Liquidity-Sensitive Trading and Corporate Bond Fund Fire Sales

By Jaewon Choi* and Sean Seunghun Shin**

This Draft: April 2018

Abstract

We examine the extent to which investor redemptions drive fire sale price pressure in corporate bond markets. To identify price pressure, we employ a difference-in-differences approach whereby we exploit same-issuer bonds held by funds with differing outflows. Bond funds absorb investor redemptions using cash buffers and selectively trade liquid securities. Despite such liquidity management tactics, outflows cause significant price impacts for bonds held by low-cash funds and for bonds that are more susceptible to mispricing. Fire sale price impacts are also stronger during turbulent times—such as the "taper tantrum" of 2013—and have real effects by substantially increasing the cost of capital for firms that have to issue bonds during such periods. Low-cash funds represent an increasing fraction of the sector, suggesting mounting concerns over financial stability.

JEL Classification: G11, G12, G14

Keywords: Corporate bond fire sales; flow-induced trading; corporate bond funds; financial stability

---

* Department of Finance, University of Illinois Urbana-Champaign. Address: 515 E. Gregory Dr., Champaign, IL 61820. Email: jaewchoi@illinois.edu

** Department of Finance, Aalto University School of Business. Address: Runeberginkatu 22-24, Helsinki, Finland. Email: sean.shin@aalto.fi.

We would like to thank Elizabeth Berger, Jens Dick-Nielson, Wayne Ferson, Mark Flannery, Song Han, Inmoo Lee, Pedro Matos, Alex Zhou and seminar participants at the SEC Conference on the Financial Market Regulation, the 2016 China International Conference in Finance, the Young Scholars Nordic Finance Workshop, and the 2016 FMA annual meetings for helpful comments and suggestions. Earlier versions of this paper were circulated under the title "Is There Flow-Driven Price Impact in Corporate Bond Markets?" All errors are our own.

1. Introduction

Understanding the extent to which investor flows drive asset fire sales of corporate bonds has become an important issue for financial stability. Since the Great Recession, unprecedented amounts of money have poured into corporate bond funds. Asset managers and retail investors following this trend are increasingly shifting their portfolios towards riskier corporate bonds (Feroli et al., 2014). On the other hand, with stricter capital requirements, market liquidity has dried up due to the now-limited balance sheet capacity of dealer banks to provide liquidity.[1] Given this backdrop, Chen, Goldstein, and Jiang (2010) and Goldstein, Jiang, and Ng (2017) express a growing concern over fragility in mutual funds that hold illiquid assets such as corporate bonds, on the premise that liquidation costs due to flow-driven asset sales should be substantial for such asset classes. This is an important issue in corporate financing as well, as price disruptions can have real consequences for firms by increasing the cost of debt financing.

However, identifying flow-driven price impacts is empirically challenging because of endogeneity issues inherent to the relationship between fund trading and price changes. Funds have discretion over which securities to trade and any unobservable factors that might affect security prices will also affect a fund's trading decisions. This is why existing studies focus instead on the rather limited cases of asset sales that follow credit rating downgrades, whereby insurance companies have to rebalance their portfolios due to institutional and regulatory frictions associated with rating downgrades.[2] In contrast, there is no research yet showing price impacts due to flows out of bond mutual funds, despite the importance of such events in the finance literature and also in recent financial market developments.

One might argue that bond fund flows could simply exert heavy price pressure, given the widespread consensus in the equity fund literature that fund flows tend to induce forced trading and temporary price pressure.[3] Unlike what occurs with equity funds, however, investor flows do

---

[1] See, e.g., Bessembinder, Jacobsen, Maxwell, and Venkataraman (2017), Bao, O'Hara, and Zhou (2017), and Schultz (2017)

[2] Ellul, Jotikasthira, and Lundblad (2011), Ambrose, Cai, and Helwege (2012), Chen, Lookman, Schürhoff, and Seppi (2014), Bao, O'Hara, and Zhou (2017), Spiegel and Stark (2017), and Dick-Nielsen and Rossi (2017) all examine price pressure around rating changes.

[3] See, e.g., Coval and Stafford (2007), Frazzini and Lamont (2008), Lou (2012), Edmans, Goldstein, and Jiang (2012), Khan, Kogan, and Serafeim (2012), Cella, Ellul, and Giannetti (2013), among many others.

not necessarily force fund trading if bond funds take precautionary measures to buffer investor redemptions, knowing that liquidation costs can be substantial. Indeed, our results show that bond funds actively absorb investor liquidity needs using internal liquidity, which contrasts with the proportional trading that has been documented in equity mutual funds. We also show that bond fund trading is highly sensitive to market liquidity as funds selectively trade liquid bonds or securities in other liquid asset classes. Thus, to investigate these matters empirically, it is crucial to carefully establish a causal link between flow-driven sales and price pressure when funds can choose which securities to liquidate.[4]

The key idea in our identification strategy is to control for any time-varying information that might drive fund-trading decisions. For example, investors might request redemptions from funds upon receiving negative signals regarding the fundamentals of their bond holdings. Or fund managers might choose to sell bonds for which the outlook is negative. Such information-driven trading will contaminate the price impact of flow-driven trading, as bond prices will change when the negative information is finally reflected in market prices. Using difference-in-differences regressions, we isolate the effects of flow-driven trading by comparing bonds issued by the same firms but under differential investor outflows. Our treated bonds are held by funds with substantial outflows, whereas the control bonds are issued by the same firms as the treated bonds but held by funds that lack substantial outflows. This identification strategy, which exploits within-firm price reactions to fund trading, allows us to control for unobservable firm-specific information and isolate flow-induced price impacts.

Before we examine flow-driven price pressure exerted by corporate bond funds, we first document how funds absorb redemption demand from investors by trading in securities with varying degrees of liquidity. In particular, we find that in response to investor redemption requests funds do not, on average, liquidate corporate bond holdings in dollar-for-dollar fashion. Instead, these funds use cash buffers or trade securities in other liquid asset classes before trading corporate bonds. For every 1% of investor outflows, for example, funds' holdings in cash and non-corporate bonds (i.e., agency bonds) decrease by 1.78% and 0.98%, respectively, whereas their corporate

---

[4] Berger (2017) argues that, even for equity funds, fund trading is not orthogonal to corporate actions associated with the stocks that funds trade, suggesting that flow-induced trading is not truly exogenous to firm-level information.

bond holdings decrease by only 0.89%. This result contrasts with reported findings regarding equity funds, according to which they shrink stock holdings almost one for one to meet investor redemption requests.[5] Funds also maintain relatively high levels of liquidity buffers, holding more than 10% of their assets in cash on average. Furthermore, trading in funds in response to flows is highly sensitive to both internal and external liquidity. Specifically, flow-driven sales are much more pronounced for bonds that are held by low-cash funds and for bonds with high market liquidity.

This liquidity management story implies that funds are likely forced to trade only when they have relatively thin liquidity buffers.[6] We examine flow-induced price impacts on bonds held by low-cash funds, exploiting a unique feature of corporate bond markets in virtue of which firms often have multiple bonds held by funds with differing outflows. In a difference-in-differences regression setting, our treated group comprises bonds under extreme outflows based on the pressure measure of Coval and Stafford (2007), whereas the control group is composed of bonds of the same issuers, credit ratings, and bond option features with similar maturities but held by funds without significant outflows. Using difference-in-differences regressions, we find evidence consistent with flow-induced price pressure when low-cash funds experience significant investor flows. Bonds under price pressure experience significantly more negative returns than control bonds with identical firm-level fundamentals, followed by return reversal in the next quarter. Specifically, we document that our treated bonds have on average 35.4 bps lower returns than control bonds during the fire-sale quarters, which almost reverses in the next quarter. In contrast, we find no evidence of price impacts on corporate bonds held by funds with larger holdings in cash and cash-like securities.

We also present evidence showing that temporary price impacts, or divergence in prices between treated and control bonds, are due to fire-sale pressure, by focusing on the particular set of bonds that are most susceptible to mispricing. In particular, we examine the effect of arbitrage costs associated with trading strategies that might dampen price divergence. Since treated and

[5] See, e.g., Coval and Stafford (2007), Dyakov and Verbeek (2013), Khan, Kogan, and Serafeim (2012), and Lou (2012).

[6] Ellul, Jotikasthira, and Lundblad (2011) also find that price pressure following rating downgrades is concentrated in liquid bonds traded by insurance companies with stricter capital requirements.

matched control bonds have almost identical cash flows, arbitrageurs can implement a hedged trading strategy that is long in treated bonds under fire sale pressure and short in matched control bonds, which will mitigate the price impacts of fire sales. Our results indeed show that fire-sale price impacts are much more pronounced in treated–control bond pairs with greater arbitrage costs. Using triple interactions in difference-in-differences regressions, we show that price impacts are much more substantial when the volatility of return differences between treated and control bonds is high, as the volatility proxies risk in the long–short arbitrage strategy. Similarly, we also find that treated bonds whose matched control bonds are small issues or high-yield tend to exhibit greater price pressure. To the extent that small bond issues are difficult to locate and borrow and high-yield bonds are volatile, this latter result is also consistent with the presence of temporary price pressure due to flow-driven fire sales.

Although fire sale price pressure typically lasts for a relatively short time, it can have substantial real effects on debt financing costs when there is market stress. Market participants in bond offerings will learn information about new bond issues from secondary market prices of bonds of the same issuers or even peer firms. Thus, fire-sale pressure can create a spillover effect on the cost of capital, much like the mechanism described in Cespa and Foucault (2014). To examine the extent to which fire sales from low-cash funds negatively affect the prices of new bond issues, we focus on a recent episode of market distress: the 2013 taper tantrum.[7] We find that, during that period, cumulative abnormal returns on pre-existing bonds fall as low as -65 bps and revert slowly over the following weeks. More importantly, the offering yields of new bonds issued by firms whose other bonds are under fire sale pressure are, on average, 35 bps higher than bonds that are not. When such firms find themselves facing the possibility of having to issue new bonds because they are rolling over maturing bonds, we find even stronger effects; their offering yields of new issues are 84 bps higher for firms under fire sale pressure. These results suggest that

[7] On May 22, 2013, Federal Reserve Chairman Ben Bernanke testified to Congress that the Fed might begin tapering down the monthly pace of purchases later in 2013, which anecdotally triggered significant selloffs in fixed income markets.

price impacts due to bond fire sales are not just a side show; substantial outflows can disrupt bond markets with real consequences.

Our results have implications for the recent debate among regulators and policymakers over financial stability in the post-financial-crisis period. Recently, the SEC proposed new liquidity-management rules for mutual funds.[8] Notably, mutual funds now have to disclose asset illiquidity while also maintaining minimum holdings in highly liquid securities to prevent disruption of financial markets. Substantial outflows from bond funds can have real consequences for corporate financing, as shown by our main results. Our results also show that funds with low cash holdings (representing less than 5% of their assets) account for a substantial portion of corporate bond fund holdings: as of 2014, they hold more than 55% of corporate bonds in the aggregate corporate bond fund sector in our sample. As the portion of low-cash funds increases, adequate liquidity cushions will certainly help stabilize market prices, consistent with our results. It should also be noted that the benefits of such policies might not outweigh the potential costs. The mandatory cash holdings requirement will hurt fund performance. It can lead to unintended consequences, e.g., by distorting the risk-taking incentives of asset managers. It may be of interest to examine in future research the net benefits of such policies to overall financial stability.

