecking order of liquidations are more likely to be sold, then the LAO would capture the price impact of bond funds' outflow-induced asset liquidations more accurately. In this case, we would expect bond returns to respond more to the LAO relative to the unadjusted imputed outflows.

To test the above conjecture, we re-estimate specification (3.5) by replacing imputed outflows with the LAO while keeping the same set of controls and fixed effects:

$$\text{Return}_{i,t} = \beta \text{Liquidation-Adjusted Outflow}_{i,t} + \gamma X_{i,t} + \delta_i + \kappa_{f(i),t} + \tau_{m(i),t} + \omega_{r(i),t} + \epsilon_{i,t}. \quad (3.7)$$

We first estimate equation (3.7) for Treasuries. From the results in Table 6b, we find that the coefficient on LAO for off-the-run Treasury bonds is more negative and statistically more significant than the coefficient on imputed outflows in Table 6a, which implies that the liquidation adjustment can better capture the price impact of bond funds by taking funds' order of liquidation into account. Magnitude wise, a 1% percent increase in the LAO corresponds to a 3.33 basis point drop in daily returns, which is almost triple that for a 1% increase in imputed outflows.

We then estimate equation (3.7) for corporate bonds and show the results in Table 7b. Observe that in all four columns, the coefficient on LAO is negative, statistically significant, and larger in magnitude than the corresponding coefficients on imputed outflow in Table 7a. This result again shows that the liquidation adjustment to outflows better captures the price impact of bond funds by incorporating the pecking order of liquidations at the bond-fund level. For the most restrictive specification in column (4), a 1% percent increase in the LAO corresponds to a 4.72 basis point drop in daily corporate bond returns, which is more than double that for a 1% increase in imputed outflows. Nevertheless, this magnitude remains a

comparison between bonds by the same issuer and of the same maturity and rating. As we will show in the next subsection, the aggregate price impact of mutual fund liquidations is larger in magnitude.

Compared to [Choi, Hoseinzade, Shin and Tehranian \(2020\)](#), who find little evidence for fire-sales by bond funds on corporate bonds from 2005 to 2014, our results likely arise for a number of reasons. First, the acute and systematic Covid-19 shock triggered outflows large enough to deplete fund cash holdings and trigger the liquidation of Treasuries and relatively liquid corporate bonds. At the same time, the fixed-income mutual fund sector has rapidly grown in size and increasingly invested in illiquid assets, which leads to a larger holding of Treasuries and corporate bonds as liquidity buffer. The systematic liquidation of this liquid buffer was eventually strong enough to affect aggregate asset prices in the Covid-19 crisis.

### **3.3 Overall Impact of Mutual Funds in the Covid-19 Crisis**

So far, we have focused on identifying the presence of mutual funds' outflow-induced liquidations that follow a pecking order and their price impact. Cleanly isolating the channel at play requires the use of rather restrictive specifications that cannot capture the aggregate impact of mutual funds on asset prices. To this end, we perform two complementary exercises to quantify the importance of mutual funds in shaping the aggregate asset price movements in the Covid-19 crisis. In subsection [3.3.1](#), we first look at bond-level variation in mutual fund ownership and asset prices to project hypothetical bond-level yields in the absence of mutual funds. Then, in subsection [3.3.2](#), we examine variation in Treasury holdings at the sector level using the Granular Instrumental Variables approach to capture the aggregate price impact of mutual funds.

#### **3.3.1 Effects of Mutual Fund Ownership on Bond Yields**

Our first exercise estimates the effect of mutual funds on asset prices by projecting bond yields on mutual fund ownership. Specifically, we first calculate the proportion of bond  $i$

that is owned by mutual funds in 2019Q4. Then, on each day, for our sample of Treasury and corporate bonds, we regress their bond yields against their proportion of mutual fund ownership:

$$\text{Yield}_{i,t} = \alpha_t + \beta_t \text{Mutual fund ownership}_i + \epsilon_{i,t}, \quad (3.8)$$

where  $\alpha_t$  is the common component of bond yield and  $\beta_t$  is bond yields' time-varying loading on mutual fund ownership. Finally, we calculate the counterfactual bond yields in the absence of mutual funds by setting the proportion of mutual fund ownership to zero. We estimate equation (3.8) separately for Treasuries, investment-grade corporate bonds, and high-yield corporate bonds.

Figure 11 plots the difference between the actual yield and the counterfactual yield in the absence of mutual fund ownership for bonds at the 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, and 90<sup>th</sup> percentile of mutual fund ownership. This difference measures the time-varying effect of mutual fund ownership on bond yields. From the top and middle panel, the projected effect of mutual fund ownership on asset prices is close to zero for Treasuries and investment-grade corporate bonds until the beginning of March. The impact of mutual fund ownership on yields continued to increase in March until the effect reached a maximum of 26 basis points on March 19 for the median Treasury and 42 basis points on March 24 for the median investment-grade corporate bonds. In other words, the yield of the median Treasury and median investment-grade corporate bond by mutual fund ownership in our sample would have been 26 and 42 basis points lower if they were not owned by mutual funds. These magnitudes are economically large. In comparison, the ten-year Treasury yield climbed by up to 64 basis points from March 9 to March 23, whereas Moody's Seasoned Aaa and Baa Corporate Bond Yields increased by up to 176 and 186 basis points, respectively. That is, the estimated effect of mutual fund ownership on the median Treasury amounted to about one-third of the overall increase in Treasury yields and about one-quarter of the overall increase in investment-grade corporate bond yields.

The top and middle panels of Figure 11 also reveal a large heterogeneity in the impact of mutual funds on bond yields. Treasuries at the 90<sup>th</sup> percentile of mutual fund ownership

had a 58 basis point larger increase in yields than Treasuries at the 10<sup>th</sup> percentile of mutual fund ownership at the peak of the impact on March 19, while the corresponding number for investment-grade corporate bonds was at 120 basis points on March 24. Hence, our estimates suggest that mutual fund ownership had a large and unequal price impact across securities in the Treasury and corporate bond market.

Our explanation for the above findings is that mutual funds sold their liquid assets, including Treasuries and highly-rated corporate bonds, to meet their large outflows during the Covid-19 crisis. Sections 3.1 and 3.2 have confirmed the presence of this channel controlling for a range of fund and bond-level characteristics. The projection results in this section are based on a less restrictive specification, which assumes that mutual fund ownership is not proxying for other unobserved characteristics that determined Treasury and investment-grade bond yields during the Covid-19 crisis. This assumption may be plausible because the projected effect of mutual fund ownership is close to zero across percentiles until early March, which is with when mutual fund outflows and liquidations started to increase. To confirm, we repeat the analysis by adding dummies for maturity buckets. The results in Internet Appendix Figure IA.6 show that the magnitudes remain similar as in our baseline estimate.

From the bottom panel of Figure 11, we also see that the projected effect of mutual fund ownership on high yield bonds is less clear. The effect of mutual fund ownership on the median high-yield bond reached up to 61 basis points on April 8, which is relatively less significant compared to the overall increase of the high-yield index yield of more than 600 basis points in this time frame.<sup>22</sup> The effect of mutual fund ownership also appears noisier and the dispersion across percentiles does not widen as much as those for investment-grade corporate bonds at the height of the asset market disruptions. Overall, these findings are consistent with more liquid assets being more subject to flow-induced selling pressure. For less-liquid high-yield corporate bonds, other considerations, such as credit risk, may be more salient.

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<sup>22</sup>This number is based on the ICE BofA US High Yield Index Effective Yield.

### 3.3.2 Granular Instrumental Variables (GIV) Approach

In this subsection, we examine the aggregate price impact of mutual funds during the Covid-19 crisis. This is a challenging task because directly regressing prices against the overall volume of mutual fund liquidations is subject to confounding factors such as co-moving macro-economic variables. At the same time, a better-identified, security-level comparison of prices and liquidations as in Section 3.2 washes out any price impact that is common across securities.

To address these challenges, we adopt the Granular Instrumental Variables (GIV) approach developed in Gabaix and Koijen (2020, 2021). The GIV approach captures the aggregate price impact by mutual funds using variation in aggregate flows at the market level. At the same time, the GIV approach resolves endogeneity concerns by estimating the aggregate sensitivity of asset prices using idiosyncratic demand shocks of large sectors as a source of exogenous variation. These idiosyncratic shocks are obtained from a factor model estimated on the changes in holdings of different sectors. The GIV is then calculated as the size-weighted sum of the idiosyncratic shocks, where the weighting by size distills the shocks to “granular” investor sectors. Finally, the GIV can be used to trace out how much aggregate market prices are moved in response to a 1% outflow of the market.

In our context, we ask how much aggregate Treasury bond prices were impacted by mutual fund liquidations during the Covid-19 crisis. We focus on the Treasury bond market because it was particularly strained during the Covid-19 crisis (e.g., Duffie, 2020, He, Nagel, and Song, 2022). Mutual funds also hold a significant portion of Treasury bonds in their portfolios and their total liquidations amounted to 2.6% of the overall volume of Treasury bonds outstanding in 2020Q1 (Table 3). Our analysis in Section 3.2 also suggests that at the security level, mutual funds’ price impact was most salient in the Treasury bond market.

We model changes in investors’ holdings of Treasury bonds as

$$\Delta q_{jt} = \alpha_j - \xi \Delta p_t + \lambda'_j \eta_t + u_{jt}, \quad (3.9)$$

where  $\xi$  is the demand elasticity of interest,  $\Delta p_t$  is the log change in Treasury bond price,  $\eta_t$  is a vector of common shocks,  $\lambda_j$  is a vector of factor loading, and  $u_{jt}$  is an idiosyncratic shock. The aggregate multiplier,  $M$ , which indicates how much aggregate Treasury bond prices move when 1% of the Treasury bond market is sold, is equal to  $\frac{1}{\xi}$ .

To estimate the aggregate multiplier,  $M$ , we follow the baseline specification from [Gabaix and Koijen \(2020, 2021\)](#). First, we obtain quarterly changes in Treasury holdings for different sectors  $j$  relative to the size of the Treasury market held by the relevant sector  $j$ ,  $\Delta q_{jt}$ , from the Flow of Funds data.<sup>23</sup> Then, we obtain the residuals,  $\Delta \check{q}_{jt}$ , of a weighted regression of  $\Delta q_{jt}$ :

$$\Delta q_{jt} = \alpha_j + \alpha_t + \beta_j GDPgrowth_t + \delta_j t + \Delta \check{q}_{jt}, \quad (3.10)$$

in which GDP growth serves as a proxy for common shocks,  $\delta_j t$  allows for a time trend as some sectors grew faster than others in different time periods, and the weights are equal to the standard deviation of  $\Delta q_{jt}$ .<sup>24</sup> This step attempts to purge out the confounding common shock components underlying different investor sectors' changes in holdings. Then, we calculate the GIV,  $Z_t$ , as the weighted residuals:

$$Z_t = \sum_{j=1}^J S_{j,t-1} \times \Delta \check{q}_{jt}, \quad (3.11)$$

where  $S_{j,t-1}$  is the share of sector  $j$ 's holdings in the previous quarter and  $J$  is the total number of sectors. In this step, the weighting by sector shares incorporates the idea that exogenous variation comes from idiosyncratic shocks to “granular” investor sectors. Finally, we estimate the aggregate multiplier,  $M$ , using the time series regression

$$\Delta p_t = \alpha + MZ_t + \lambda_1 GDPgrowth_t + \lambda_2 PC_{1t} + \lambda_3 PC_{2t} + \epsilon_t, \quad (3.12)$$

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<sup>23</sup>We provide more details on the construction in Internet Appendix [IA.2](#).

<sup>24</sup>Specifically, we have weights  $E_j = \min\left(\frac{1.5}{N}, \zeta \frac{\sigma_j^{-2}}{\sum_{k=1}^K \sigma_k^{-2}}\right)$ , where  $\sigma_j = \sigma(\Delta_j)$  and  $\zeta$  is chosen such that  $\sum_j E_j = 1$ .

where  $\Delta p_t$  is the log change in Treasury bond price,  $Z_t$  is the GIV, and  $PC_{1t}$  and  $PC_{2t}$  are the first two principal components extracted from the residuals in (3.10). To obtain Treasury bond prices, we use the 20-year zero-coupon yield constructed by [Grkaynak, Sack, and Wright \(2007\)](#).