This paper contributes to the literature on asset fire sales (Shleifer and Vishny 1992; Pulvino 1998; Mitchell, Pulvino, and Stafford 2004; Coval and Stafford 2007; Mitchell, Pedersen, and Pulvino 2007; Campbell, Giglio, and Pathak 2011; Ellul, Jotikasthira, and Lundblad 2011; Jotikasthira, Lundblad, and Ramadorai 2012; and Ben-David, Franzoni, and Moussawi 2012). There is also a growing body of literature on fire sales and price pressure in corporate bond markets. Manconi, Massa, and Yasuda (2012) show that investors sell more liquid corporate bonds when their securitized bond holdings are exposed to liquidity shocks. Ellul, Jotikasthira, and Lundblad (2011) document price pressure in corporate bonds driven by regulatory capital requirements for insurance companies. Bao, O’Hara, and Zhou (2017) show that, in a difference-in-differences setting, the price impacts of a rating downgrade are much stronger after the Volcker Rule was enforced. Helwege and Wang (2017) examine price pressure from issuing mega bonds in the corporate bond market.

[8] http://www.sec.gov/news/pressrelease/2015-201.html

Two contemporaneous studies are related to ours. Based on the idea that mutual funds provide liquidity transformation services to end-investors, Chernenko and Sunderam (2016) show that mutual funds' cash holdings play a key role in providing such services. Our paper differs from their study insofar as we focus on the trading of corporate bonds and its impacts on prices, while both studies provide consistent implications for our understanding of market-wide financial stability. Similar to our paper, Hoseinzade (2016) also examines price changes due to selling pressure from mutual funds. Without conditioning on fund cash holdings, Hoseinzade (2016) concludes that investor flows do not affect bond prices. The conclusion of our paper is different. We document substantial price pressure driven by mutual fund flows and show the importance of conditioning on fund liquidity in a difference-in-differences setting to identify flow-driven price pressure. We also document the real consequences of bond fire sales for corporate financing.

2. Data

2.1. Mutual Fund and Corporate Bond Data

Our sample consists of U.S. open-end corporate bond mutual funds from July 2002 through December 2014. We obtain data on mutual fund quarterly holdings from the Morningstar Direct database and on fund returns and characteristics from the Center for Research in Security Prices (CRSP) survivorship-bias-free mutual fund database. We use fund-level observations in our empirical exercises by value-weighting share-class-level variables within the same funds using net asset values.

We classify mutual funds as corporate bond funds when the Lipper objective code is A, BBB, HY, SII, SID, or IID, or the CRSP objective code starts with 'IC.' We exclude index funds, exchange-traded funds, and exchange-traded notes from our sample. Fund net asset values (*TNA*) should be at least \$1MM, with at least one year of holdings data and 10 distinct holdings available at some point in the past. We further require that $0.5 < \frac{TNA_{j,t}}{TNA_{j,t-1}} < 3$ for fund j in month t to eliminate funds with overly extreme changes in *TNA*. To focus on funds that invest largely in corporate bonds, we require that corporate bonds constitute the largest asset class in the previous quarter. As a result, 685 unique corporate bond funds remain in our final sample.

The data source for corporate bond pricing is the enhanced Trade Reporting and Compliance Engine (TRACE) database from the Financial Industry Regulatory Authority (FINRA). We use bond pricing data from 2005, since the coverage of the TRACE becomes comprehensive after February 2005.[9] To filter reporting errors in TRACE, we follow the procedures described in Dick-Nielsen (2009, 2014).[10] In addition, we obtain terms-and-conditions information from the Mergent Fixed Income Securities Database (FISD), including coupons, ratings, maturity, amounts outstanding, and other characteristics. We exclude convertible bonds and also bonds with time-to-maturity of less than one year. Our final bond-level sample after merging TRACE, FISD, and Morningstar data consists of 251,730 bond-quarter observations from 2005 through 2014.

2.2. Main Variable Construction

Our measure of monthly fund flows is constructed as follows:

$$flow_{j,t} = \frac{TNA_{j,t} - TNA_{j,t-1} * (1 + r_{j,t})}{TNA_{j,t-1}} \tag{1}$$

where $TNA_{i,t}$ is total net assets for fund *j* at the end of month *t* and $r_{j,t}$ is monthly returns for fund *j* over month *t*. We define quarterly flows as the sum of monthly flows during a quarter, following Coval and Stafford (2007).

A monthly return on corporate bond *i* during month *t* is computed as

$$r_{i,t} = \frac{P_{i,t} + AI_{i,t} + Cpn_{i,t}}{P_{i,t-1} + AI_{i,t-1}} - 1 \tag{2}$$

where $P_{i,t}$ is a clean price, $AI_{i,t}$ is accrued interest, and $Cpn_{i,t}$ is a coupon payment, if there are any. Since the majority of bonds do not trade on a daily basis, we define the month-end price $P_{i,t}$ as the last available daily price within five days of the end of month *t*, where the daily price is a trading-volume-weighted price for each day after excluding retail-sized transactions (less than

[9] The TRACE begins the full dissemination of bond transactions for the entire universe of corporate bonds as of Feb. 7, 2005. See http://www.finra.org/newsroom/2005/nasds-fully-implemented-trace-brings-unprecedented-transparency-corporate-bond-market.

[10] We also use the SAS codes available on Dick-Nielsen's website, and we add price-sequence-based filters (reversal and median filters) as suggested in Dick-Nielsen (2014) and Edwards, Harris, and Piwowar (2007). About 0.2% of our observations are removed from the reversal and median filters.

$100,000), following the procedures described in Bessembinder, Kahle, Maxwell, and Xu (2009). Definitions for all the variables used in this study are also detailed in Appendix A.

2.2 Summary Statistics

Table 1 provides sample statistics for fund-level (Panel A) and bond-level (Panel B) variables. Our sample funds maintain relatively high cash and cash-like holdings on average (10.33% of total net assets).[11] At the same time, the standard deviation of cash holdings is quite substantial (9.81%) and the bottom 25th–percentile firms have only 3.00% of cash holdings, suggesting that many funds can be forced to liquidate given substantial outflows. Panel B reports bond illiquidity measured as percentiles of zero trading days (*ZTD*) in a quarter, as in Chen, Lesmond, and Wei (2007). The average *ZTD* is 59.12% and the 75th percentile is 95.38%, indicating that these bonds are traded for approximately 40% of the days in a quarter, and more than 25% of the bonds are almost never traded in a quarter.

Figure 1 plots our sample funds' average holdings in corporate bonds (Panel A) and cash (Panel B) by percentages of their total net assets, quarterly from 2002 Q2 through 2014 Q4. Funds in our sample hold approximately 60% of their assets in corporate bonds. Cash holding ratios hover around 10%–12% of their assets.

3. Liquidity-Sensitive Trading by Mutual Funds

In a frictionless market with perfect liquidity, funds' portfolio decisions would not depend on investor flows. Funds would not pile up cash holdings either, since holding cash hurts fund performance. In this section, we examine the extent to which internal liquidity (i.e., cash buffers) and external liquidity (i.e., market liquidity) affect fund trading.

3.1. Trading by Corporate Bond Funds in Response to Flows

Table 2 shows the overall trading behavior of funds sorted on fund flows. Panel A shows how funds trade corporate bonds and use cash buffers in response to flows. In particular, Columns

[11] We categorize Treasury bonds, money market funds, and repurchase agreements as cash-like securities. See Appendix C for detailed descriptions of cash items.

(5) and (6) show that for low-decile funds the ratio of corporate bond holdings increases, while the ratio of cash holdings decreases. If these funds would adjust corporate bond holdings proportionally and would not use cash buffers given their outflows, changes in these ratios should be zero. Thus, Columns (5) and (6) suggest that funds sell disproportionally fewer corporate bonds and instead use cash reserves. Note also that flows vary significantly in the cross section (see Column 1), ranging from -13.84% to 23.33% per quarter, and thus funds experiencing substantial outflows likely to be forced to trade even with relatively high cash holdings.

In Table 2 Panel B we further examine fund trading behavior in corporate bonds across the flow deciles. We follow Coval and Stafford (2007) and examine how high-inflow versus low-inflow funds expand or shrink existing corporate bond holdings. Funds with extreme outflow indeed reduce or eliminate substantial portions of their holdings. For the lowest decile, funds reduce or eliminate 33% of existing holdings, whereas the highest-flow funds reduce or eliminate only 13%. In contrast, the extreme-outflow funds expand their holdings by only 4%, while the inflow funds expand by 19%. These results are largely consistent with Coval and Stafford's (2007) results insofar as funds tend to shrink or expand current holdings. At the same time, even extreme-decile funds keep over 50% of their holdings unchanged, a much higher fraction than Coval and Stafford (2007) reported for equity funds.[12] Thus, flow-induced trading in corporate bonds is concentrated in a smaller set of bond holdings that are potentially more liquid. In the next section, we further examine the extent to which fund trading is sensitive to bond liquidity and cash holdings.

3.2. Liquidity-Sensitive Trading by Corporate Bond Funds

3.2.1. Fund Trading at the Asset Class Level

We first examine how funds trade across asset classes of varying degrees of market liquidity in response to investor liquidity demand. In particular, we regress fund trades in corporate bonds, cash-like securities, and other asset classes separately on flows:

$$Trade_{j,t} = \alpha + \beta_1 Flow_{j,t} + \varepsilon_{j,t} \tag{3}$$

[12] For example, in Table 2 Panel B Coval and Stafford (2007) report that inflow and outflow funds constitute less than 30% of holdings.

where the variable, $Trade_{j,t} = \frac{AmtHold_{j,t}}{AmtHold_{j,t-1}} - 1$, is the aggregate trading of fund j at the end of quarter t in an asset class. The two main asset classes that we examine are corporate bonds and cash-like securities, which help us underscore the contrast between using internal liquidity and using the market liquidity of corporate bonds. We bundle all the other asset classes (i.e., agency bonds, asset-backed securities, and equity) into a single "other" category to reduce estimation noise, as most of our sample funds do not have positions in these asset classes (see Table 1). We run the regressions using fund-quarter-level observations and require funds at *t-1* to hold at least 1% of their total assets in the asset class under consideration. We also include Lipper-code-times-quarter fixed effects.

If funds engage in proportional scaling of asset allocations in response to investor flows, we should observe that β_1 equals one. If, on the other hand, funds resort to cash buffers to service investor liquidity demand, β_1 should be greater for cash-like securities. Likewise, if funds trade less in an asset class with lower overall liquidity (i.e., corporate bonds), we expect β_1 to be less than one for that asset class. We divide the sample into inflow and outflow funds to examine any differential fund trading behavior given inflows versus outflows.

In Panel A of Table 3, we report evidence showing that investors tend not to liquidate corporate bonds and use cash holdings to meet investor liquidity needs. As seen in Columns (1) and (2), for example, the coefficient on outflows β_1 is 1.784 for cash, while the same coefficient for corporate bonds is only 0.892. These coefficients are statistically different from one, with p-values of 0.00 for both cash-like securities and corporate bonds. Thus, funds do not liquidate corporate bonds proportionally but instead use cash buffers. As seen in Column (4) for the other asset classes, β_1 is statistically indistinguishable from one at conventional levels of significance. We find similar results for the inflow sample (Columns 6, 7, and 9), although β_1 is estimated to be much higher for cash because funds can simply pile up cash.