Table 8 presents the estimation results. The coefficient on the GIV implies that a 1% inflow into Treasury bonds increases Treasury bond prices by 173 basis points at the aggregate level, which is robust to the number of principal factors we control for. Converting the change in bond prices to yields at the 20-year maturity, a 1% outflow into Treasury bonds increases the Treasury bond yield by 8.7 basis points. Given that mutual funds sold 2.6% of Treasury bonds in 2020Q1, our estimate suggests that their overall price impact amounted to  $2.6 * 8.7 = 22.62$  basis points. In comparison, the 20-year Treasury yield increased by up to 69 basis points.<sup>25</sup> Therefore, our estimates imply that the aggregate price impact of mutual funds was sizable at about one-third of the overall increase in Treasury bond yields during the Covid-19 crisis.

A few comments are in order. First, the identifying assumption is that conditioning on GDP growth and the principal components of  $\Delta \check{q}_{jt}$ ,  $Z_t$  is a truly idiosyncratic shock. This condition could be violated if common shocks are not properly controlled for or if the loadings on the omitted factors are correlated with size. To this end, we check how our estimates change upon the inclusion of additional principal components in Internet Appendix Table IA.10. We confirm that they remain statistically significant and similar in magnitude as in our baseline results. Second, our macro multipliers are estimated from sector-level data and total Treasury holdings, which assumes the same demand elasticity across sectors and Treasury types. We resorted to these approximations because of data limitations. As [Gabaix and Koijen \(2021\)](#) show, sector-specific elasticities could be obtained from using investor-level data. At the same time, sector-level holdings by Treasury type would allow for a more accurate differentiation between the elasticities for different types of Treasuries.

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<sup>25</sup>The 20-year constant maturity Treasury yield was 87 basis points on March 9, 2020 and increased to 156 basis points on March 19, 2020.

These extensions are beyond the scope of this paper, but they may be promising avenues for future work.

## 4 Conclusion

This paper shows that fixed-income mutual funds contributed to the volatile and concentrated selling pressure in liquid asset markets during the Covid-19 crisis. Mutual funds have increasingly engaged in liquidity transformation in which redeemable shares are backed by a portfolio of mostly illiquid assets. This liquidity transformation amplified investor redemptions, which lead to a sell-off of liquid assets as funds optimally depleted their stock of liquid assets before tapping into more-illiquid ones to minimize expected liquidation discounts. Mutual funds' concentrated liquidations of Treasuries and investment-grade corporate bonds had a sizeable price impact and played an important role in straining liquid asset markets during the Covid-19 crisis.

In the long run, if financial intermediation is increasingly performed by non-bank intermediaries like fixed-income mutual funds, liquidity transformation may become more cyclical, and liquid asset markets will experience more pronounced volatility over the business cycle. During downturns in particular, when investors are flocking out of fund shares, there can be large and concentrated selling pressure in more liquid assets. This may challenge the “safe haven” status of US Treasuries in the long run (Duffie, 2020). Strains in secondary corporate bond markets, if left unresolved, may also spill over to affect primary market issuance and thus the funding supply for firms.

With the increased reliance on mutual fund liquidity transformation, central bank interventions like the Fed's purchase of corporate bonds during the Covid-19 crisis may become inevitable for alleviating strains in liquid asset markets going forward.

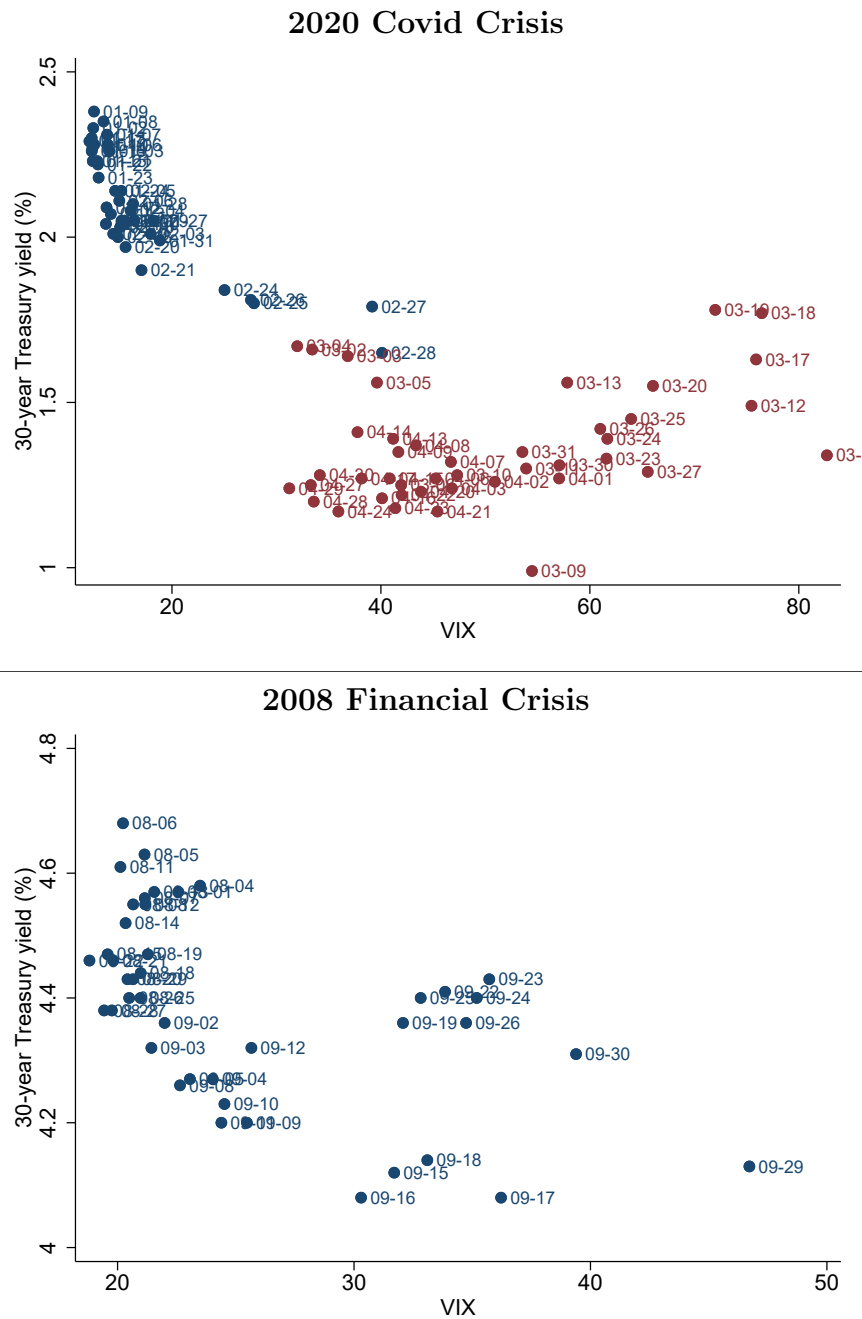
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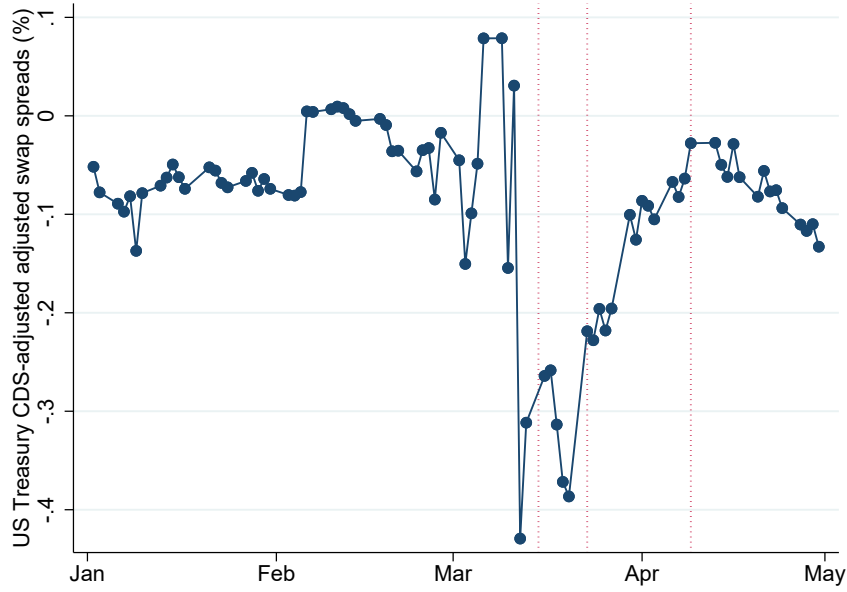
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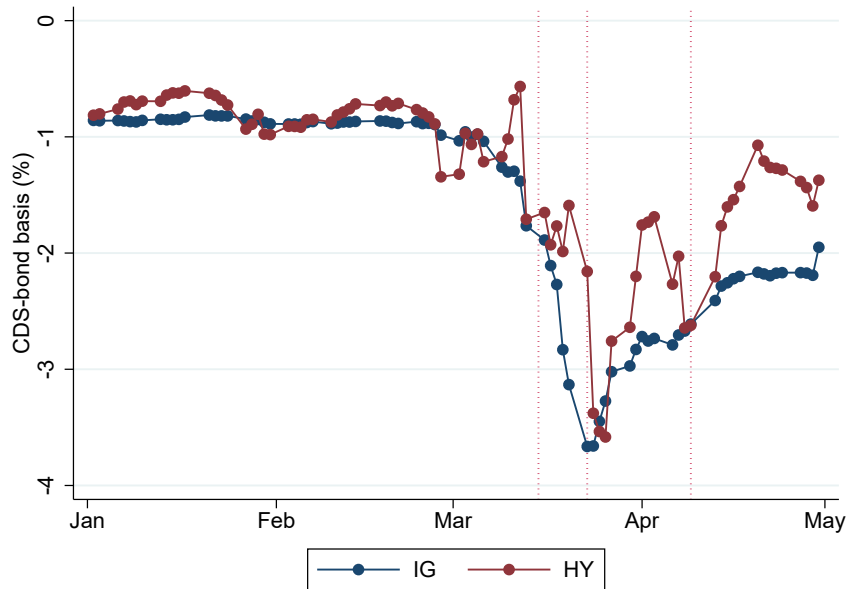
**Figure 1: Relationship between Treasury Yield and VIX**

This figure shows the scatter plots of 30-year US Treasury yields against the VIX. The upper panel shows the Covid-19 crisis with blue dots for days in January and February of 2020 and red dots for days in March and April of 2020. The lower panel shows the 2008 financial crisis from August 1, 2008 to September 30, 2008. Data source: FRED.



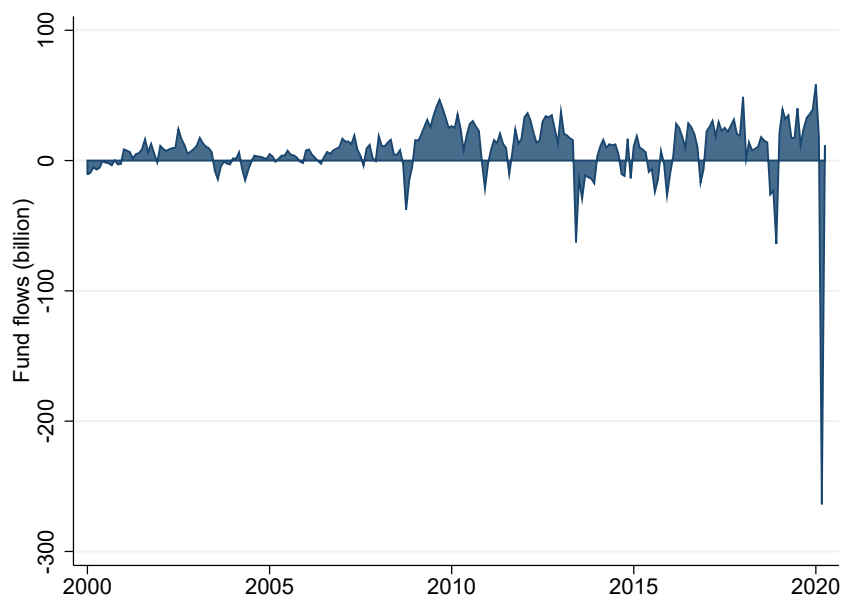
**Figure 2: Treasury CDS-adjusted Swap Spreads during Covid-19**

This figure plots the 30-year US Treasury CDS-adjusted adjusted swap spreads, which is defined as the interest swap rate plus the sovereign CDS rate minus the Treasury yield. The sample period is January 1, 2020 to April 30, 2020. Data source: Bloomberg, FRED.



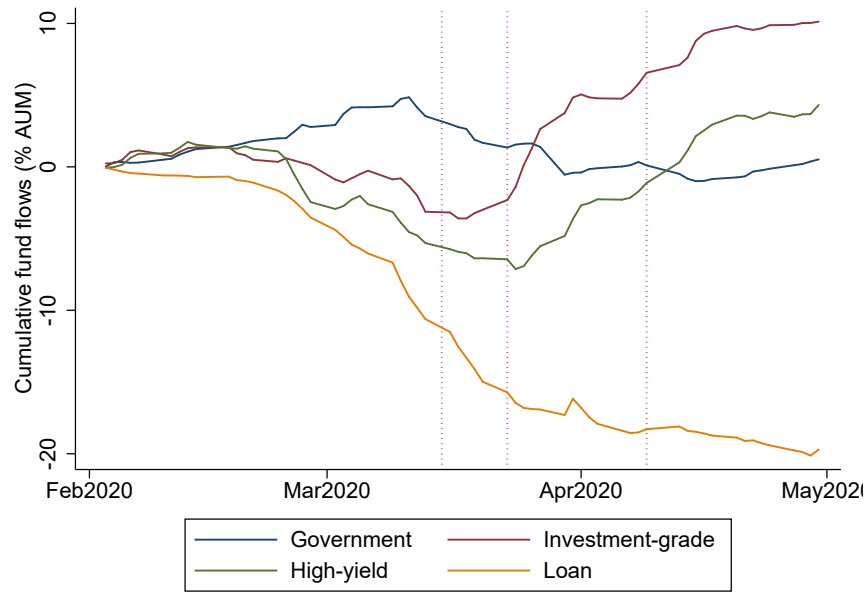
**Figure 3: CDS-Bond Basis of US Corporate Bonds**

This figure plots the US corporate CDS-bond basis, defined as the difference between the corporate bond CDS and the corporate bond yield spread. The solid and dashed lines indicate investment-grade and high-yield bonds, respectively. Data source: Bloomberg, FRED.

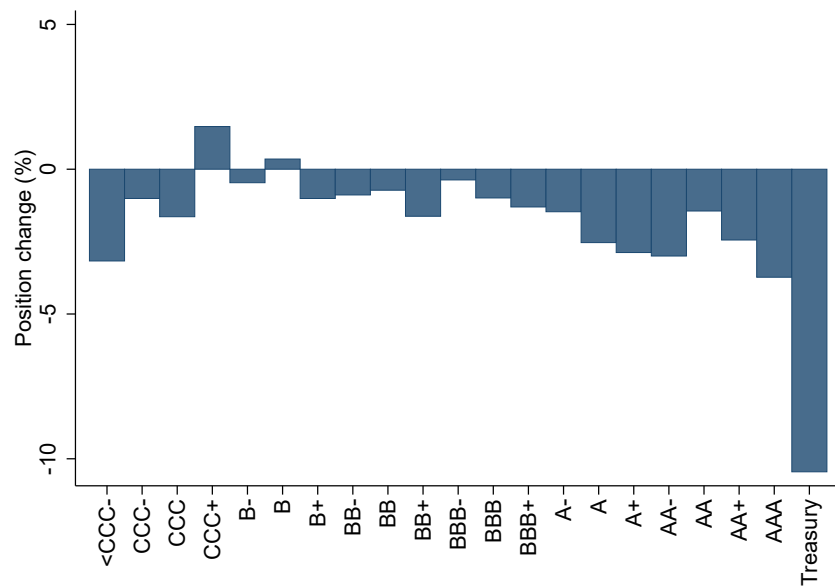


**Figure 4: Monthly Flows to US Fixed-Income Mutual Funds**

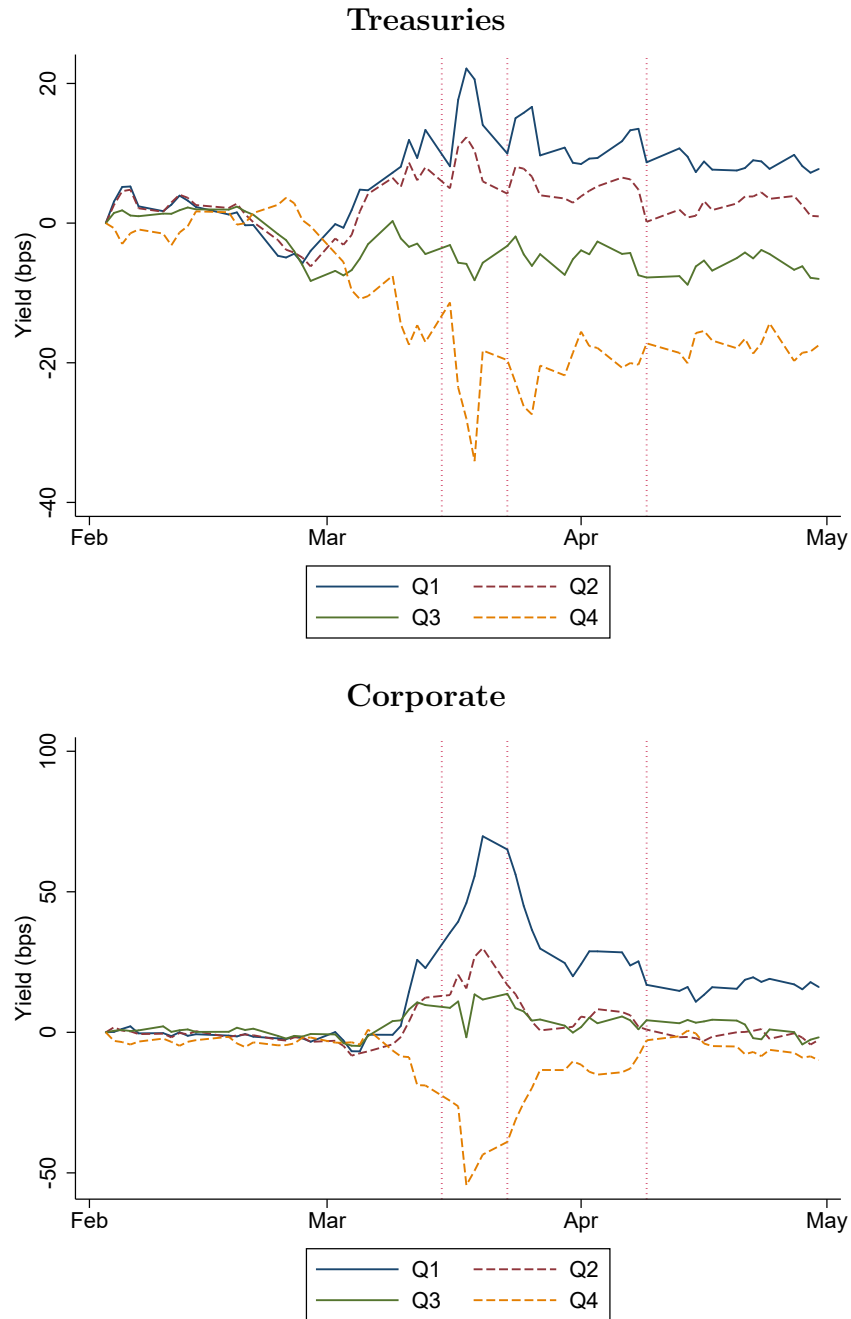
This figure plots the monthly fund flows in dollar value to US fixed-income mutual fund sector from 2000 to 2020. Data source: Morningstar.



**Figure 5: Cumulative Fund Flows of US Fixed-Income Funds by Fund Type**  
 This graph plots asset-weighted cumulative fund flows for US fixed-income funds, where the cumulative flows are expressed as a percentage of funds' AUM at the start of the sample period, February 1, 2020.

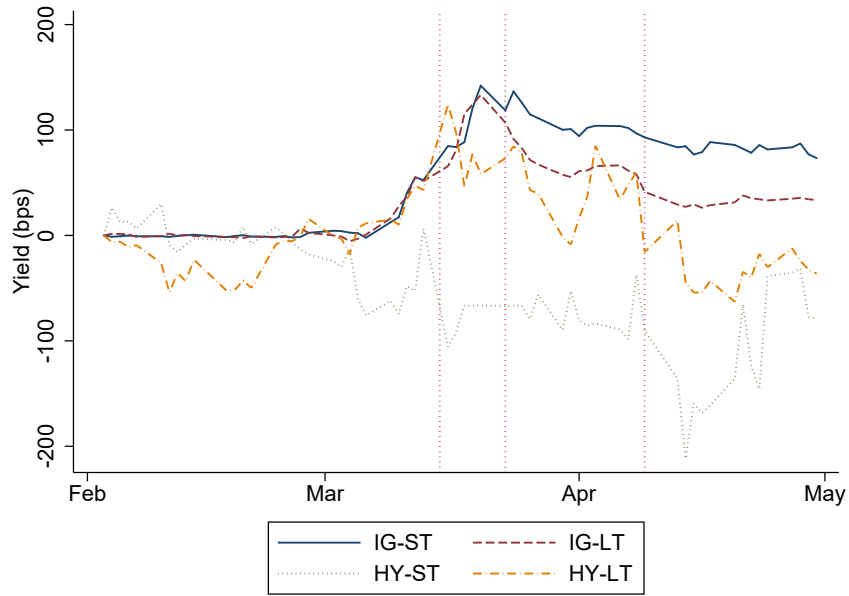


**Figure 6: Liquidation by Bond Type in March 2020**  
 This graph plots fund liquidation as a percentage of fund holdings at the end of February 2020 by bond type for US fixed-income funds in March 2020.



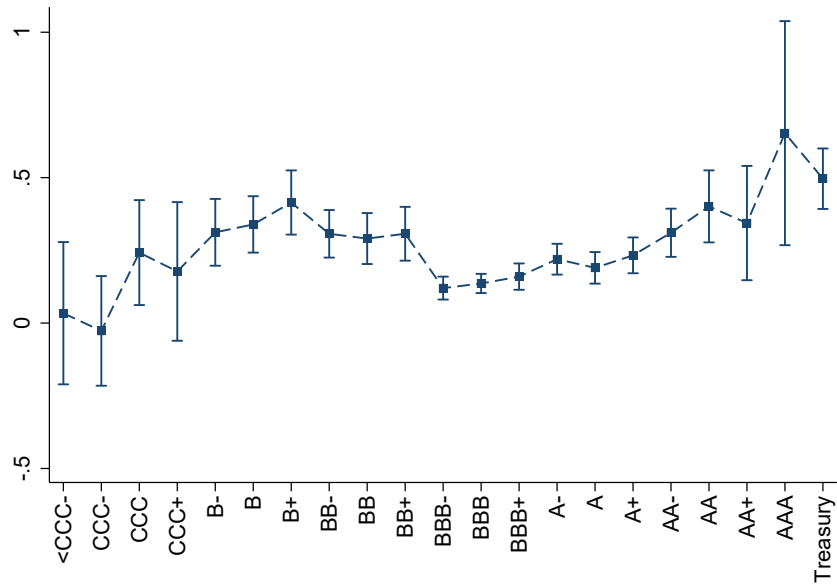
**Figure 7: Mutual Fund Holdings and Bond Yields**

This graph plots bond yields by quartiles of fixed-income mutual funds' holdings of the outstanding bonds. Bonds in the first quartile have the highest proportion of mutual fund ownership, while bonds in the fourth quartile have the lowest proportion of mutual fund ownership. Bond yields are demeaned by rating-date fixed effects. We also control for zero-trading days for corporate bonds.



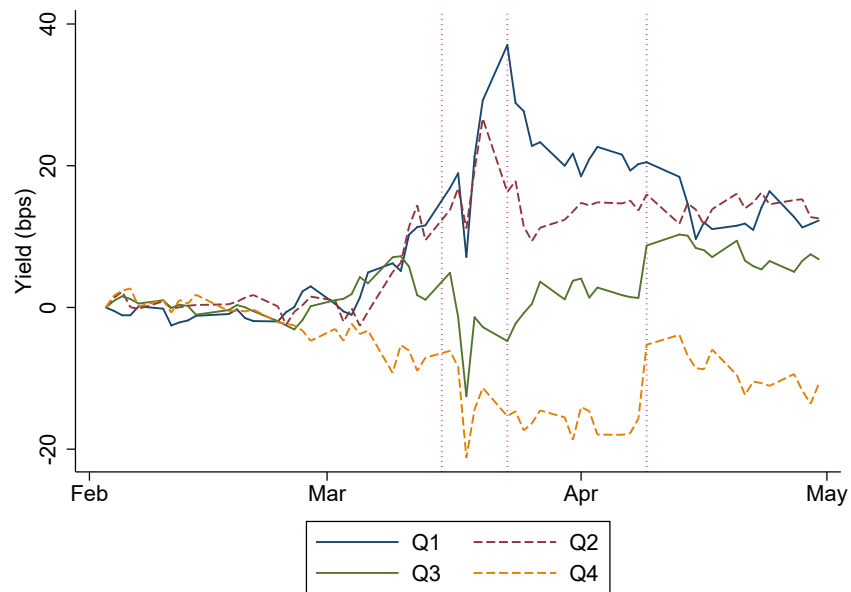
**Figure 8: Spread in Bond Yields Between the Top and Bottom Quartiles of Mutual Fund Ownership**

This graph plots the spread in bond yields between bonds in the top and bottom quartiles of mutual fund ownership. We plot the spreads in four subsamples split by rating and maturity buckets. IG and HY stand for investment-grade and high-yield, respectively. ST and LT stand for short-term ( $\leq 5$  years) and long-term ( $> 5$  years), respectively.