In Column (3) of Panel A, we interact flows with lagged cash holdings to examine the extent to which cash buffers mitigate fund liquidation of corporate bonds in response to outflows. We standardize cash holdings using an in-sample mean and standard deviation for easier interpretation of economic significance. The coefficient estimate on the interaction term shown in Column (3) is negative (-0.056) and also statistically significant at the 5% level, indicating that funds with high cash holdings further reduce the selling of corporate bonds. The coefficient estimate is also economically sizable, as a one-standard-deviation increase in cash holdings reduces the sensitivity of corporate bond trading to outflows by 6.3% (=0.056/0.888). The results reported in Panel A of Table 3 show that funds tend to use cash buffers and reduce the liquidation of corporate bonds to meet investor liquidity needs.

3.2.2. Fund Trading at the Individual Bond Level

In Panel B of Table 3, we further examine the effects of both internal and market liquidity on fund trading by exploiting rich bond-level data on corporate bonds. In particular, we regress funds' bond-level trades in corporate bonds on flows, using a regression specification similar to that in (3). We also include interactions between flows and a set of variables representing internal and market liquidity including cash holdings, zero trading days, and the Roll measure of illiquidity (*Roll*) as in Bao, Pan, and Wang (2011). We control for issuer-times-quarter fixed effects to control for unobservable firm-level information.

In Columns (1) through (4) of Table 3 Panel B, we report the results for the outflow sample. We find in Column (1) that the coefficient on outflows (β_1) is 0.779, which is statistically different from 1. Thus, funds liquidate only 78 bps of their corporate bond holdings for 1% outflows. Note that β_1 is estimated to be smaller than the β_1 estimate reported in Panel A, possibly because the bond-level regressions shown in Panel B place more weight on small bond holdings that are illiquid and funds try to avoid liquidating these bond issues in response to outflows.

Columns (2) and (3) of Panel B show the results of examining the effects of cash holdings and bond market liquidity on trading-to-flow sensitivity (i.e., the interaction term between *Flow* and *X*). Column (2) shows that the coefficient on the interaction between flows and cash holdings is -0.099 with a t-statistic of -3.01, indicating that low-cash funds liquidate more corporate bonds in response to outflows, while high-cash funds sell smaller fractions of corporate bonds. With a one-standard-deviation decrease in the cash ratio, the coefficient on flows increases by about 13.1%(=0.099/0.756). In Columns (3) and (4), we also find that funds sell fewer corporate bonds in response to outflows when these bonds are illiquid. Specifically, the interaction terms of *Flow* with *ZTD* in Column (3) and *Roll* in Column (4) are -0.059 and -0.105, respectively, and both estimates are highly statistically significant. With a one-standard-deviation increase in *ZTD* and *Roll*, the coefficients on flows decrease by about 7.9%(=0.059/0.744) and 13.2%(=0.105/0.797), respectively.

Columns (5) through (8) report largely similar results for the inflow sample. The coefficient on flow is even smaller, 0.474, as seen in Column (5), possibly because funds do not have to immediately purchase more bonds in response to inflows. We also find that funds with high cash holdings or illiquid corporate bonds reduce trading in corporate bonds, as indicated by negative coefficients on the interaction of flows with liquidity. Note also that inflow funds tend to open positions, for example, in new bond issues, instead of expanding existing positions (see Panel B of Table 2), which might also explain why the coefficient on flow is much smaller in Column (5) than the flow coefficient reported in Column (1).

In the online Appendix, we perform several robustness checks. For example, we show that our main results are robust to using bond trade measures based on market values. We also show that our results are robust to controlling for the fraction of bond amounts that are retiring in a given quarter, as trading-to-flow sensitivity can deviate from one because of reinvestment of proceeds from bond retirement. We find that our results are robust to controlling for retirement amounts.

In summary, the results reported above show that, unlike what evidence documented in previous studies of equity suggests, corporate bond mutual funds do not engage in proportional liquidation of investment holdings given investor liquidity demand. Instead, these funds absorb liquidity demand using cash buffers or selectively trading relatively liquid bonds.

4. Identifying Flow-Driven Price Impacts: A Diff-in-Diffs Approach

The results reported thus far suggest that funds absorb liquidity demand from investors using cash holdings. An important question is whether fund trading accompanied by significant outflows can exert fire sale price impacts on corporate bond prices even under active liquidity management. Before we discuss our identification strategy based on difference-in-differences regressions, we first explain how we measure fire-sale pressure.

4.1. Measuring Fire-Sale Pressure

We measure fire sale pressure for each bond in a manner similar to that of Coval and Stafford (2007) and Khan, Kogan, and Serafeim (2012). Specifically, we first calculate *Pressure*, the fraction of purchases by funds under severe inflows minus sales by funds under severe outflows:

$$Pressure_{i,t} = \frac{\sum_j \left(max\left(0, \Delta Holding_{i,j,t}\right) \middle| Flow_{j,t} > 90^{th} pct_t\right)}{AmtOutstanding_{i,t-1}} - \frac{\sum_j \left(max\left(0, -\Delta Holding_{i,j,t}\right) \middle| Flow_{j,t} < 10^{th} pct_t\right)}{AmtOutstanding_{i,t-1}} \quad (4)$$

where $Flow_{j,t}$ is the quarterly capital flows of fund *j* during quarter *t*, $AmtOutstanding_{i,t-1}$ is the lagged amount outstanding of bond *i*, and $\Delta Holdings_{i,j,t}$ is holding changes in bond *i* held by fund *j*. Flows are sorted quarterly within Lipper objective codes to calculate the 10th and 90th percentiles. We require that bonds be held by at least two funds to be included in the sample.

Likewise, we calculate *UPressure*, the fraction of trading by funds without severe flows:

$$UPressure_{i,t} = \frac{\sum_j \left(\Delta Holding_{i,j,t} \middle| 10^{th} pct_t \leq Flow_{j,t} \leq 90^{th} pct_t\right)}{AmtOutstanding_{i,t-1}} \quad (5)$$

Thus, *Pressure* measures bond-level fund trading in response to severe outflows, while *UPressure* measures funds' discretionary trading.

We focus mainly on bonds held by low-cash funds (funds with cash holdings that represent less than 5% of total net assets) to better isolate forced trading. In each quarter *t*, we then define fire-sale bonds as bonds held by low-cash funds with $Pressure_{i,t}$ below the 10^{th} percentile but with $UPressure_{i,t}$ in the middle four deciles (deciles four through seven). We also control for bond liquidity when sorting these bonds into *Pressure* and *UPressure* deciles, as Table 3 shows that funds liquidate disproportionally more liquid bonds. Specifically, in each quarter and fund we first rank bonds into two liquidity buckets (i.e., below and above the 50th percentile) based on zero trading days of the previous quarter and further sort them into *Pressure* and *UPressure* deciles within each liquidity bucket.

4.2. Difference-in-Differences Regressions

Identifying flow-driven price impacts is empirically challenging because fund trading and price changes can be affected by information that is unavailable to econometricians. Although fund flows are driven largely by past performance (see, e.g., Appendix B),[13] funds still can choose which bonds to sell given outflows. For example, faced with large redemption requests, a fund will sell bonds with negative outlooks, the prices of which will decline as negative news realizes.

We employ a difference-in-differences approach to address this issue by exploiting a unique feature of corporate debt financing. It is common for corporations to have multiple bond issues outstanding. Our main idea is to compare two distinct bonds that are issued by the same firm but are held by two distinct mutual funds with unequal fund flows. Since these bonds share the same firm-level fundamentals, any unobservable, firm-specific information will be controlled for by comparing these two bonds. We further match bonds from the same issuers based on bond-level characteristics that would affect relative pricing, including maturity, rating, and other bond features. Differential price changes in such bonds held by mutual funds with unequal outflows enable us to identify flow-driven price impacts irrespective of information-driven trading.

Specifically, the treatment group consists of bonds under file sales, as defined in Section 4.1. We construct the control group by matching treated bonds based on the following three criteria: (a) the bonds should be issued by the same firm, (b) they should have the same credit rating and option features including call, put, and sinking fund provisions, and (c) the difference in time-to-maturity between the treated and control bonds should be less than one year. If there are multiple control bonds satisfying these conditions, we pick two bonds with bond ages closest to the age of the treated bond.

4.2.1. Difference Tests between Treated and Matched Control Bonds

Table 5 Panel A provides summary statistics for the treatment, control, and non-treatment groups for the last quarters prior to fire-sale (i.e., event) quarters. The matching is performed one quarter before the event quarters. The treatment group consists of 473 bonds issued by 433 firms

[13] In Table A-1 in the Appendix, we show that fund flows are driven largely by past performance.

and the control group consists of 639 bonds (issued by the same firms in the treatment group). The non-treatment group consists of all other sample bonds held by the low-cash funds. In Panel A, we find that firms in the treatment group are larger than those in the non-treated group (see issuer-level characteristics). This is expected, because firms are by construction required to have multiple bonds outstanding and larger firms are more likely to have more bond issues.

Panel A also shows that the treated and control group bonds are similar along many key dimensions of bond and mutual fund characteristics. For example, the average values of the Roll illiquidity measures are 0.0091 and 0.0096 for the treated and control groups, respectively, and the difference is not statistically significant. We find similar results for average rating, for which the mean and median tests do not reject the equality of the two groups. (Note that treated bonds can have multiple matched control bonds and so their rating differences are not necessarily zero even though we match on ratings.) In comparison, we find that bonds in the treatment group tend to be larger and younger with longer times-to-maturity. However, these differences are not substantial in magnitude. The average difference in time-to-maturity, for example, is approximately 0.65 years (around 8 months), which does not seem to challenge our identification strategy. For robustness, we later include these variables in difference-in-differences regressions as controls. We also find that mutual fund holders of treated and control group bonds are not significantly different with respect to total net assets, the number of corporate bonds held, or cash holding ratios, as can be seen in the last three rows of Panel A.

As seen in Table 4 Panel B, we also test for equality in returns between the treatment and control groups during quarters prior to fire-sale quarters to examine any differential pre-event trends in returns. The various tests show that pre-event returns on bonds in the two groups are almost identical and are not statistically significant in any of the four quarters before fire-sale quarters. As seen in the bottom row, for example, the average monthly returns during the four quarters are 0.71% and 0.68% for the treatment and control groups, respectively, and the p-values are 0.35 and 0.31. These results are expected, as these bonds are same-issuer bonds.

4.2.2. Difference-in-Difference Regressions: Empirical Results

In Table 5, we estimate the following regression model:

$$R_{i,t} = \alpha + \sum_{n=-1}^{2} \beta_n Q(n)_{i,t} \cdot Treat_i + \sum_{n=-1}^{2} \gamma_n Q(n)_{i,t} + ctrl_{i,t} + \varepsilon_{i,t} \tag{6}$$

where $R_{i,t}$ is a monthly return on bond i in month t, $Treat_i$ is an indicator variable for the treatment group bonds, and $Q(n)_{i,t}$ is a dummy variable indicating the nth quarter from an event quarter (i.e., fire-sale quarter) for bond *i* in month *t*. For example, $Q(-1)_{i,t}$ is equal to 1 if month *t* belongs to the last quarter before the fire-sale quarter.[14] We also include issuer-times-month fixed effects to control for any monthly frequency issuer-level unobservable variables,[15] which might drive funds' liquidation decisions and bond prices. In addition, we control for bond-level fixed effects as well as bond-level characteristics $ctrl_{i,t}$. The standalone $Treat_i$ dummy variable is subsumed by the bond fixed effects. Our regression sample includes monthly observations from four quarters prior to the treatment quarter through two quarters after the treatment. Finally, our sample requires that both the treated bond and at least one of its control bonds should have returns available in month t.