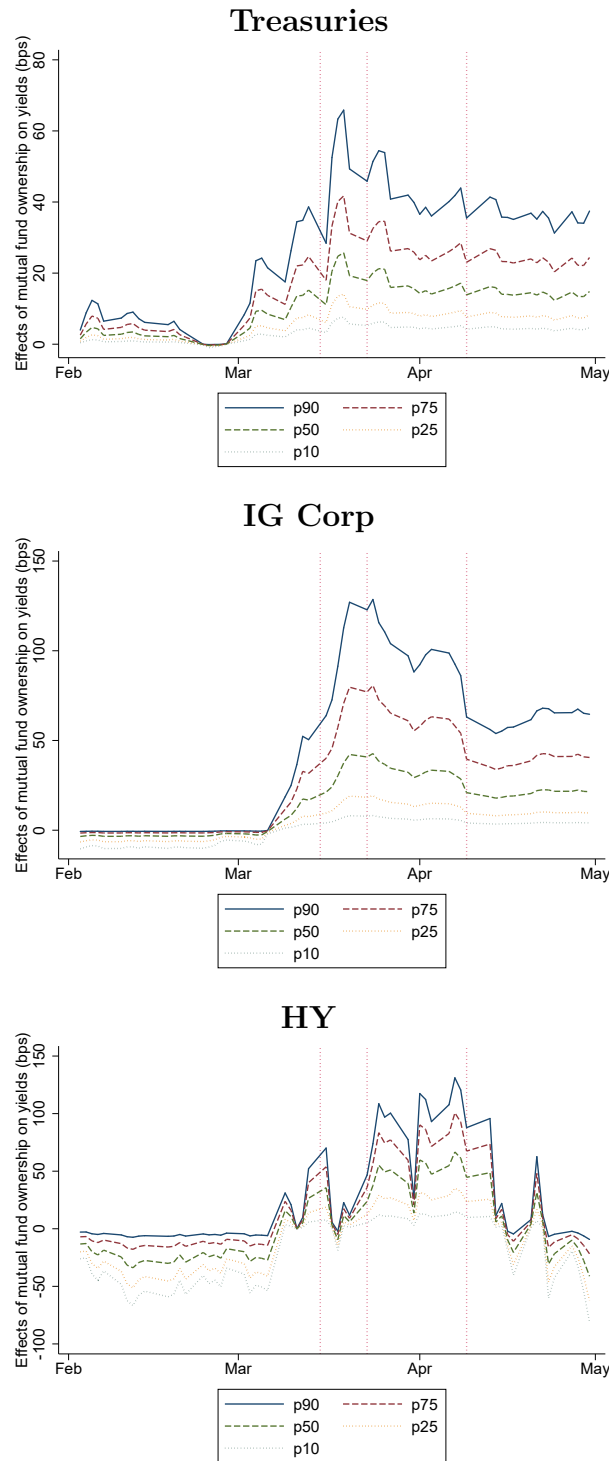
**Figure 9: Liquidation-Outflow Sensitivity**

This graph plots the liquidation-to-outflow sensitivities for different types of bonds. The regression model is defined in equation (3.1). The sample includes actively-managed open-end fixed-income funds in March 2020.



**Figure 10: Bond Yields and Pecking Order**

This graph plots bond yields by quartiles of their average liquidation rank in fixed-income mutual funds' portfolios. The liquidation rank for a given bond held by a given fund is the proportion of the funds' other holdings that are less liquid than the bond in question. Yields are demeaned by rating-date fixed effects.



**Figure 11: Effects of Mutual Fund Ownership on Bond Yields**

This graph shows the effects of mutual fund ownership on bond yields during the Covid-19 crisis. The lines correspond to the the differences between the actual yield and the counterfactual yield in the absence of mutual fund ownership for bonds at the 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, and 90<sup>th</sup> percentile of mutual fund ownership. The counterfactual bond yields in the absence of mutual fund ownership are estimated by running equation (3.8) and setting mutual fund ownership to zero.

**Table 1:** Summary Statistics  
Fund-level data

|                                 | mean   | sd    | p10     | p25    | p50    | p75    | p90    |
|---------------------------------|--------|-------|---------|--------|--------|--------|--------|
| Outflows                        | 2.551  | 8.089 | -8.088  | -0.754 | 2.377  | 6.183  | 12.760 |
| Return                          | -5.801 | 4.881 | -12.819 | -9.257 | -4.580 | -2.535 | -0.547 |
| Asset illiquidity               | 4.667  | 1.098 | 3.040   | 4.082  | 4.628  | 5.515  | 5.982  |
| Liquidity Provision Index (LPI) | 4.184  | 1.010 | 3.143   | 4.184  | 4.184  | 4.184  | 5.354  |
| Volatility                      | 0.727  | 0.560 | 0.000   | 0.350  | 0.708  | 0.929  | 1.377  |
| Yield                           | 0.475  | 0.723 | 0.171   | 0.203  | 0.262  | 0.435  | 0.727  |
| Maturity                        | 11.424 | 5.597 | 5.187   | 6.760  | 10.924 | 14.923 | 19.022 |
| Expense ratio                   | 0.848  | 0.282 | 0.517   | 0.717  | 0.848  | 1.005  | 1.137  |
| Turnover ratio                  | 0.993  | 1.320 | 0.150   | 0.290  | 0.600  | 0.993  | 2.030  |

Security-level data

|                              | mean   | sd    | p10    | p25    | p50    | p75    | p90    |
|------------------------------|--------|-------|--------|--------|--------|--------|--------|
| Return                       | -0.017 | 1.690 | -1.081 | -0.117 | 0.000  | 0.211  | 1.153  |
| Yield                        | 3.347  | 1.883 | 1.591  | 1.999  | 2.860  | 3.935  | 6.103  |
| Zero-trading days            | 0.309  | 0.278 | 0.045  | 0.087  | 0.217  | 0.500  | 0.773  |
| Outflows                     | 0.034  | 0.389 | -0.185 | -0.080 | -0.008 | 0.104  | 0.333  |
| Liquidation-adjusted outflow | 0.011  | 0.139 | -0.063 | -0.026 | -0.003 | 0.033  | 0.110  |
| ETF outflows                 | -0.019 | 0.532 | -0.367 | -0.203 | -0.082 | 0.097  | 0.548  |
| Mutual fund ownership        | 10.618 | 9.968 | 1.465  | 3.404  | 7.719  | 14.975 | 23.819 |

The top panel presents the summary statistics of a snapshot of US fixed-income mutual funds at the end of March 2020. “Outflows” are the percentage change in fund-level assets under management in March 2020. “Return” is the total fund return in March 2020. “Volatility” is the volatility of fund returns in March 2020. “Yield” is the average yield to maturity of a fund’s portfolio quoted in percent. “Maturity” is the average maturity of the bonds in the portfolio quoted in years. “Expense ratio” and “Turnover ratio” are quoted in percent. The bottom panel presents the summary statistics of a panel of Treasury and corporate bonds held by mutual funds. The frequency is daily. The sample period is from January 1, 2020 to April 30, 2020. “Return” is the daily bond return quoted in percent. “Yield” is the yield to maturity quoted in percent. “Zero-trading days” is the fraction of days in a month that a bond has no transaction. “Outflows” (“ETF outflows”) are the weighted average outflows at funds (ETFs) that hold the bond, where the weight is the share of holdings at the end of 2019. “Liquidation-adjusted outflow” is the outflow adjusted by funds’ empirical liquidation policy. “Mutual fund ownership” is the share of the bond outstanding that is held by mutual funds as of the end of 2019.

**Table 2:** Stock and Flow of Treasuries by Sector

|                                     | Flow    | Level     |
|-------------------------------------|---------|-----------|
| Rest of the world                   | -287.05 | 6690.81   |
| Mutual funds                        | -235.69 | 1310.90   |
| Households                          | -170.89 | 2080.83   |
| Local governments                   | -49.53  | 740.28    |
| Broker dealers                      | -19.47  | 229.51    |
| Foreign banking offices in U.S.     | -14.69  | 121.08    |
| Pension funds                       | -3.12   | 671.48    |
| Credit unions                       | -1.92   | 37.54     |
| ABS                                 | -1.01   | 33.03     |
| Closed-end funds                    | -0.76   | 3.17      |
| Banks                               | 2.55    | 704.08    |
| GSEs                                | 14.37   | 171.29    |
| Nonfinancial business               | 15.60   | 127.12    |
| Insurance companies                 | 17.01   | 368.70    |
| ETFs                                | 20.46   | 231.76    |
| Money market funds                  | 231.25  | 1036.54   |
| Federal Reserve and the US Treasury | 477.39  | -16477.96 |

This table presents the sector-level stock of Treasuries as of 2019Q4 and the sector-level flow of Treasuries in 2020Q1. The unit is in \$billion. The last row combines the accounts of the Federal Reserve and the US Treasury, where Treasuries issued by the US Treasury is reported as a negative holding level. Data source: Flow of Funds.

**Table 3:** Fixed-Income Mutual Fund Liquidations in 2020Q1

|        | Liquidation | % of initial position | % of outstanding | Trading volume |
|--------|-------------|-----------------------|------------------|----------------|
| T-bill | 12.5        | 62.2                  | .5               | 128.3          |
| T-note | 138.1       | 37.6                  | 1.4              | 461.9          |
| T-bond | 61.4        | 23.9                  | 2.6              | 68.5           |
| IG     | 96.1        | 13.6                  | 1.2              | 21.2           |
| HY     | 60.5        | 17.3                  | 3.2              | 11.8           |

This table presents statistics regarding fixed-income mutual funds' liquidations by bond type. Column 1 reports mutual funds' liquidations of each bond type in 2020Q1 in \$billion. Column 2 reports mutual funds' liquidations of each bond type as a percentage of their position at the end of 2019. Column 3 reports mutual funds' liquidation of each bond type as a percentage of the aggregate amount outstanding at the end of 2019. Column 4 reports the daily trading volume of each bond type in 2020Q1 in \$billion. Data source: CRSP, SIFMA.

**Table 4:** Liquidation-Outflow Sensitivity: Treasuries

|                     | (1)<br>T-bill<br>all | (2)<br>T-note<br>on-the-run | (3)<br>T-note<br>off-the-run | (4)<br>T-bond<br>on-the-run | (5)<br>T-bond<br>off-the-run |
|---------------------|----------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
| Outflows            | -0.061<br>[0.366]    | 1.008***<br>[0.090]         | 0.629***<br>[0.059]          | 1.509***<br>[0.141]         | 1.193***<br>[0.084]          |
| Control             | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Bond F.E.           | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Fund objective F.E. | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Observations        | 206                  | 3,630                       | 5,582                        | 1,344                       | 2,557                        |
| Adj. R-squared      | -0.002               | 0.101                       | 0.097                        | 0.127                       | 0.174                        |

This table presents the results of regressing bond-fund-level liquidations on fund outflows for different types of Treasuries as in equation (3.1). For each bond that is held by a fund at the end of February 2020, we calculate the percentage change in its quantity in that fund's portfolio from the end of February 2020 to the end of March 2020 to obtain bond-fund level liquidations. Outflows are at the fund level and denote the percentage change in fund-level AUM from the end of February 2020 to the end of March 2020. Controls include lagged fund size and fund returns.

**Table 5:** Pecking Order and Liquidation-Outflow Sensitivity

|                     | (1)<br>Open-end<br>All | (2)<br>Open-end<br>Active | (3)<br>Open-end<br>Passive |
|---------------------|------------------------|---------------------------|----------------------------|
| Outflows            | 0.268***<br>[0.016]    | 0.208***<br>[0.024]       | 0.224***<br>[0.035]        |
| Outflows*Rank       | 0.198***<br>[0.047]    | 0.386***<br>[0.060]       | 0.082<br>[0.151]           |
| Bond F.E.           | Yes                    | Yes                       | Yes                        |
| Fund objective F.E. | Yes                    | Yes                       | Yes                        |
| Observations        | 79,050                 | 37,945                    | 39,410                     |
| Adj. R-squared      | 0.067                  | 0.071                     | 0.050                      |

This table presents the results of regressing bond-fund-level liquidations on fund outflows interacted with bond-fund level liquidations rank as in equation (3.3). For each bond that is held by a fund at the end of February 2020, we calculate the percentage change in its quantity in that fund’s portfolio from the end of February 2020 to the end of March 2020 to obtain bond-fund level liquidations. Outflows are at the fund level and denote the percentage change in fund-level AUM from the end of February 2020 to the end of March 2020. Rank is measured by the relative liquidation rank of each bond in a fund’s portfolio.

**Table 6:** Effect of Fund Outflows on Bond Returns (Treasuries)  
(a) Imputed Outflows

|                    | (1)<br>T-bill<br>all | (2)<br>T-note<br>on-the-run | (3)<br>T-note<br>off-the-run | (4)<br>T-bond<br>on-the-run | (5)<br>T-bond<br>off-the-run |
|--------------------|----------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
| Imputed outflow    | -0.160<br>[0.159]    | 0.090<br>[0.330]            | 0.145<br>[0.187]             | -0.710<br>[2.251]           | -1.022**<br>[0.494]          |
| Control            | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Maturity-Time F.E. | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Bond F.E.          | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Observations       | 494                  | 3,334                       | 9,476                        | 624                         | 3,186                        |
| Adj. R-squared     | 0.823                | 0.986                       | 0.936                        | 0.998                       | 0.996                        |

(b) Liquidation-adjusted Outflows

|                              | (1)<br>T-bill<br>all | (2)<br>T-note<br>on-the-run | (3)<br>T-note<br>off-the-run | (4)<br>T-bond<br>on-the-run | (5)<br>T-bond<br>off-the-run |
|------------------------------|----------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
| Liquidation-adjusted outflow | -0.404<br>[0.280]    | 0.023<br>[0.667]            | 0.085<br>[0.689]             | -4.331<br>[5.718]           | -3.334***<br>[1.227]         |
| Control                      | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Maturity-Time F.E.           | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Bond F.E.                    | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Observations                 | 494                  | 3,296                       | 9,290                        | 624                         | 3,186                        |
| Adj. R-squared               | 0.825                | 0.986                       | 0.936                        | 0.998                       | 0.996                        |

This table presents the results of regressing daily security-level returns on the imputed outflows and liquidation-adjusted outflows as in equations (3.5) and (3.7) for Treasury securities. The sample period is from January 1, 2020 to March 31, 2020. The control variable is ETF outflows. The returns are expressed in basis points and the flows are expressed in percentage points of AUM.

**Table 7:** Effect of Fund Outflows on Bond Returns (Corporate Bonds)  
(a) Imputed Outflows

|                    | (1)       | (2)       | (3)       | (4)      |
|--------------------|-----------|-----------|-----------|----------|
|                    | Return    | Return    | Return    | Return   |
| Imputed outflow    | -2.517*** | -2.317*** | -2.399*** | -2.004** |
|                    | [0.724]   | [0.727]   | [0.744]   | [0.814]  |
| Control            | Yes       | Yes       | Yes       | Yes      |
| Rating-Time F.E.   | Yes       | Yes       | Yes       | Yes      |
| Maturity-Time F.E. | Yes       | Yes       | Yes       | Yes      |
| Issuer-Time F.E.   | No        | No        | No        | Yes      |
| Issuer F.E.        | No        | Yes       | No        | No       |
| Bond F.E.          | No        | No        | Yes       | Yes      |
| Observations       | 445,584   | 445,584   | 445,583   | 413,700  |
| Adj. R-squared     | 0.183     | 0.185     | 0.176     | 0.255    |

(b) Liquidation-adjusted Outflows

|                              | (1)       | (2)       | (3)       | (4)      |
|------------------------------|-----------|-----------|-----------|----------|
|                              | Return    | Return    | Return    | Return   |
| Liquidation-adjusted outflow | -6.825*** | -6.317*** | -6.467*** | -4.719** |
|                              | [2.023]   | [2.032]   | [2.077]   | [2.270]  |
| Control                      | Yes       | Yes       | Yes       | Yes      |
| Rating-Time F.E.             | Yes       | Yes       | Yes       | Yes      |
| Maturity-Time F.E.           | Yes       | Yes       | Yes       | Yes      |
| Issuer-Time F.E.             | No        | No        | No        | Yes      |
| Issuer F.E.                  | No        | Yes       | No        | No       |
| Bond F.E.                    | No        | No        | Yes       | Yes      |
| Observations                 | 445,523   | 445,523   | 445,522   | 413,639  |
| Adj. R-squared               | 0.183     | 0.185     | 0.176     | 0.256    |

This table presents the result of regressing daily security-level returns on the imputed outflows and liquidation-adjusted outflows as in equations (3.5) and (3.7) for corporate bonds. The sample period is from January 1, 2020 to March 31, 2020. The control variables include ETF outflows and the proportion of zero-trading days. The returns are expressed in basis points and the flows are expressed in percentage points of AUM.

**Table 8:** Macro Multiplier for Treasury Bonds

|                | (1)                  | (2)                  |
|----------------|----------------------|----------------------|
|                | Return               | Return               |
| Z              | 1.727***<br>[0.509]  | 1.732***<br>[0.512]  |
| GDP growth     | -4.974***<br>[1.339] | -4.978***<br>[1.345] |
| PC1            | 0.481<br>[0.593]     | 0.486<br>[0.596]     |
| PC2            |                      | -0.099<br>[0.498]    |
| Observations   | 104                  | 104                  |
| Adj. R-squared | 0.166                | 0.158                |

This table presents estimates of the macro multiplier for Treasury bonds using the Granular Instrumental Variables (GIV) approach. The dependent variable is the log change in Treasury bond prices implied by the 20-year zero-coupon Treasury yield, in which 20-year is chosen as the representative maturity for Treasury bonds. The main explanatory variable is the GIV, Z, as defined in equation (3.11). GDP Growth, PC1, and PC2 correspond to the quarterly GDP growth, and the first two principal components of the residuals in equation (3.10). The data is quarterly from 1993Q1 to 2018Q4. Standard errors in brackets are corrected for auto-correlation.

Internet Appendix of  
Mutual Fund Liquidity Transformation  
and Reverse Flight to Liquidity

## IA.1 Liquidity Transformation and Fund Outflows

This appendix analyzes the relationship between fund liquidity transformation and fund outflows in the data. Our first proxy for fund liquidity transformation is the average illiquidity of their asset portfolio. We measure fund asset illiquidity using the weighted average of haircuts incurred by \$1 invested in the fund’s portfolio. Intuitively, when assets are more illiquid, haircuts are higher so that less cash can be raised against them.<sup>26</sup> The upper panel of Figure IA.4 shows a binned scatter plot of fund outflows in March 2020 against their respective asset illiquidity in 2019Q4.<sup>27</sup> The positive relationship between the two variables suggests that fund outflows are indeed more pronounced for funds invested in more illiquid assets.

Funds’ asset illiquidity is closely tied to their liquidity transformation because it is the illiquid assets (on the asset side of the balance sheet) that are transformed into liquid fund shares (on the liability side of the balance sheet). Specifically, we measure fund liquidity transformation using the Liquidity Provision Index (LPI). Intuitively, the LPI captures how much more can be obtained by redeeming \$1 of fund shares relative to the direct liquidation value of the underlying assets. The more liquidity is transformed by a fund, the higher its LPI. We repeat the same binned scatter plot of outflows against fund LPI. The results shown in the lower panel of Figure IA.4 suggest that higher fund liquidity transformation in 2019Q4 came at the expense of larger outflows in March 2020.

Recognizing that funds may differ along dimensions other than their liquidity transformation, we repeat our analysis while holding a range of fund characteristics constant. Specifically, we regress cumulative outflows for fund  $j$  in March 2020 against its asset illiquidity and control for fund characteristics including volatility, return, yield, expense ratio, and turnover ratio in 2019Q4 (see equation (IA.1.1)). We denote the vector of fund-level controls with  $X_j$ . We also include a fixed effect  $\theta_{o(j)}$  for different investment objectives  $o(j)$ ,

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<sup>26</sup>Although funds do not directly trade in repo markets, repo haircuts can be seen as a proxy for illiquidity in general.

<sup>27</sup>Alternatively, we can use portfolio holding data in February 2020 to measure asset illiquidity. February 2020 data are closer to the Covid-19 crisis but have a smaller sample coverage.

so our results should be interpreted as a within fund-type effect that absorbs differences in fundamentals across asset classes. We present the results in Table [IA.1](#).

$$\text{Outflows}_j = \beta \text{Asset Illiquidity}_j + \gamma X_j + \theta_{o(j)} + \epsilon_j. \quad (\text{IA.1.1})$$

In Table [IA.1](#), we see that the coefficient on asset illiquidity remains significant at the 1% level regardless of how the model is saturated with controls and fixed effects. The fit of the model is also only minimally improved with the addition of explanatory variables.

$$\text{Outflows}_j = \beta \text{LPI}_j + \gamma X_j + \theta_{o(j)} + \epsilon_j. \quad (\text{IA.1.2})$$

We repeat the same specification with fund LPI in place of fund illiquidity (equation [\(IA.1.2\)](#)). The results in Table [IA.2](#) are consistent with fund liquidity provision leading to higher outflows in March 2020. In particular, when fund LPI increases by one standard deviation, outflows increase by  $1.01 * 0.816 = 0.824\%$  in the most restrictive specification in column 4.<sup>28</sup> This effect is economically important. In comparison, a one standard deviation increase in volatility increases outflows by 0.819% while a one standard deviation drop in expense ratio and turnover ratio are correlated with 0.183% and 0.537% higher outflows.<sup>29</sup>

Taken together, we have shown that mutual fund liquidity transformation contributed to the unprecedentedly large fund outflows during the Covid-19 crisis. These findings are consistent with [Falato, Goldstein and Hortacsu \(2021\)](#), who find similar patterns and who further decompose the factors that contributed to outflows from funds during the Covid-19 crisis.

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<sup>28</sup>In the sample of specification [\(IA.1.2\)](#), one standard deviation in the Liquidity Provision Index (LPI) is 1.010 (Table [1](#)), and the coefficient estimate for the effect of the LPI on outflow is 0.816 (Table [IA.2](#)).

<sup>29</sup>In the sample of specification [\(IA.1.2\)](#), one standard deviation in volatility, expense ratio, and turnover ratio are 0.560, 0.282, and 1.320, respectively (Table [1](#)). The corresponding coefficient estimates for their effects on outflows are 1.463, -0.648, and -0.407, respectively (Table [IA.2](#)).

## IA.2 GIV Data Appendix

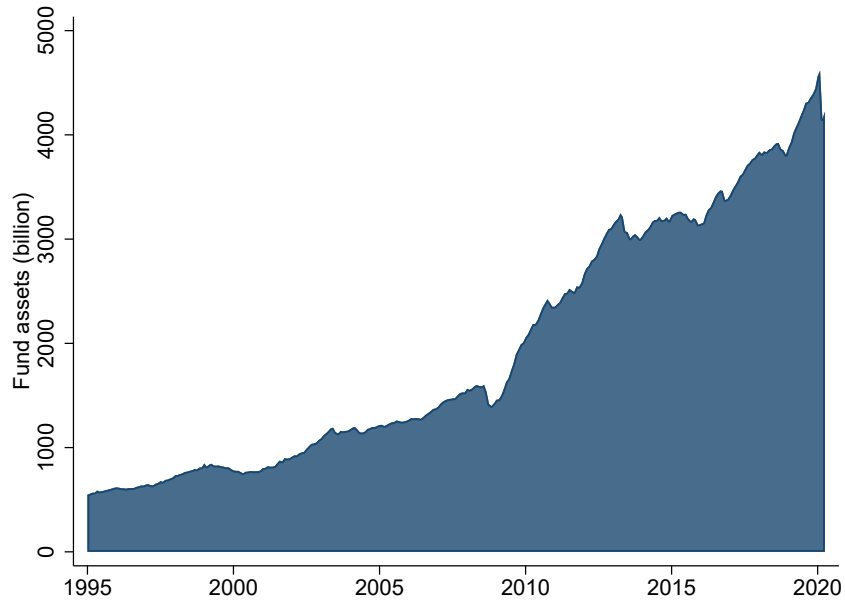
This data appendix describes our sector-level Treasury holdings data from the Flow of Funds.