Table 5 shows the estimation results for Equation (6). In Panel A, the results reported indicate significant price pressure impacts from fire sales. As seen in Column (1), the coefficient estimate on $Q(0) \cdot Treat$ is negative (-0.118) and statistically significant at the 5% level, showing that treated bond returns are 0.118% lower per month during the fire-sale quarter (totaling 0.354% for the quarter) compared with control bonds. In the next quarter, most of the temporary price pressure reverses, as shown by the positive coefficient estimates on $Q(1) \cdot Treat$, which is statistically significant at the 5% level and also shows that treated bond returns are 0.114% higher per month. In the following quarter, $Q(2)$, returns on treated bonds are not statistically different from those matched on control bonds, suggesting that the price pressure effect is temporary and almost non-existent after $Q(2)$. Column (2) controls for bond characteristics including time-to-maturity, zero trading days, bond age, and amounts outstanding and the results shown are qualitatively similar to those listed in Column (1).

One important assumption in our difference-in-differences identification strategy is that information-driven trading does not differentially affect treated and control bonds. Although our

[14] We use quarter-by-quarter event dummy variables, as mutual fund holdings data are available quarterly.

[15] The quarter dummies are not subsumed by issuer-time-month fixed effects because the dummy variables indicate event time, not calendar time.

identification strategy controls for firm-level channels by matching the bonds based on issuer, rating, and maturity, it is possible that funds holding treated bonds possess negative private information and liquidate the bonds earlier than funds holding control bonds. To investigate this possibility, we examine regression coefficients on the quarter dummies (i.e., $Q(0)$, $Q(1)$, and $Q(2)$). If fire sales are driven by private information available to funds holding treated bonds, the coefficient estimates on $Q(1)$ and $Q(2)$ should be negative and coefficient estimates of treated bond returns (i.e., $Q(1) \cdot Treat + Q(1)$ and $Q(2) \cdot Treat + Q(2)$) should equal zero, so that the negative price response in $Q(0)$ becomes permanent. We find that the coefficient estimates on $Q(1)$ and $Q(2)$ are all indistinguishable from zero, which rules out the possibility that sales by funds holding treated bonds are driven by private information about the bonds. Note that the coefficient estimate on $Q(0)$ is positive, which suggests that, given severe outflows, funds liquidate bonds that otherwise yield positive returns, perhaps because these bonds are easier to sell and funds want to lock in gains.

In Columns (3) and (4) of Table 5, we provide difference-in-differences regression results using treated bonds held by high-cash funds (those whose cash holdings are greater than 5%). Our results show that when funds have relatively high cash cushions, bonds that are sold by funds with severe outflows do not experience temporary price pressure. For example, the coefficients on the interaction terms between the treatment dummy and quarter dummies are neither large in magnitude nor statistically significant at conventional levels. These results are consistent with our previous results, indicating that funds tend to use cash buffers to absorb investor liquidity demand, so that fund trading is not particularly forced and does not exert significant price pressure.

In Table 5 Panel B, we examine monthly price impacts during the event quarter and the following quarter, using monthly event dummy variables instead of quarterly dummy variables. Consistent with the results provided in Panel A, we find the evidence of fire-sale price impacts followed by reversal only for bonds held by low-cash funds. In both Columns (1) and (2), the coefficient estimates on the interaction between the treated dummy and monthly event dummies, $M(0) \cdot Treat$ and $M(1) \cdot Treat$, are statistically significant at the 5% level, indicating that temporary price pressure is especially pronounced in $M(0)$ (the last month of the event quarter) and $M(1)$ (the first month after the event quarter).

In Figure 2, we visualize the results shown in Table 5 Panel B by cumulating the regression coefficient estimates on the interaction terms between the treatment dummy and the month dummies. We also report, in Table 6, the cumulative coefficient estimates and their t-statistics. For bonds held by outflow funds with low cash holdings, we find significant temporary price impacts in $M(0)$, which reverses in $M(1)$. In $M(0)$, the cumulative estimates reaches -0.329%, which is statistically significant at the 5% level. In contrast, we find no cumulative return pattern that is consistent with price pressure due to fire sales for bonds held by outflow funds with high cash holdings.

4.2.3 Fire-Sale Price Pressure and Limits to Arbitrage

The results reported in the previous section show that significant price divergence between treated and control bonds occurred in our sample. Since treated and matched control bonds have almost identical cash flows, one could implement a hedged trading strategy that is long in treated bonds under pressure and short in control bonds to gain arbitrage-like profits when prices converge. If price divergence is caused by temporary price pressure from fire sales as opposed to information-driven sales, we should observe wider price divergence in matched treated–control bond pairs for which the arbitrage strategy is difficult to implement.

In Table 7 we examine whether price pressure is stronger for bonds with high arbitrage costs. Similar to Equation (6), we regress bond returns on the triple-interaction of the event and treated dummies with indicator variables proxying for arbitrage costs. In particular, we employ three proxies for arbitrage costs. The first is the volatility of return differences between treated and control bonds, as the high volatility of arbitrage strategies exposes arbitrageurs to significant risk (Shleifer and Vishny 1997). We estimate the volatility using four quarters of monthly return data prior to one quarter before the event quarter.[16] The second proxy measure is the issue size of control bonds, which we assume captures shorting costs because smaller bonds are difficult to locate and more difficult to borrow, according to Asquith, Au, Covert, and Pathak (2013). The third proxy is whether treated (and also control) bonds are high-yield rated bonds, as such bonds

[16] To avoid issues with asynchronous trading, we estimate volatility using data that skips one quarter from the event quarter.

incur higher borrowing costs (Asquith, Au, Covert, and Pathak 2013) and also have higher volatility. We employ dummy variables D_i for these three proxies in difference-in-differences regressions. Specifically, the dummy variable for high volatility takes the value of one if the volatility of return differences is in the top 20%, the dummy for small issue size takes the value of one if the issue size of control bonds is in the bottom 20%, and the dummy for high yield takes the value of one if bonds are high-yield rated.

Table 7 provides the estimation results using the triple interaction with dummy variables for the three arbitrage cost proxies. To save space, we report regression coefficients only on the triple interactions and omit all other combinations of interaction terms. Columns (1) and (2) show that fire sale price impacts are much stronger on treated bonds if the volatility of return difference between treated–control pairs is particularly high. As seen in Column (1), for example, the coefficient estimate on $M(-1)_{i,t} \cdot Treat_i \cdot D_i$ is negative (-0.922) and statistically significant at the 10% level, indicating that differences in returns on treated and matched control bonds in the second month of the event quarter, $M(-1)$, are 0.922% lower when the return difference between treated and control bonds are high. Also, in the last month of the event quarter, $M(0)$, we find a substantially negative coefficient, although it is not statistically significant. As seen in Columns (3) through (6) we find similar results showing that returns on treated bonds are particularly low during months in event quarters if control bonds are small issue or high-yield bonds. In Column (3), for example, the coefficient estimate of -1.115 is statistically significant at the 10% level.

In summary, the results reported in Table 7 show that returns on treated bonds are particularly low when treated–control bond pairs are susceptible to relative mispricing. Thus, substantial outflows from mutual funds lead to fire-sale price pressure on corporate bonds.

5. Implications for Financial Stability

On the one hand, the results thus far show that funds with low cash holdings exert significant price pressure through fire-sales of their corporate bond holdings. On the other hand, the results also suggest that funds can internalize fire sale risks through liquidity management to the extent that they have adequate liquidity buffers.

Three important questions follow. First, to what extent can liquidity-sensitive trading mitigate price pressure on unstable markets that experience widespread outflows? This question is particularly important since it can be coupled with recent findings in Goldstein et al. (2017) that investor capital flows are more fragile and strategic complementarities are more pronounced for funds with relatively low cash holdings. Second, and most importantly, what would be the real consequences of fire sale pressure for corporate financing? We examine whether market disruption is just a side show that dissipates in a relatively short time or instead can have a substantial impact on the cost of debt capital. Lastly, how large are these low-cash funds in corporate bond markets? If they account for only a small fraction of the entire corporate bond mutual fund space or hold a small fraction of total corporate bonds outstanding, any flow-induced price pressure caused by these funds is not likely to pose a serious threat to financial stability.

To examine the first two questions, we employ the 2013 taper tantrum episode. In the summer of 2013, the Fed announced that it would tighten monetary policy, leading substantial amounts of investor money to flow out of corporate bond fund markets.[17] We believe that the taper tantrum episode represents a relatively exogenous shock to aggregate capital flows to the corporate bond fund industry, compared with other major sources of market distress that can simultaneously affect or be caused by the fundamental values of corporate bonds.

5.1. Price Impact during the Taper Tantrum

To examine flow-driven price impacts during the taper tantrum episode, we form value-weighted portfolios by investing in bonds under fire sales as defined in Section 4.1., during the taper tantrum quarter (2013 Q2). We form two portfolios of fire sales bonds based on the cash holdings of funds holding such bonds. In particular, low-cash portfolios consist of fire-sale bonds held by funds with cash holdings of less than 5% and high-cash portfolios consist of the remaining fire-sale bonds. We diverge from our strategy in Section 4.2 and do not employ a difference-in-differences approach here, as the matching process will substantially reduce the sample size.

[17] On May 22, 2013, Federal Reserve Chairman Ben Bernanke testified to Congress that the Fed might begin tapering down the monthly pace of purchases later in 2013. On June 19, 2013, he held a press conference positively about the tapering.

Instead, we calculate abnormal returns on the bond portfolios using the matching portfolio approaches of Bessembinder et al. (2009). Specifically, for each bond in the two fire-sale portfolios, we subtract returns on value-weighted portfolios of the same rating and maturity bins using bonds that are not in the top or bottom 10th percentiles in *Pressure*.[18]

Note that this matching process does not necessarily control for firm-level information that might drive fund trading. On the one hand, by using a larger sample that consists of most of the bonds outstanding in the market, our results can be comparable to overall market-level outcomes. On the other hand, our results might be driven by any unobservable variables affecting both flows and corporate bond prices. We believe that this endogeneity concern might be less severe in the case of the taper tantrum episodes since the size of the shock is arguably greater than any shock caused by firm-level information that might have become available during that time in the market.

In Table 8, we report the results of our examination of weekly average abnormal returns on the fire-sale portfolios formed in 2013 Q2 for low-cash funds and high-cash funds. We form portfolios in 2013 Q2, since in May 2013 Fed chairman Ben Bernanke commented during his testimony to Congress that the Fed might start tapering down quantitative easing later in 2013. We use weekly returns instead of monthly returns to zoom in on the taper tantrum episode. The results for low-cash funds show significant negative abnormal returns on fire-sale bonds during May. In particular, during the week of May 10, the average abnormal returns are -0.264%, which is significant at the 1% level. These negative returns start to revert from the middle of June. The average abnormal return in the week of June 21 is 0.296% (statistically significant at the 5% level). Abnormal returns in the following weeks through July 12 are all positive, albeit statistically insignificant, which is consistent with gradual recovery of prices. As seen in Panel B, we find no strong evidence of price pressure due to fire sales by high-cash funds, showing the importance of liquidity buffers in reducing fire-sale risk.

[18] We group bonds into five ratings bins based on the S&P's major rating categories (AAA, AA, A, BBB, and high yield), excluding unrated bonds. We then assign bonds to three time-to-maturity bins. For investment grade bonds, we group them into 0-to-5 year, 5-to-10 year, and 10+-year bins. For noninvestment grade bonds, we group them into 0-to-6 year, 6-to-9 year, and 9+-year bins. Since there are limited numbers of AAA bonds, we instead group them into two bins, 0-to -7 year and 7+-year bins.

In Figure 3, we plot cumulative average abnormal bond returns (CAARs) during the taper tantrum period. We find a cumulative return pattern that is consistent with price pressure, but only for low-cash funds. The CAARs drop to approximately -0.7% in mid June and recover over the next four weeks. For the high-cash portfolio, we find no patterns of price pressure. CAARs are relatively flat during the taper tantrum quarter. In summary, funds with thinner liquidity buffers are more fragile and potentially threaten market stability.

5.2. Cost of Debt Capital During the Taper Tantrum

In this section, we show that price disruption during a market distress episode can amount to something more than a side show. Rather, it can have real consequences on firms' cost of capital. When a newly issued bond is priced in the primary market, market participants obtain information continuously from secondary market prices of same-issuer bonds. Thus, issuing firms whose other bond issues are under fire sale pressure might experience discounts in their new bond offerings. Moreover, the effects of price pressure will be stronger when firms find it relatively difficult to cancel or postpone the issue, such as when they have to rollover expiring bonds.

In Table 9, we present the results of examining the extent to which the offering yields of new bond issues increase when the pre-existing bonds of the same issuers are exposed to fire sale pressure. As in Section 5.2, we employ the 2013 taper tantrum episode as a quasi-experiment. Specifically, we estimate the following model for the period from February 2013 to June 2013:

$$Y_{i,t} = \alpha + \beta_1 Event_t \cdot Treat_i + \beta_2 Treat_i + \varepsilon_{i,t} \tag{7}$$

where $Y_{i,t}$ is an offering yield of bond i issued in month t (obtained from the FISD database) and $Event_t$ is an indicator variable for the taper tantrum event, which is one for the May through June 2013 period and zero otherwise. Our choice of the event period is motivated by the results reported in the previous section, as price pressure is the greatest during that period. $Treat_i$ is a time-invariant indicator for bond i issued by a firm whose pre-existing bonds are under fire sale pressure during the event period. We define a bond as under fire sale pressure if it is held by low-cash mutual funds with fund flows in the bottom 30^{th} percentile. We include both rating-times-month and time-to-maturity-times-month fixed effects. We also control for industry fixed effects as well as bond-level characteristics. The standalone $Event_i$ dummy variable is subsumed by month fixed effects.

Table 9 provides the estimation results for Equation (7). As seen in Columns (1) and (2), we find that the offering yields of new issues are higher when issuing firms are exposed to fire sale pressure. We show in Column (1), for example, that the estimated coefficient on $Event_t \cdot Treat_i$ is positive (0.330) and statistically significant at the 1% level. Thus, holding all else constant, bonds issued by firms whose pre-existing bonds are exposed to fire sale pressure have on average 0.33% higher yield-to-maturity at issuance.

And yet, the results we report in Columns (1) and (2) might underestimate the true impact of fire sale pressure on the cost of debt capital, because firms can cancel or delay issuance when market conditions are unfavorable. Thus, we focus on a situation in which firms face inflexibility in bond issuance timing because they might have to roll over expiring bonds. We proxy bond rollover with an indicator variable $M_{i,t,}$ that takes the value of one if the issuer of bond *i* has pre-existing bonds that mature within one month from the issuance date of bond *i*. To examine whether fire sale pressure has greater impact when firms roll over expiring bonds, we employ triple interactions of the event and treatment dummies and the rollover dummy, $M_{i,t}$, and present the results in Columns (3) and (4).

As seen in Table 9 Columns (3) and (4), we find that a treated firm's new issues have higher yields in the event period if they are likely to have to roll over maturing bonds. In Column (3), for example, we report that the estimated coefficient on $Event_t \cdot Treat_i \cdot M_{i,t}$ is 0.909 and statistically significant at the 1% level. The economic magnitude of this effect is substantial; firms under fire sale pressure pay approximately 1.16% (=0.909+0.249) higher yields when issuing new bonds. After controlling for bond characteristics and industry fixed effects, we find that firms under fire sales pay 0.84% (=0.530+0.308) higher yields, as seen in Column (4).

This latter result implies that the prices of treated bond issues are discounted by 5.2% (=0.84%×6.2), given that the average duration of the bonds is 6.2 years. The value of the average bond issue of the treated group is 0.6 billion dollars. Thus, average shortfalls in new bond proceeds are approximately 30 million dollars per issue. In the presence of market turmoil, bond fund fire sales can produce substantial negative externalities for bond issuers. We find that, in contrast to the effect of fire sale pressure on issuing firms, outflows from high-cash funds do not affect the offering yields of new bond issues. As seen in Columns (5) through (8), for example, we find that none of the coefficient estimates on $Event_t \cdot Treat_i$ or $Event_t \cdot Treat_i \cdot M_{i,t}$ is statistically significant at the conventional levels. In particular, the estimated coefficient on $Event_t \cdot Treat_i$ is nearly zero (0.005) and negative (-0.062), as seen in Columns (5) and (6), respectively. Combined with the results we report in previous sections, these results are consistent with the fire sale story in which price disruption due to flow-driven fire sales can also disrupt primary market prices and the cost of capital.

In summary, the results shown in Table 9 indicate that price pressures in the secondary market can affect the prices of new bond issues and hence the cost of debt. This shows how fire-sale risks in financial markets can be contagious in the real economy.

5.3. Total Amounts of Bonds Held by Low-Cash Funds

In Figure 4, we plot how large a fraction of these low-cash funds account for the corporate bond fund universe over time. Although average holdings of cash among corporate bond funds are high, i.e., 10% on average (see Table 1), Figure 4 shows that low-cash funds with a cash ratio that is lower than 5% hold a disproportionately larger fraction of corporate bonds: they hold from 20% to 55% of the total amounts of corporate bonds held by corporate bond funds in our sample. More importantly, low-cash funds increasingly account for higher fractions from 2009 towards late 2011 and again from 2012 towards late 2014. This trend suggests excessive risk-taking, or so-called reaching for yield, by corporate bond funds in a low-interest-rate environment during the post–financial crisis period (Choi and Kronlund 2017).

Overall, Figure 4 illustrates that low-cash funds—those with less than 5% of net assets in cash—account for a substantial portion of total corporate bond holdings by corporate bond funds. There is also an upward trend in the late sample period, suggesting that the potential risk posed by corporate bond mutual funds to financial stability is increasing.

6. Conclusion

Using a difference-in-differences regression approach, we provide novel results showing the extent to which investor outflows induce price pressure in corporate bonds. We first document that fund trading is highly sensitive to both internal and external liquidity and thus to some extent absorbs investor liquidity demand using cash holdings and trading relatively more liquid securities upon investor redemptions. Despite liquidity management by bond funds, we still find substantial flow-driven price pressure, particularly for bonds that are held by low-cash funds.

Such low-cash funds account for a substantial portion of the corporate bond fund universe, representing potential threats to financial stability. Approximately 20% to 55% of corporate bonds held by the entire corporate bond fund sector are held by funds with cash holdings of less than 5%, indicating that a substantial fraction of corporate bonds might experience flow-induced trading. We further examine flow-induced price impacts of the 2013 taper tantrum and find significant price impacts during May 2013. Moreover, fire sale pressure has real effects on corporate financing, as firms whose pre-existing bonds are under fire sales have to pay substantially higher bond offering yields.

Overall, our evidence suggests that flow-induced trading and price pressure in corporate bonds can be significant when funds are not adequately equipped with cash cushions. We also find an increasing tendency toward maintaining lower liquidity cushions by low-cash funds, which might also exacerbate fire-sale risk. At the same time, inefficient levels of cash holdings would hurt fund performance and potentially distort fund risk-taking incentives. Whether a mandatory liquidity buffer would enhance investor welfare would be an interesting topic for future research.

Appendix A. Variable Definitions

Variables	Definitions
	Fund Characteristics
Flow	Quarterly fund flows. First, we estimate monthly flows using monthly returns from the CRSP mutual fund database as $$Flow_{j,t} = \frac{TNA_{j,t} - TNA_{j,t-1}(1 + R_{j,t})}{TNA_{j,t-1}}$$ where $TNA_{j,t}$ is a fund's total net assets and $R_{j,t}$ is the monthly return on fund j at time t. We then define quarterly *Flow* as aggregated monthly flows during quarter t. The variable is winsorized at the 1st and 99th percentiles.
CashRatio	Percentage amounts of cash and cash-like security holdings scaled by total net assets at the end of each quarter. i.e. $Cash_t/TNA_t$. We define cash as cash and cash-like securities in MorningStar (typecoded in C, CH, CL, CP, CR, CT, FM, or FV) plus government treasury holdings in MorningStar (typecoded in BT or TP). The definitions of typecodes are detailed in Appendix C. The variable is winsorized at the 1st and 99th percentiles.
CorpRatio	Percentage amounts of US corporate bond holdings scaled by total net assets at the end of each quarter, i.e., $Corp_t/TNA_t$. Holding information is from MorningStar, which we merge with the Mergent FISD database to obtain bond information. We use only Mergent FISD bond types CCOV, CDEB, CLOC, CMTN, CMTZ, CP, CPAS, CPIK, or CS. The variable is winsorized at the 1st and 99th percentiles.
$Trade_{j,t}$ (*Fund-level*)	Aggregate trading in an asset class (cash and cash-like security, corporate bond, or others) by a mutual fund in a quarter, by percentage. Specifically, $$Trade_{j,t} = \frac{AmtHold_{j,t}}{AmtHold_{j,t-1}} - 1$$ where and $AmtHold_{j,t}$ is the aggregate par-value amount of an asset class held by fund *j* at the end of quarter *t*, obtained from the Morningstar database. The variable is winsorized at the 1st and 99th percentiles.
	Bond Characteristics
TTM(Year)	Times to maturity in years
Age(Year)	Age of a bond in years
Rating	The credit rating of a bond converted into integers. We assign 21 to a AAA rating, 20 to AA+, 19 to AA, and so on.
$Trade_{i,j,t}$ (*Bond-level*)	Trading in a bond by a mutual fund in a quarter, by percentage. Specifically,

$$Trade_{i,j,t} = \frac{AmtHold_{i,j,t}}{AmtHold_{i,j,t-1}} - 1$$

where $Amt\ Hold_{i,j,t}$ is the amount (in par value) of bond *i* held by fund *j* at the end of quarter t, obtained from the Morningstar database. The variable is winsorized at the 1st and 99th percentiles.

ZTD	Ratio of zero-trading days in a quarter for a bond, as used in Chen, Lesmond, and Wei (2007) and Dick-Nielsen et al. (2012). If there is no transaction recorded in TRACE for a bond during a given day, we call it a zero trading day. The variable is winsorized at the 1st and 99th percentiles.
Roll	Roll's (1984) illiquidity measure. $dailyRoll_{i,t} = 2\sqrt{-cov(\Delta p_{i,s}, \Delta p_{i,s-1})}$ where $p_{i,s}$ is the natural logarithm of the price of bond i on day s. We calculate the daily price as the trading-volume-weighted price for each day. We require a volume of at least $100k to exclude retail transactions. For each day, we calculate the Roll measure with a rolling window of 21 days. To be well-defined, we require at least 4 observations to be available within the rolling window and discard positive covariance observations. We define quarterly *Roll* as the median of the daily Roll measure within the quarter. The variable is winsorized at the 1st and 99th percentiles.
Monthly Return	Monthly total return on corporate bonds. Price information is obtained from TRACE, while other bond characteristics used to calculate accrued interest and coupon payments are obtained from the Mergent FISD database. We follow Bessembinder et. al. (2009), calculating a bond's daily price as the trading-volume-weighted price for each day. We require a volume of at least $100k to exclude retail transactions. To calculate monthly returns, we use the last daily price within 5 days of the end of each month. Since the TRACE price is a 'clean' price, we calculate returns as follows: $$Return_{i,t} = \frac{P_{i,t} + AI_{i,t} + Cpn_{i,t}}{P_{i,t-1} + AI_{i,t-1}} - 1$$ where $P_{i,t}$ is the price, $AI_{i,t}$ is accrued interest, and $Cpn_{i,t}$ is coupon payments, if any, in month t.