Following [Gabaix and Koijen \(2021\)](#), we obtain flows and levels of Treasuries by sector from the Flow of Funds data from 1993 to 2018. We use unadjusted flows and market values when available for levels (LM). For money market funds and issuers of ABS, we use the estimated levels because market values are unavailable. Similar to [Gabaix and Koijen \(2021\)](#), we combine US banks, credit unions, foreign banks, and US banks in affiliated areas into an aggregate banking sector. Since ETFs and ABS issuers only appear from 2000 onward, we combine them with the mutual fund sector. We note that the results are not sensitive to this decision—dropping ETFs and ABS issuers from the sample would result in estimates of similar magnitude and statistical significance. Notice that [Gabaix and Koijen \(2021\)](#) exclude the nonfinancial corporate sector because they are the issuers in equity markets and may hold equities of other companies for strategic reasons. Since we focus on the Treasury market, we include the nonfinancial corporate sector in our sample.

As a result, our sample includes 18 sectors as shown in [Table IA.11](#). For each sector-quarter, we compute  $\Delta q_{j,t}$  as

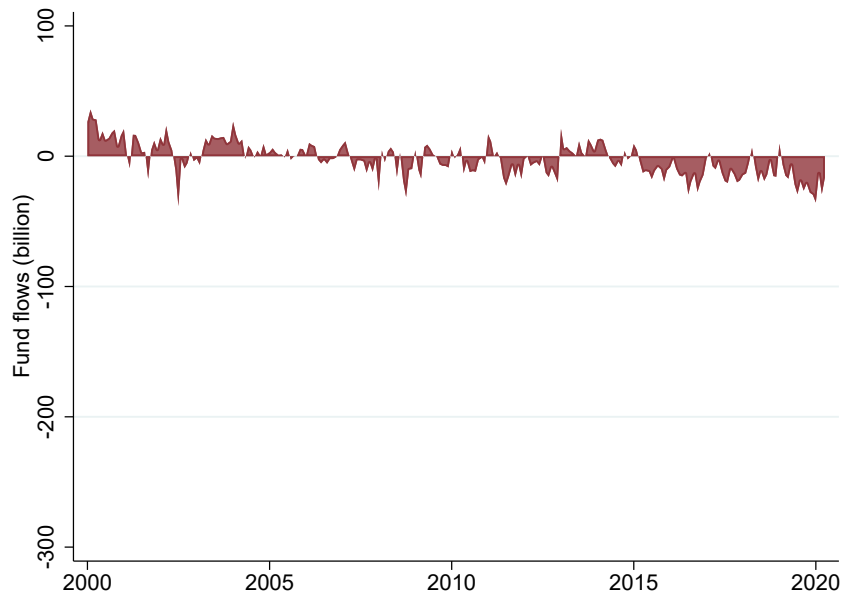
$$\Delta q_{j,t} = 100 * \frac{Flow_{j,t}}{Level_{j,t-1}}. \tag{IA.2.1}$$

The resulting data has a few large outliers. For instance, the household sector went from holding \$1,738 million in Treasuries in 2007Q4 to holding \$151,792 million in Treasuries in 2008Q1. To this end, we winsorize  $\Delta q_{j,t}$  at the 1% level for each sector.



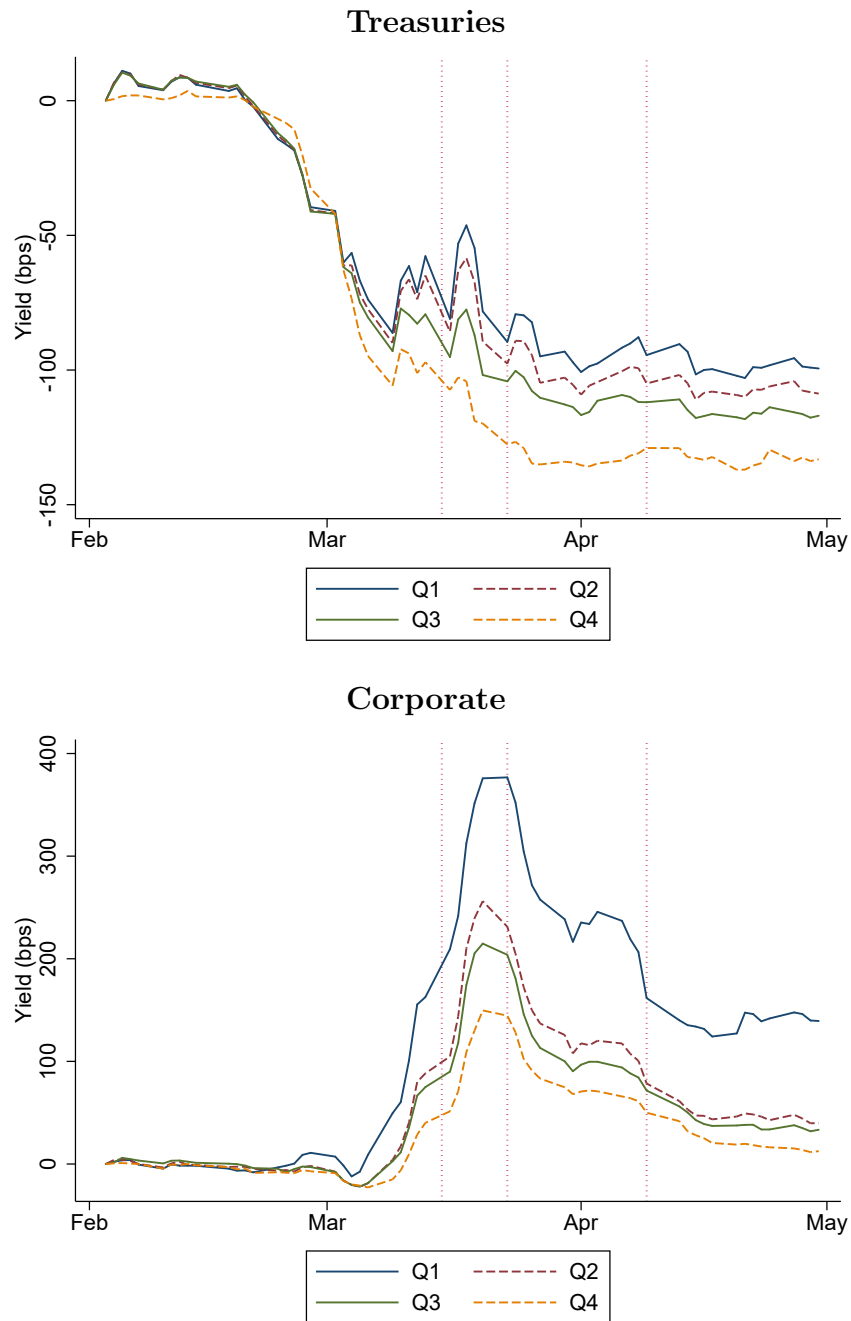
**Figure IA.1: Total Asset Size of US Fixed-Income Mutual Funds**

This figure plots the total asset size of US fixed-income mutual funds from 1995 to 2019. Data source: Morningstar and Flow of Funds.



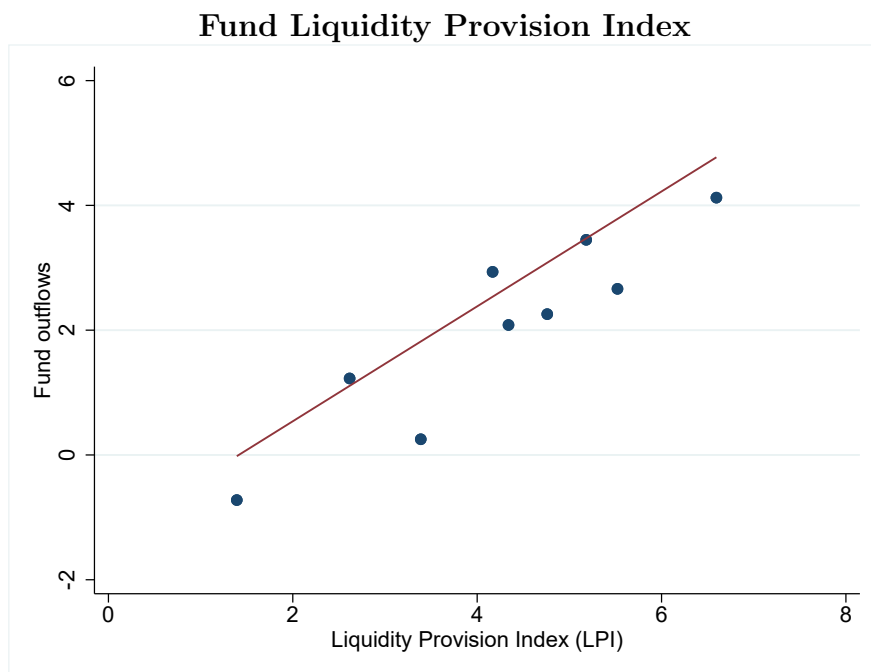
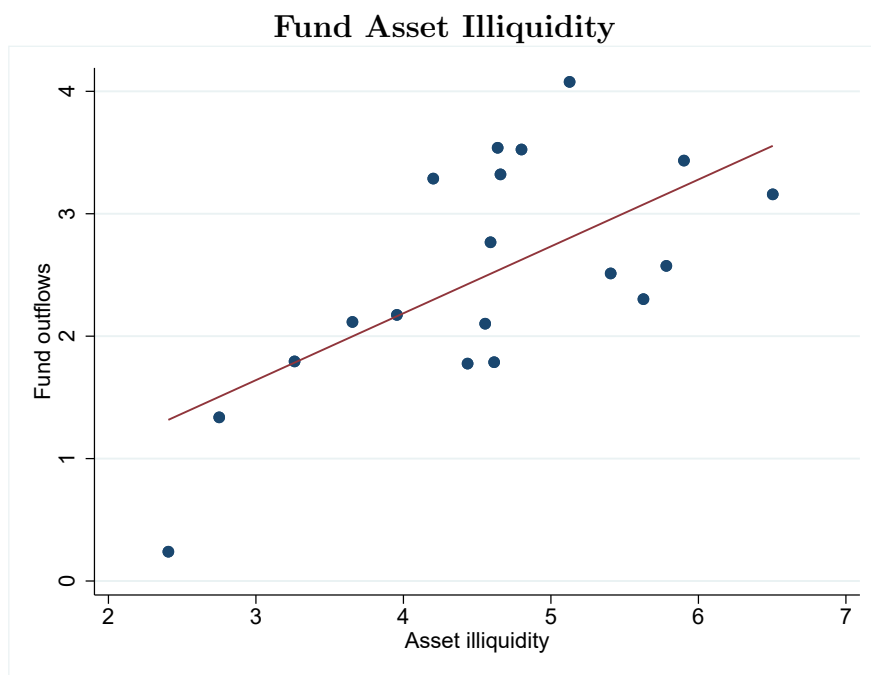
**Figure IA.2: Fund Flows to US Equity Funds**

This figure plots monthly fund flows to US equity mutual funds from 2000 to 2020. Data source: Morningstar.



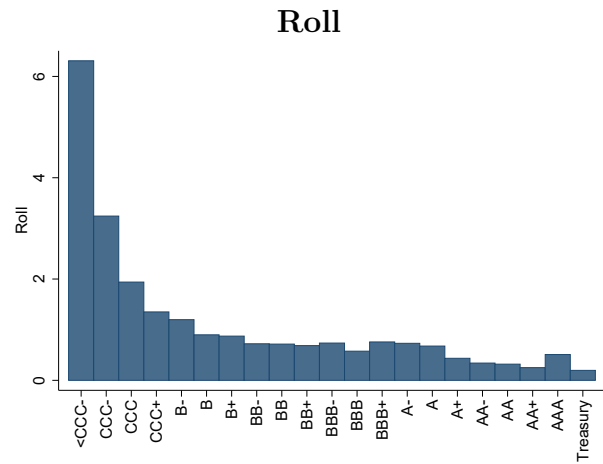
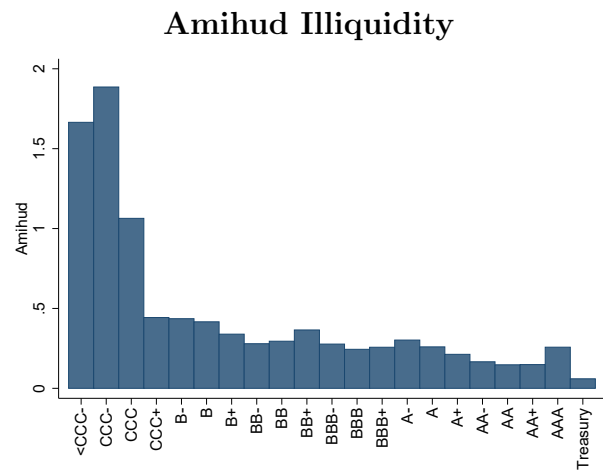
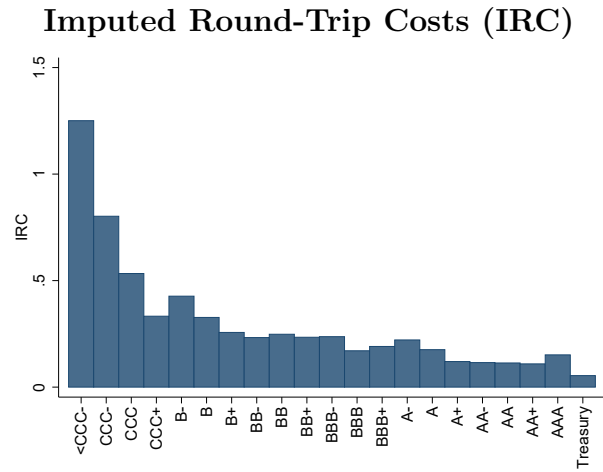
**Figure IA.3: Mutual Fund Holdings and Bond Yields (No Fixed Effects)**

This graph plots bond yields by quartiles of fixed-income mutual funds' holdings of the outstanding bonds. Bonds in the first quartile have the highest proportion of mutual fund ownership, while bonds in the fourth quartile have the least proportion of mutual fund ownership.