Appendix B. Relationship between Past Performance and Future Fund Flows

Previous studies on equity mutual funds document that fund flows are strongly related to past performance (e.g., Sirri and Tufano 1998 and Coval and Stafford 2007). In this Appendix, we establish that flows are driven in large part by past performance. Specifically, we regress fund flows on lagged fund flows and fund:

$$flow_{j,t} = \alpha + \sum_{n=1}^{N} \beta_n \, flow_{j,t-n} + \sum_{m=1}^{M} \gamma_m \, return_{j,t-m}.$$

Table A-1 in the Appendix reports the regression results for quarterly fund flows.[19] Like previous studies of equity funds, ours finds that flows to corporate bond funds are related strongly to past returns and flows. For quarterly regressions in Columns (1) and (3), for example, fund returns for up to the past five quarters are positively related to future flows. Also note that R^2s are higher for corporate bond funds than for the equity funds reported in Columns (2) and (4), indicating that returns and flows explain future flows better for corporate bond funds than for equity funds.

[19] In unreported results, we obtain almost identical results from monthly regressions.

Appendix C. Morningstar Typecodes for Cash Holdings

Morningstar Typecode	Definitions
BT	Bond - US Treasury
C	Cash
CD	Cash - CD/Time Deposit
CL	Cash - Currency Future
CP	Cash - Commercial Paper
CR	Cash - Repurchase Agreement
CT	Cash - T-Bill
FM	Mutual Fund -MMkt
FV	Mutual Fund -VA
TP	Bond - TIPS

References

Ambrose, B. W., Cai, N., and Helwege, J., 2012. Fallen Angels and Price Pressure. *Journal of Fixed Income* 21:74-86.

Asquith, P., Au, A. S., Covert, T., and Pathak, P. A., 2013. The Market for Borrowing Corporate Bonds. *Journal of Financial Economics* 107:55-182.

Bao, J., O'Hara, M., and Zhou, X. A., 2017. The Volcker Rule and Market-making in Times of Stress. *Journal of Financial Economics, forthcoming.*

Bao, J., Pan, J., and Wang, J., 2011. The Illiquidity of Corporate Bonds. *Journal of Finance* 66:911-946.

Ben-David, I., Franzoni, F., and Moussawi, R., 2012. Hedge Fund Stock Trading in the Financial Crisis of 2007–2009. *Review of Financial Studies* 25:1-54.

Berger, E.A., 2017, Does Stock Mispricing Drive Firm Policies? Mutual Fund Fire Sales and Selection Bias. *Cornell University Working Paper.*

Bessembinder, H., Jacobsen, S. E., Maxwell, W. F., and Venkataraman, K., 2017. Capital Commitment and Illiquidity in Corporate Bonds. *Journal of Finance, forthcoming.*

Bessembinder, H., Kahle, K. M., Maxwell, W. F., and Xu, D., 2009. Measuring Abnormal Bond Performance. *Review of Financial Studies* 22:4219-4258.

Campbell, J. Y., Giglio, S., and Pathak, P., 2011. Forced Sales and House Prices. *American Economic Review* 101:2108-31.

Cella, C., Ellul, A., and Giannetti, M., 2013. Investors' Horizons and the Amplification of Market Shocks. *Review of Financial Studies*, 26:1607-1648.

Cespa, G., and Foucault, T., 2014. Illiquidity Contagion and Liquidity Crashes. *Review of Financial Studies*, 27:1615-1660.

Chen, Q., Goldstein, I., and Jiang, W., 2010. Payoff Complementarities and Financial Fragility: Evidence from Mutual Fund Outflows. *Journal of Financial Economics* 97:239-262.

Chen, L., Lesmond, D. A., and Wei, J., 2007. Corporate Yield Spreads and Bond Liquidity. *Journal of Finance* 62:119-149.

Chen, Z., Lookman, A. A., Schürhoff, N., and Seppi, D. J., 2014. Rating-based Investment Practices and Bond Market Segmentation. *Review of Asset Pricing Studies*, 4:162-205.

Chernenko, S., and Sunderam, A., 2016. Liquidity Transformation in Asset Management: Evidence from the Cash Holdings of Mutual Funds. *NBER Working Paper.*

Choi, J. and Kronlund, M., 2017. Reaching for Yield by Corporate Bond Mutual Funds. *University of Illinois Working Paper.*

Coval, J., and Stafford, E., 2007. Asset Fire sales (and Purchases) in Equity Markets. *Journal of Financial Economics* 86:479-512.

Dick-Nielsen, J., 2009. Liquidity Biases in TRACE. *Journal of Fixed Income* 19:43-55.

Dick-Nielsen, J., 2014. How to Clean Enhanced TRACE data. *Copenhagen Business School Working Paper*.

Dick-Nielsen, J., Feldhütter, P., and Lando, D., 2012. Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis. *Journal of Financial Economics* 103:471-492.

Dick-Nielsen, J., and Rossi, M., 2017. The Cost of Immediacy for Corporate Bonds. *Copenhagen Business School Working Paper*.

Dyakov, T., and Verbeek, M., 2013. Front-Running of Mutual Fund Fire-Sales. *Journal of Banking and Finance* 37:4931-4942.

Edmans, A., Goldstein, I., and Jiang, W., 2012. The Real Effects of Financial Markets: The Impact of Prices on Takeovers. *Journal of Finance* 67:933-971.

Edwards, A. K., Harris, L. E., and Piwowar, M. S., 2007. Corporate Bond Market Transaction Costs and Transparency. *Journal of Finance* 62:1421-1451.

Ellul, A., Jotikasthira, C., and Lundblad, C. T., 2011. Regulatory Pressure and Fire Sales in the Corporate Bond Market. *Journal of Financial Economics* 101:596-620.

Feroli, M., Kashyap, A. K., Schoenholtz, K. L., and Shin, H. S., 2014. Market Tantrums and Monetary Policy. *Chicago Booth Research Paper* 14-09.

Frazzini, A., and Lamont, O. A., 2008. Dumb Money: Mutual Fund Flows and the Cross-section of Stock Returns. *Journal of Financial Economics* 88:299-322.

Goldstein, I., Jiang, H., and Ng, D. T., 2017. Investor Flows and Fragility in Corporate Bond Funds. *Journal of Financial Economics*.

Helwege, J. and Wang, W., 2017. Liquidity and Price Pressure in the Corporate Bond Market: Evidence from Mega-Bonds, Working Paper

Hoseinzade, S., 2016. Do Bond Mutual Funds Destabilize the Corporate Bond Market?, *Suffolk University Working Paper.*

Huang, J., Sialm, C., and Zhang, H., 2011. Risk Shifting and Mutual Fund Performance. *Review of Financial Studies* 24:575-2616.

Jotikasthira, C., Lundblad, C., and Ramadorai, T., 2012. Asset Fire Sales and Purchases and the International Transmission of Funding Shocks. *Journal of Finance* 67:2015-2050.

Khan, M., Kogan, L., and Serafeim, G., 2012. Mutual Fund Trading Pressure: Firm-Level Stock Price Impact and Timing of SEOs. *Journal of Finance* 67:1371-1395.

Lou, D., 2012. A Flow-based Explanation for Return Predictability. *Review of Financial Studies* 25:3457-3489.

Manconi, A., Massa, M., and Yasuda, A., 2012. The Role of Institutional Investors in Propagating the Crisis of 2007–2008. *Journal of Financial Economics*, 104:491-518.

Mitchell, M., Pedersen, L. H., and Pulvino, T., 2007. Slow Moving Capital. American *Economic Review* 97:215-220.

Mitchell, M., Pulvino, T., and Stafford, E., 2004. Price Pressure Around Mergers. *Journal of Finance* 59:31-63.

Pulvino, T. C., 1998. Do Asset Fire Sales Exist? An Empirical Investigation of Commercial Aircraft Transactions. *Journal of Finance* 53:939-978.

Roll, R., 1984. A Simple Implicit Measure of the Effective Bid-ask Spread in an Efficient Market. *Journal of Finance* 39:1127-1139.

Schultz, P., 2017., Inventory Management by Corporate Bond Dealers. *University of Notre Dame Working Paper*.

Shleifer, A., and Vishny, R. W., 1992. Liquidation Values and Debt Capacity: A Market Equilibrium Approach. *Journal of Finance* 47:1343-1366.

Shleifer, A., and Vishny, R. W., 1997. The Limits of Arbitrage. *Journal of Finance*, 52:35-55.

Sirri, E. R., and Tufano, P., 1998. Costly Search and Mutual Fund Flows. *Journal of Finance* 53:1589-1622.

Spiegel, M., and Starks, L., 2016. Institutional Rigidities and Bond Returns Around Rating Changes. *University of Texas and Yale School of Management Working Paper.*

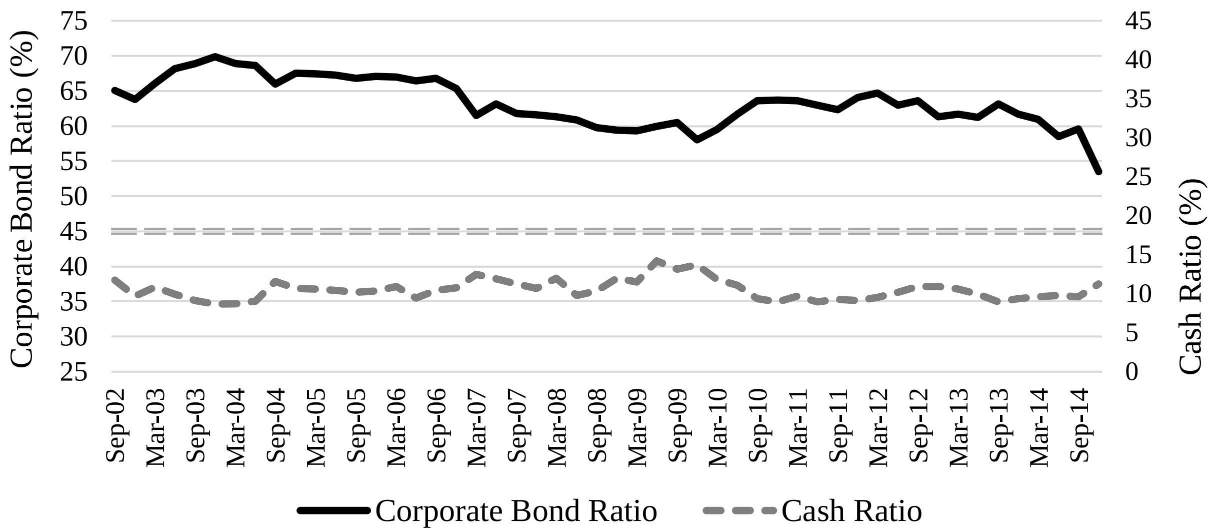

Figure 1. Time Series of Cash and Corporate Bond Ratios

This figure plots quarterly time series of average corporate bond ratios ($CorpRatio$) and average cash ratios ($CashRatio$) for our sample corporate bond funds. The corporate bond and cash ratios are defined in Appendix A. The averages are value-weighted based on total net assets at the end of the previous quarter. The corporate bond and cash ratios are plotted in solid black and dashed gray lines, respectively. The x-axis represents ends of quarters in our sample period running from 2002 Q2 through 2014 Q4. The y-axis along the left side represents corporate bond ratios in percentages. The y-axis on the right side represents cash ratios in percentages.

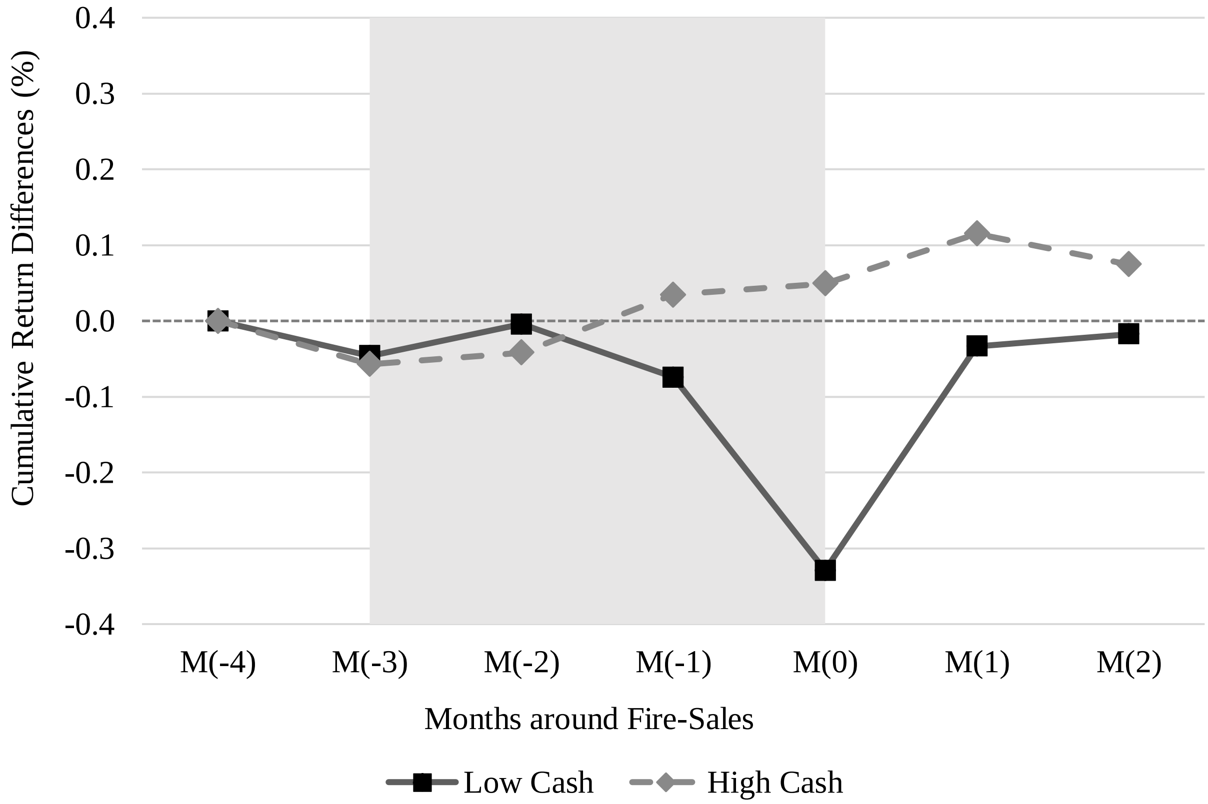

Figure 2. Cumulative Returns on Fire Sale Bonds

This figure shows cumulative coefficient estimates obtained from difference-in-differences regressions of fire sale bond returns from two months before the fire sale quarter, *M(-4)*, through two months after, *M(2)*. The coefficient estimates are obtained from Columns (2) and (4) of Table 5 Panel B. The shaded area represents the fire sale quarters.

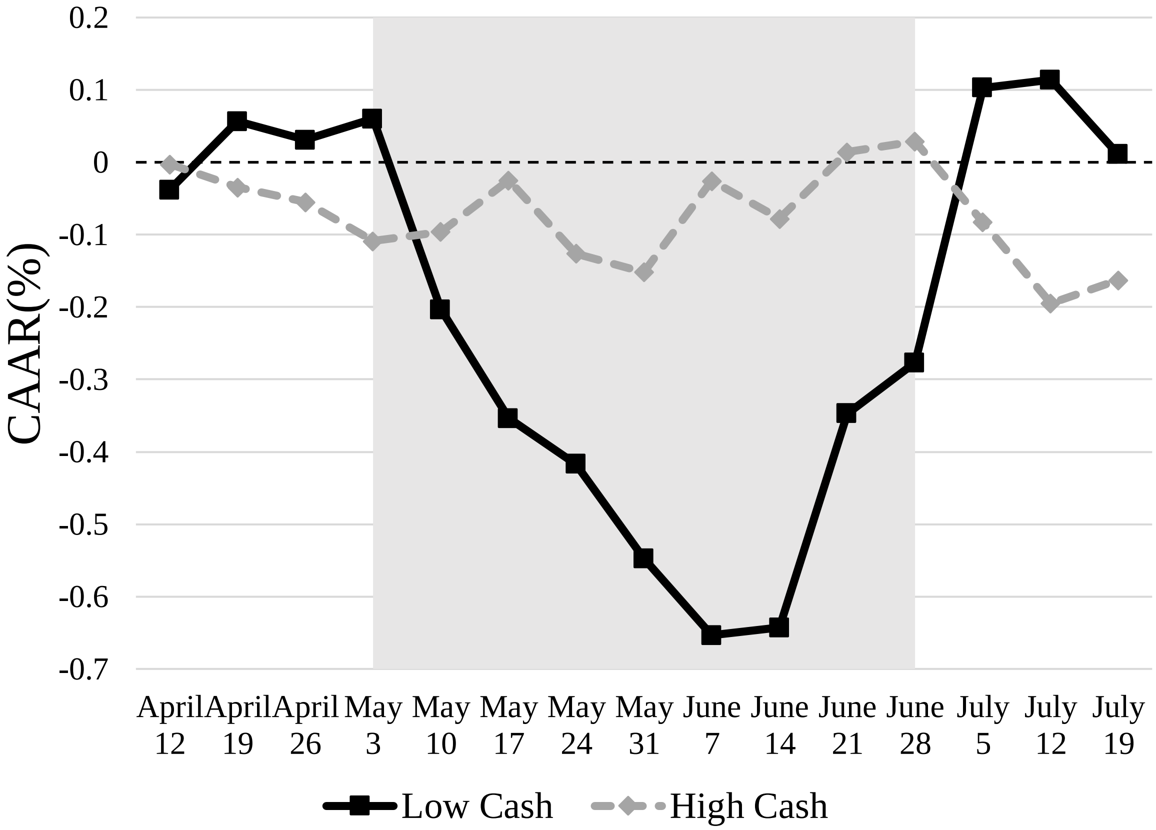

Figure 3. Cumulative Abnormal Returns on Fire-Sale Portfolios around the Taper Tantrum in 2013

This figure presents value-weighted cumulative average abnormal returns (CAARs) on the fire-sale corporate bond portfolios around the 2013 taper tantrum. We report weekly CAARs on portfolios of bonds held by low-cash funds (black solid line) and high-cash funds (gray dashed line). We calculate abnormal returns following the matching-portfolio approach (by rating and maturity) of Bessembinder et al. (2009). Dates on the x-axis represent the last business days of each week from April 12 through July 19.

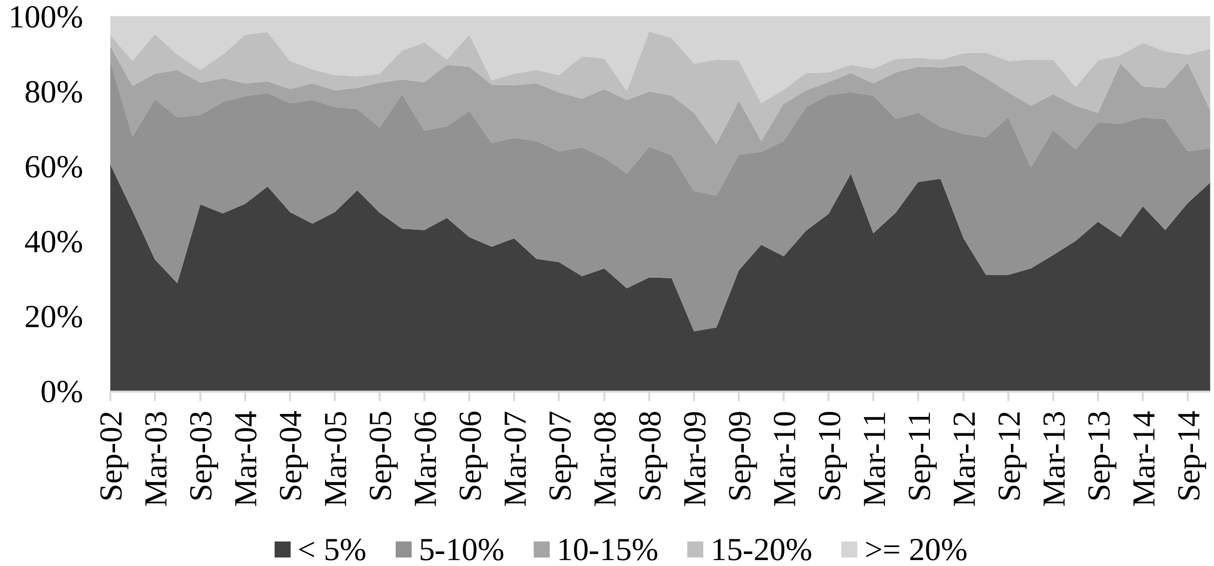

Figure 4. Time Series of Fractions of Corporate Bonds Held by Low-Cash Funds

This figure plots fractions of corporate bonds held by our sample funds across groups based on their cash ratios. At the end of each quarter, we divide our sample funds into five groups (<5%, 5-10%, 10-15%, 15-20%, and >=20%). We then sum the face values of all U.S. corporate bonds held by each group at the end of each quarter. We plot percentage shares of bonds based on the sum of the face values for each group, from 2002 Q2 through 2014 Q4.

Table 1. Descriptive Statistics for the Sample Funds and Bonds

This table provides fund-level (Panel A) and bond-level (Panel B) summary statistics. The sample consists of U.S. open-end corporate bond mutual funds that are available in the Morningstar Direct and CRSP databases. In Panel A, *TNA* is total net assets in millions of dollars, and *Quarterly Flow* is net capital flows to a fund during a quarter. *Corporate Bond Ratio*, *Cash Ratio*, *Treasury Ratio*, *Agency Bond Ratio*, *ABS Ratio*, *Equity Ratio*, and *Other* are ratios of dollar amounts of U.S. corporate bonds, cash and cash-like securities (including Treasury bonds and money market funds), Treasury bonds, agency bonds, asset-backed bonds, equity, and other assets including muni bonds, respectively, to total net assets at the end of a quarter. In Panel B, we provide summary statistics for corporate bonds held by our sample mutual funds. *TTM* is time-to-maturity in years; *Age* is the age of a bond in years; *Rating* is the credit rating of a bond in integers where we assign 21 to a AAA rating, 20 to AA+, 19 to AA, and so on; *Amount Outstanding* is the dollar amount of bonds outstanding in millions of dollars, *Zero Trading Days* (*ZTD*) is the percentage of the days on which a bond is not traded during a quarter; *Roll* is the Roll (1994) illiquidity measure; and *Monthly Return* is the total return on a bond during a month. Variable definitions are detailed in Appendix A. We report the number of observations (N), means, standard deviations (Std.), and the 5th, 25th, median (50th), 75th, and 95th percentiles. The sample period runs from 2002 Q3 through 2014 Q4.