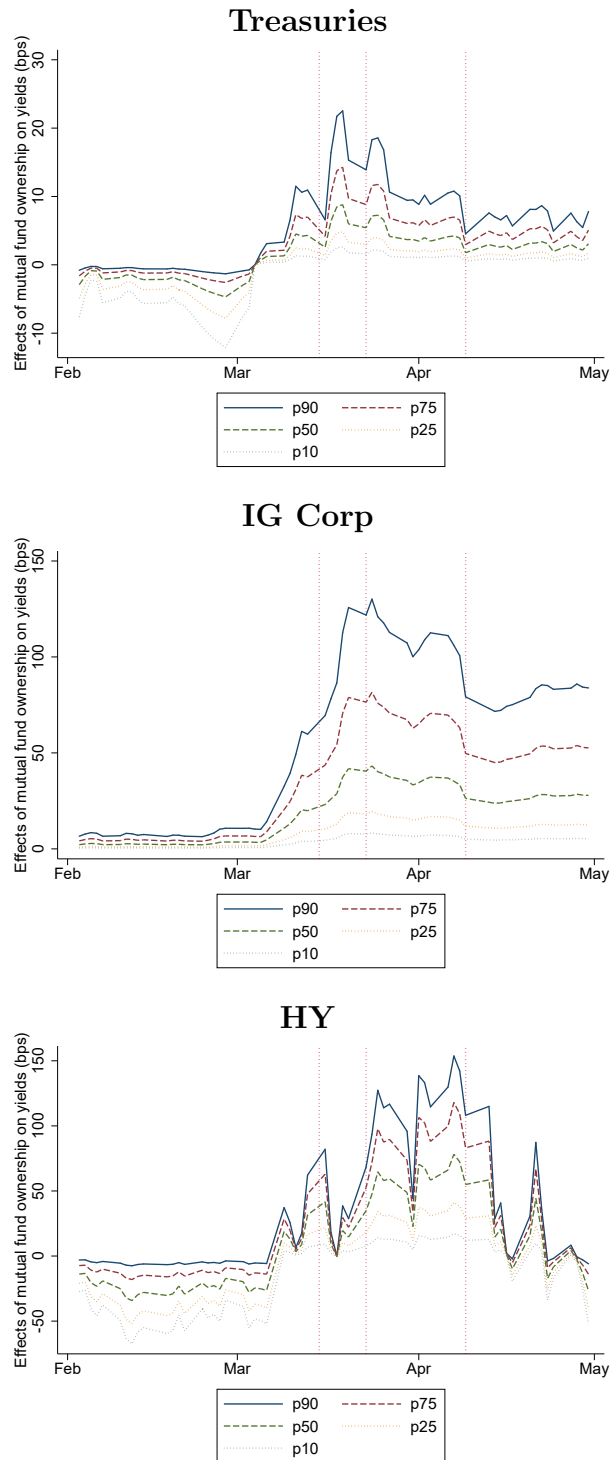
**Figure IA.4: Fund Illiquidity, Liquidity Provision, and Cumulative Fund Outflows**

The upper panel is a binned scatter plot of cumulative fund outflows in March 2020 against funds' asset illiquidity by the end of 2019. The lower panel is a binned scatter plot of fund outflows in March 2020 against funds' Liquidity Provision Index (LPI) by the end of 2019. The sample includes all US open-end fixed-income mutual funds.



**Figure IA.5: Liquidity Measure**

This graph plots measures of illiquidity by bond liquidation group. The sample period is 2019Q4. Imputed round-trip costs (IRC) is the difference between the highest and lowest price in a set of imputed round-trip trades. Amihud Illiquidity is the price impact of a trade per unit traded. Roll measures the auto-correlation of bond returns.



**Figure IA.6: Effects of Mutual Fund Ownership on Bond Yields (Robustness)**  
 This graph shows the effects of mutual fund ownership on bond yields during the Covid-19 crisis, controlling for a dummy that indicates whether the bond maturity is less than five years.

**Table IA.1: Fund Asset Illiquidity and Fund Outflows**

|                     | (1)                 | (2)                 | (3)                 | (4)                  |
|---------------------|---------------------|---------------------|---------------------|----------------------|
|                     | Outflow             | Outflow             | Outflow             | Outflow              |
| Asset illiquidity   | 0.546***<br>[0.092] | 0.545***<br>[0.092] | 0.537***<br>[0.094] | 0.564***<br>[0.096]  |
| Institutional       |                     | 0.137<br>[0.203]    | 0.135<br>[0.203]    | 0.283<br>[0.204]     |
| Index fund          |                     |                     | -0.259<br>[0.595]   | -0.614<br>[0.602]    |
| Volatility          |                     |                     |                     | 1.600***<br>[0.192]  |
| Yield               |                     |                     |                     | -0.179<br>[0.141]    |
| Expense ratio       |                     |                     |                     | -0.724*<br>[0.384]   |
| Turnover ratio      |                     |                     |                     | -0.474***<br>[0.077] |
| Fund objective F.E. | No                  | No                  | No                  | Yes                  |
| Observations        | 6,355               | 6,355               | 6,355               | 6,355                |
| Adj. R-squared      | 0.005               | 0.005               | 0.005               | 0.021                |

This table presents cross-sectional regressions of outflows in March 2020 on fund characteristics measured by the end of 2019 as equation (IA.1.1). “Asset illiquidity” is the weighted average of bonds’ haircuts in the fund portfolio. “Volatility” is the standard deviation of monthly return over the past five years. “Return” is the monthly return. “Yield” is the average income yield of the fund portfolio holdings. The sample includes all US fixed-income open-end mutual funds.

**Table IA.2:** Fund Liquidity Transformation and Fund Outflows

|                                 | (1)      | (2)      | (3)      | (4)       |
|---------------------------------|----------|----------|----------|-----------|
|                                 | Outflow  | Outflow  | Outflow  | Outflow   |
| Liquidity Provision Index (LPI) | 0.921*** | 0.921*** | 0.915*** | 0.816***  |
|                                 | [0.100]  | [0.100]  | [0.101]  | [0.103]   |
| Institutional                   |          | 0.159    | 0.156    | 0.282     |
|                                 |          | [0.202]  | [0.202]  | [0.204]   |
| Index fund                      |          |          | -0.274   | -0.698    |
|                                 |          |          | [0.586]  | [0.596]   |
| Volatility                      |          |          |          | 1.463***  |
|                                 |          |          |          | [0.190]   |
| Yield                           |          |          |          | -0.197    |
|                                 |          |          |          | [0.141]   |
| Expense ratio                   |          |          |          | -0.648*   |
|                                 |          |          |          | [0.382]   |
| Turnover ratio                  |          |          |          | -0.407*** |
|                                 |          |          |          | [0.078]   |
| Fund objective F.E.             | No       | No       | No       | Yes       |
| Observations                    | 6,355    | 6,355    | 6,355    | 6,355     |
| Adj. R-squared                  | 0.013    | 0.013    | 0.013    | 0.026     |

This table presents cross-sectional regressions of outflows in March 2020 on fund characteristics measured by the end of 2019 as equation (IA.1.2). “LPI” is the liquidity provision index introduced by [Ma, Xiao and Zeng \(2019\)](#). “Volatility” is the standard deviation of monthly return over the past five years. “Return” is the monthly return. “Yield” is the average income yield of the fund portfolio holdings. The sample includes all US fixed-income open-end mutual funds.

**Table IA.3:** Liquidation-Outflow Sensitivity: Corporate Bonds  
By remaining maturity

|                     | (1)<br>Maturity $\in (0, 5]$ | (2)<br>Maturity $\in (5, 10]$ | (3)<br>Maturity $> 10$ |
|---------------------|------------------------------|-------------------------------|------------------------|
| Outflows            | 0.157***<br>[0.013]          | 0.321***<br>[0.022]           | 0.207***<br>[0.021]    |
| Bond F.E.           | Yes                          | Yes                           | Yes                    |
| Fund objective F.E. | Yes                          | Yes                           | Yes                    |
| Observations        | 38,727                       | 22,608                        | 16,288                 |
| Adj. R-squared      | 0.133                        | 0.122                         | 0.066                  |

By maturity at issuance

|                     | (1)<br>Maturity $\in (0, 5]$ | (2)<br>Maturity $\in (5, 10]$ | (3)<br>Maturity $> 10$ |
|---------------------|------------------------------|-------------------------------|------------------------|
| Outflows            | 0.144***<br>[0.018]          | 0.240***<br>[0.015]           | 0.219***<br>[0.019]    |
| Bond F.E.           | Yes                          | Yes                           | Yes                    |
| Fund objective F.E. | Yes                          | Yes                           | Yes                    |
| Observations        | 14,648                       | 42,233                        | 20,743                 |
| Adj. R-squared      | 0.194                        | 0.117                         | 0.066                  |

By age

|                     | (1)<br>Age $\in [0, 1)$ | (2)<br>Age $\in [1, 5)$ | (3)<br>Age $\in [5, 10)$ | (4)<br>Age $> 10$   |
|---------------------|-------------------------|-------------------------|--------------------------|---------------------|
| Outflows            | 0.333***<br>[0.034]     | 0.214***<br>[0.013]     | 0.165***<br>[0.020]      | 0.124***<br>[0.010] |
| Bond F.E.           | Yes                     | Yes                     | Yes                      | Yes                 |
| Fund objective F.E. | Yes                     | Yes                     | Yes                      | Yes                 |
| Observations        | 10,714                  | 46,894                  | 16,283                   | 99,062              |
| Adj. R-squared      | 0.103                   | 0.112                   | 0.152                    | 0.198               |

This table presents a cross-sectional regression of bond-level liquidations on fund outflows as in equation (3.1) for different types of corporate bonds. Liquidations and outflows are measured as their percentage changes from the end of February to the end of March 2020. Controls include lagged fund size and fund returns.

**Table IA.4:** Summary Statistics of Outflows at Funds Hold On-the-run vs. Off-the-run Treasuries

| Outflows at funds that hold on-the-run Treasuries |        |       |        |        |        |       |       |
|---|--------|-------|--------|--------|--------|-------|-------|
|   | mean   | sd    | p10    | p25    | p50    | p75   | p90   |
| Outflows  | -0.691 | 9.200 | -7.334 | -3.016 | -0.218 | 2.679 | 7.073 |

| Outflows at funds that hold off-the-run Treasuries |        |       |        |        |        |       |       |
|--|--------|-------|--------|--------|--------|-------|-------|
|  | mean   | sd    | p10    | p25    | p50    | p75   | p90   |
| Outflows   | -0.756 | 9.456 | -7.419 | -3.020 | -0.265 | 2.358 | 7.073 |

This table presents summary statistics of monthly outflows in March 2020 for funds that hold on-the-run Treasuries and off-the-run Treasuries. “Outflows” are defined as percentage changes in the assets under management.

**Table IA.5:** Liquidation Policy: Treasury Breakdown By Maturity  
On-the-run

|                     | (1)      | (2)      | (3)      | (4)      | (5)      | (6)      |
|---------------------|----------|----------|----------|----------|----------|----------|
|                     | Two      | Three    | Five     | Seven    | Ten      | Thirty   |
| Outflows            | 1.391*** | 1.086*** | 0.867*** | 0.937*** | 0.999*** | 1.593*** |
|                     | [0.363]  | [0.252]  | [0.190]  | [0.179]  | [0.153]  | [0.147]  |
| Control             | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Bond F.E.           | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Fund objective F.E. | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Observations        | 338      | 484      | 860      | 747      | 1,200    | 1,183    |
| Adj. R-squared      | 0.069    | 0.099    | 0.098    | 0.139    | 0.091    | 0.136    |

Off-the-run

|                     | (1)     | (2)      | (3)      | (4)      | (5)      | (6)      |
|---------------------|---------|----------|----------|----------|----------|----------|
|                     | Two     | Three    | Five     | Seven    | Ten      | Thirty   |
| Outflows            | 1.394** | 1.457*** | 0.687*** | 0.423*** | 0.666*** | 1.193*** |
|                     | [0.556] | [0.300]  | [0.131]  | [0.081]  | [0.101]  | [0.084]  |
| Control             | Yes     | Yes      | Yes      | Yes      | Yes      | Yes      |
| Bond F.E.           | Yes     | Yes      | Yes      | Yes      | Yes      | Yes      |
| Fund objective F.E. | Yes     | Yes      | Yes      | Yes      | Yes      | Yes      |
| Observations        | 150     | 401      | 1,314    | 2,040    | 1,677    | 2,557    |
| Adj. R-squared      | 0.146   | 0.228    | 0.116    | 0.080    | 0.063    | 0.174    |

This table presents a cross-sectional regression of bond-level liquidations on fund outflows as in equation (3.1) for different types of Treasury securities. Liquidations and outflows are measured as their percentage changes from the end of February to the end of March 2020. Controls include lagged fund size and fund returns.

**Table IA.6:** Pecking Order and Liquidation-Outflow Sensitivity (IG vs. HY)

| IG                  |                        |                           |                            |
|---------------------|------------------------|---------------------------|----------------------------|
|                     | (1)<br>Open-end<br>All | (2)<br>Open-end<br>Active | (3)<br>Open-end<br>Passive |
| Outflows            | 0.246***<br>[0.016]    | 0.106***<br>[0.025]       | 0.223***<br>[0.027]        |
| Outflows*Rank       | -0.133***<br>[0.051]   | 0.246***<br>[0.072]       | -0.561***<br>[0.141]       |
| Bond F.E.           | Yes                    | Yes                       | Yes                        |
| Fund objective F.E. | Yes                    | Yes                       | Yes                        |
| Observations        | 43,766                 | 15,300                    | 27,209                     |
| Adj. R-squared      | 0.088                  | 0.101                     | 0.095                      |

| HY                  |                        |                           |                            |
|---------------------|------------------------|---------------------------|----------------------------|
|                     | (1)<br>Open-end<br>All | (2)<br>Open-end<br>Active | (3)<br>Open-end<br>Passive |
| Outflows            | 0.202***<br>[0.030]    | 0.193***<br>[0.034]       | 0.196***<br>[0.053]        |
| Outflows*Rank       | 0.693***<br>[0.084]    | 0.706***<br>[0.089]       | -7.615<br>[7.639]          |
| Bond F.E.           | Yes                    | Yes                       | Yes                        |
| Fund objective F.E. | Yes                    | Yes                       | Yes                        |
| Observations        | 19,876                 | 17,857                    | 1,943                      |
| Adj. R-squared      | 0.091                  | 0.092                     | 0.010                      |

This table presents the results of regressing bond-fund-level liquidations on fund outflows interacted with bond-fund level liquidations rank as in equation (3.3). For each bond that is held by a fund at the end of February 2020, we calculate the percentage change in its quantity in that fund's portfolio from the end of February 2020 to the end of March 2020 to obtain bond-fund level liquidations. Outflows are at the fund-level and denote the percentage change in fund-level AUM from the end of February 2020 to the end of March 2020. Rank is measured by the relative liquidation rank of each bond in a fund's portfolio.

**Table IA.7:** Effect of Fund Outflows on Bond Returns (Treasury w.o. Controls)  
**(a) Imputed Outflows**

|                    | (1)<br>T-bill<br>all | (2)<br>T-note<br>on-the-run | (3)<br>T-note<br>off-the-run | (4)<br>T-bond<br>on-the-run | (5)<br>T-bond<br>off-the-run |
|--------------------|----------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
| Imputed outflow    | -0.156<br>[0.157]    | 0.085<br>[0.330]            | 0.146<br>[0.186]             | -0.578<br>[2.291]           | -1.015**<br>[0.499]          |
| Control            | No                   | No                          | No                           | No                          | No                           |
| Maturity-Time F.E. | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Bond F.E.          | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Observations       | 494                  | 3,334                       | 9,476                        | 624                         | 3,186                        |
| Adj. R-squared     | 0.824                | 0.986                       | 0.936                        | 0.998                       | 0.996                        |

**(b) Liquidation-adjusted Outflows**

|                              | (1)<br>T-bill<br>all | (2)<br>T-note<br>on-the-run | (3)<br>T-note<br>off-the-run | (4)<br>T-bond<br>on-the-run | (5)<br>T-bond<br>off-the-run |
|------------------------------|----------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
| Liquidation-adjusted outflow | -0.395<br>[0.277]    | 0.010<br>[0.662]            | 0.079<br>[0.686]             | -4.057<br>[5.749]           | -3.297**<br>[1.251]          |
| Control                      | No                   | No                          | No                           | No                          | No                           |
| Maturity-Time F.E.           | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Bond F.E.                    | Yes                  | Yes                         | Yes                          | Yes                         | Yes                          |
| Observations                 | 494                  | 3,296                       | 9,290                        | 624                         | 3,186                        |
| Adj. R-squared               | 0.825                | 0.986                       | 0.936                        | 0.998                       | 0.996                        |

This table presents the result of regressing daily security-level returns on the imputed outflows and liquidation-adjusted outflows as in equations (3.5) and (3.7) for Treasury securities. The sample period is from January 1, 2020 to March 31, 2020. The returns are expressed in basis points and the flows are expressed in percentage points of the AUM.

**Table IA.8:** Effect of Fund Outflows on Bond Returns (Corporate Bonds w.o. Controls)  
**(a)** Imputed Outflows

|                    | (1)       | (2)       | (3)       | (4)       |
|--------------------|-----------|-----------|-----------|-----------|
|                    | Return    | Return    | Return    | Return    |
| Imputed outflow    | -2.680*** | -2.551*** | -2.661*** | -2.054*** |
|                    | [0.707]   | [0.710]   | [0.727]   | [0.795]   |
| Control            | No        | No        | No        | No        |
| Rating-Time F.E.   | Yes       | Yes       | Yes       | Yes       |
| Maturity-Time F.E. | Yes       | Yes       | Yes       | Yes       |
| Issuer-Time F.E.   | No        | No        | No        | Yes       |
| Issuer F.E.        | No        | Yes       | No        | No        |
| Bond F.E.          | No        | No        | Yes       | Yes       |
| Observations       | 452,355   | 452,355   | 452,354   | 420,629   |
| Adj. R-squared     | 0.180     | 0.183     | 0.174     | 0.253     |

**(b)** Liquidation-adjusted Outflows

|                              | (1)       | (2)       | (3)       | (4)      |
|------------------------------|-----------|-----------|-----------|----------|
|                              | Return    | Return    | Return    | Return   |
| Liquidation-adjusted outflow | -7.247*** | -6.946*** | -7.152*** | -4.896** |
|                              | [1.980]   | [1.988]   | [2.032]   | [2.222]  |
| Control                      | No        | No        | No        | No       |
| Rating-Time F.E.             | Yes       | Yes       | Yes       | Yes      |
| Maturity-Time F.E.           | Yes       | Yes       | Yes       | Yes      |
| Issuer-Time F.E.             | No        | No        | No        | Yes      |
| Issuer F.E.                  | No        | Yes       | No        | No       |
| Bond F.E.                    | No        | No        | Yes       | Yes      |
| Observations                 | 452,294   | 452,294   | 452,293   | 420,568  |
| Adj. R-squared               | 0.180     | 0.183     | 0.174     | 0.253    |

This table presents the result of regressing daily security-level returns on the imputed outflows and liquidation-adjusted outflows as in equations (3.5) and (3.7) for Treasury securities. The sample period is from January 1, 2020 to March 31, 2020. The returns are expressed in basis points and the flows are expressed in percentage points of the AUM.

**Table IA.9:** Effect of Fund Outflows on Bond Returns: Corporate Bond by Bond Age  
**(a)** Imputed Outflows

|                    | (1)          | (2)          | (3)       | (4)       |
|--------------------|--------------|--------------|-----------|-----------|
|                    | Age $\leq$ 1 | Age $\leq$ 1 | Age $>$ 1 | Age $>$ 1 |
| Imputed outflow    | -2.988       | -2.350       | -2.369*** | -2.272*** |
|                    | [2.063]      | [2.079]      | [0.757]   | [0.761]   |
| Control            | Yes          | Yes          | Yes       | Yes       |
| Rating-Time F.E.   | Yes          | Yes          | Yes       | Yes       |
| Maturity-Time F.E. | Yes          | Yes          | Yes       | Yes       |
| Issuer F.E.        | No           | Yes          | No        | Yes       |
| Observations       | 68,244       | 68,244       | 383,385   | 383,385   |
| Adj. R-squared     | 0.254        | 0.254        | 0.169     | 0.171     |

**(b)** Liquidation-adjusted Outflows

|                              | (1)          | (2)          | (3)       | (4)       |
|------------------------------|--------------|--------------|-----------|-----------|
|                              | Age $\leq$ 1 | Age $\leq$ 1 | Age $>$ 1 | Age $>$ 1 |
| Liquidation-adjusted outflow | -7.467       | -6.268       | -6.417*** | -6.162*** |
|                              | [5.671]      | [5.712]      | [2.124]   | [2.134]   |
| Control                      | Yes          | Yes          | Yes       | Yes       |
| Rating-Time F.E.             | Yes          | Yes          | Yes       | Yes       |
| Maturity-Time F.E.           | Yes          | Yes          | Yes       | Yes       |
| Issuer F.E.                  | No           | Yes          | No        | Yes       |
| Observations                 | 68,244       | 68,244       | 383,324   | 383,324   |
| Adj. R-squared               | 0.254        | 0.254        | 0.169     | 0.171     |

This table presents the result of regressing daily security-level returns on the imputed outflows and liquidation-adjusted outflows as in equations (3.5) and (3.7) for Treasury securities. The sample period is from January 1, 2020 to March 31, 2020. The returns are expressed in basis points and the flows are expressed in percentage points of the AUM.

**Table IA.10:** Macro Multiplier for Treasury Bonds (Robustness)

|                | (1)                  | (2)                  |
|----------------|----------------------|----------------------|
|                | Return               | Return               |
| Z              | 1.546***<br>[0.538]  | 1.555***<br>[0.549]  |
| GDP growth     | -4.804***<br>[1.353] | -4.813***<br>[1.363] |
| PC1            | 0.334<br>[0.611]     | 0.341<br>[0.619]     |
| PC2            | -0.090<br>[0.498]    | -0.090<br>[0.500]    |
| PC3            | 0.636<br>[0.570]     | 0.633<br>[0.574]     |
| PC4            |                      | -0.057<br>[0.623]    |
| Observations   | 104                  | 104                  |
| Adj. R-squared | 0.160                | 0.151                |

This table presents estimates of the macro multiplier for Treasury bonds using the Granular Instrumental Variables (GIV) approach. The dependent variable is the log change in Treasury bond prices implied by the twenty-year zero-coupon Treasury yield. The main explanatory variable is the GIV, Z, as defined in equation (3.11). GDP Growth, PC1, PC2, PC3, and PC4 correspond to the quarterly GDP growth, and the first four principal components of the residuals in equation (3.10). The data is quarterly from 1993Q1 to 2018Q4. Standard errors in brackets are corrected for auto-correlation.

**Table IA.11:** Sectors in GIV Data

| Sector  | Obs |
|---|-----|
| 1 Banks   | 104 |
| 2 Closed-end funds  | 104 |
| 3 Federal government retirement funds                                   | 104 |
| 4 Holding companies   | 104 |
| 5 Households and nonprofit organizations                                | 104 |
| 6 Life insurance companies  | 104 |
| 7 Monetary authority  | 104 |
| 8 Money market funds  | 104 |
| 9 Mutual funds  | 104 |
| 10 Nonfinancial business  | 104 |
| 11 Nonfinancial corporate business                                      | 104 |
| 12 Pension funds  | 104 |
| 13 Private pension funds  | 104 |
| 14 Property-casualty insurance companies                                | 104 |
| 15 Rest of the world  | 104 |
| 16 Security brokers and dealers   | 104 |
| 17 State and local government employee defined benefit retirement funds | 104 |
| 18 State and local governments  | 104 |