Panel A: Fund-level Variables								
	N	Mean	Std.	5%	25%	50%	75%	95%
TNA ($MM)	13,569	1,203	2,638	16.60	93.40	327.1	997.3	5,746
Quarterly Flow (%)	13,569	1.45	12.16	-12.74	-3.98	-0.15	4.43	20.41
Corporate Bond Ratio (%)	13,569	65.99	22.20	30.76	45.23	68.82	86.67	95.70
Cash Ratio (%)	13,569	10.33	9.81	0.00	3.00	6.88	15.78	30.51
Treasury Ratio (%)	13,569	6.74	9.00	0.00	0.00	2.00	11.55	26.46
Agency Bond Ratio (%)	13,569	8.11	11.17	0.00	0.00	0.55	15.87	31.16
ABS Ratio (%)	13,569	5.33	8.27	0.00	0.00	0.52	8.34	23.91
Equity Ratio (%)	13,569	1.57	3.02	0.00	0.00	0.35	1.80	7.07
Other (%)	13,569	8.64	9.43	0.00	2.34	5.98	12.03	27.48
Panel B: Bond-level Variables								
	N	Mean	Std.	5%	25%	50%	75%	95%
TTM (Years)	322,243	8.75	8.85	1.54	3.55	6.04	9.21	27.21
Age (Years)	322,257	4.53	4.20	0.40	1.54	3.33	6.31	13.30
Rating	302,616	12.51	4.07	5	10	13	15	18
Amount Outstanding ($MM)	321,555	511.6	552.1	50	200	350	600	1,500
Zero Trading Days (ZTD)	251,730	59.12	35.14	3.08	26.15	64.62	95.38	100
Roll	95,596	0.012	0.015	0.002	0.004	0.008	0.015	0.036
Monthly Return (%)	305,270	0.62	4.54	-3.56	-0.34	0.48	1.57	4.73

Table 2. Mutual Fund Trading Across Flow Deciles

This table reports changes in quarterly holdings across deciles of funds sorted on fund flows. In Panel A, we form flow deciles based on flows sorted within each quarter and Lipper objective code. *Flow* is quarterly percentage flows. *Number of holdings* is the number of corporate bond holdings. We report the ratio of lagged corporate bond holdings $Corp_{t-1}/TNA_{t-1}$, the ratio of lagged cash holdings $Cash_{t-1}/TNA_{t-1}$, quarterly changes in the ratio of corporate bond holdings $\Delta(Corp_t/TNA_t)$, quarterly changes in the ratio of cash holdings $\Delta(Cash_t/TNA_t)$, quarterly changes in corporate bond holdings scaled by lagged total net assets $(\Delta Corp_t)/TNA_{t-1}$, and quarterly changes in cash holdings scaled by lagged total net assets $(\Delta Cash_t)/TNA_{t-1}$. In Panel B, we report the average fraction of market-values of corporate bond positions that are maintained, expanded, reduced, eliminated, or eliminated due to retirement as well as new positions opened and new positions opened in newly-issued bonds. Retirement includes maturing, calling, or converting of bonds that reduces total amounts of bonds outstanding by more than 90%. All fractions of positions are scaled by the total market values of corporate bond holdings in the previous quarter. There is no double-counting across fractions, i.e., *eliminated* does not include *eliminated due to retirement* and *new position opened* does not include *new position opened in new issues*. All variables are winsorized at the 1st and 99th percentiles. The sample period runs from 2002 Q3 through 2014 Q4.

Panel A: Flow Deciles and Asset Compositions								
Flow Decile	$Flow_t$ (%)	Number of Holdings $_{t-1}$	$\frac{Corp_{t-1}}{TNA_{t-1}}$(%)	$\frac{Cash_{t-1}}{TNA_{t-1}}$(%)	$\Delta(\frac{Corp_t}{TNA_t})$(%)	$\Delta(\frac{Cash_t}{TNA_t})$(%)	$\frac{\Delta Corp_t}{TNA_{t-1}}$(%)	$\frac{\Delta Cash_t}{TNA_{t-1}}$ (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 (Outflow)	-13.84	156.03	67.06	9.51	0.37	-0.48	-7.65	-1.45
2	-6.48	165.75	66.99	9.46	-0.01	-0.19	-3.22	-0.59
3	-3.88	180.59	66.23	10.14	0.01	-0.21	-1.44	-0.37
4	-2.26	191.37	66.65	10.10	-0.35	0.02	-0.77	0.04
5	-0.84	196.91	66.52	9.98	-0.40	0.29	0.25	0.43
6	0.67	192.95	66.76	9.97	-0.34	0.25	1.07	0.51
7	2.34	192.85	66.69	10.07	-0.63	0.49	1.92	0.98
8	4.83	200.34	66.17	10.62	-0.72	0.39	3.59	1.16
9	9.18	196.76	65.64	10.38	-0.84	0.72	6.67	2.04
10 (Inflow)	23.33	168.57	66.03	10.48	-1.56	1.22	15.70	4.37

Panel B: Fund Trading in Corporate Bonds								
		Fraction of Positions (%)						
Flow Decile	$Flow_t$ (%)	Maintained	Expanded	Reduced	Eliminated	Eliminated Due to Retirement	New Position Opened	New Position Opened in New Issues
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 (Outflow)	-13.84	59.24	3.84	19.38	13.45	3.24	5.05	5.28
2	-6.48	66.97	4.48	14.16	10.61	3.14	5.85	5.62
3	-3.88	71.20	5.23	10.65	9.60	3.03	6.07	5.59
4	-2.26	71.18	5.89	10.39	8.93	3.02	5.88	5.56
5	-0.84	73.27	6.38	9.00	8.22	2.93	5.96	5.57
6	0.67	73.99	6.77	8.05	7.85	2.93	6.21	5.92
7	2.34	73.48	7.91	7.67	7.59	3.06	6.35	6.34
8	4.83	72.24	9.41	7.77	7.34	3.01	7.33	6.62
9	9.18	70.50	12.17	6.70	7.25	3.02	7.92	8.44
10 (Inflow)	23.33	63.00	19.41	5.03	7.85	3.32	10.47	13.31

Table 3. Liquidity-Sensitive Trading

This table provides the results of the regression of mutual fund trading on contemporaneous fund flows. Panel A reports the fund-level regressions of trades in corporate bonds (*Corporate Bond*), cash and cash-like securities (*Cash*), and all other asset classes (*Other*), separately:

$$Trade_{j,t} = \alpha + \beta_1 Flow_{j,t} + \varepsilon_{j,t}$$

where $Trade_{j,t} = AmtHold_{j,t}/AmtHold_{j,t-1} - 1$ is the percentage trading by mutual fund j in quarter t and $Amt\ Hold_{j,t}$ is the amount of an asset class held by fund j at the end of quarter t. To reduce noise in $Trade_{j,t}$, we require that time *t-1* holdings in the asset class should be greater than 1%. $Flow_{j,t}$ is the quarterly investor flow of fund j during quarter t. We also include interactions of flows with cash ratios ($CashRatio_{j,t-1}$). We standardize $CashRatio_{j,t-1}$ to have sample mean of zero and standard deviation of one. We also include Lipper-code-times-quarter fixed effects. Panel B reports the following regression of fund j's trading on corporate bond i during quarter t on flows:

$$Trade_{i,j,t} = \alpha + \beta_1 Flow_{j,t} + \beta_2 Flow_{j,t} \cdot X_{i,j,t-1} + \beta_3 X_{i,j,t-1} + \varepsilon_{j,t}$$

where $Trade_{i,j,t} = AmtHold_{i,j,t}/AmtHold_{i,j,t-1} - 1$ is the percentage trading in corporate bond i and $AmtHold_{i,j,t}$ is the amount of bond i held by fund j at the end of quarter t. The independent variables include: $Flow_{j,t}$; $CashRatio_{j,t-1}$; zero trading days of bonds in a quarter, $ZTD_{i,t-1}$; and the bond illiquidity measure of Roll (1994), $Roll_{i,t-1}$. Variable definitions are detailed in Appendix A. All independent variables except *Flow* are lagged by one quarter and standardized to have sample mean of zero and standard deviation of one. We also include both issuer-times-quarter fixed effects and Lipper-code-times-quarter fixed effects. We require $AmtHold_{i,j,t-1}$ to be positive and we exclude bonds with maturity of less than 1 year and bonds that are retired during the quarter. In the first half of Columns in each Panel A and B, we report the results for the outflow subsample (funds with $Flow_{j,t} < 0$). In the second half of Columns, we report the results for the inflow subsample (funds with $Flow_{j,t} \geq 0$). In the last row of each Panel, we report the p-values from the tests of coefficients on flows (β_1) equal to one. All variables are winsorized at the 1st and 99th percentiles. The sample period runs from 2002 Q3 through 2014 Q4. In specifications requiring the lagged bond-liquidity variables, the sample period is restricted to the period between 2005 Q2 and 2014 Q4 where the lagged liquidity variables can be calculated from TRACE. The values in parentheses are t-statistics using standard errors clustered at the fund level. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Liquidity-Sensitive Trading at the Asset Class Level										
	Dependent Variable: $Trade_{j,t}$									
	Outflow Sample					Inflow Sample				
	Cash	Corporate Bond		Other		Cash	Corporate Bond		Other	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$Flow_{j,t}$	1.784***	0.892***	0.888***	0.975***	0.970***	3.200***	0.901***	0.898***	1.889***	1.879***
	(7.832)	(43.345)	(42.605)	(6.501)	(6.540)	(7.789)	(39.310)	(38.903)	(10.592)	(10.476)
$Flow_{j,t} \cdot CashRatio_{j,t-1}$			-0.056**		-0.019			0.014		0.020
			(-2.473)		(-0.156)			(0.653)		(0.095)
$CashRatio_{j,t-1}$			0.579***		3.477**			0.490**		2.748
			(3.213)		(2.438)			(2.461)		(1.346)
$Lipper \cdot Quarter\ F.E.$	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	6,156	6,949	6,949	6,628	6,628	5,949	6,620	6,620	6,349	6,349
Adj. R^2	0.022	0.313	0.319	0.021	0.022	0.062	0.540	0.541	0.080	0.080
p-value from testing $H_0: \beta_1 = 1$	0.00	0.00	0.00	0.87	0.84	0.00	0.00	0.00	0.00	0.00

Panel B: Liquidity-Sensitive Trading at the Individual Bond Level

	Dependent Variable: $Trade_{i,j,t}$							
	Outflow Sample				Inflow Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Flow_{j,t}$	0.779***	0.756***	0.744***	0.797***	0.474***	0.472***	0.462***	0.503***
	(23.284)	(22.468)	(20.032)	(20.210)	(16.492)	(16.633)	(14.312)	(13.803)
$Flow_{j,t} \cdot CashRatio_{j,t-1}$		-0.099***	-0.114***	-0.151***		-0.032	-0.028	-0.009
		(-3.008)	(-3.078)	(-3.711)		(-1.423)	(-1.161)	(-0.338)
$Flow_{j,t} \cdot ZTD_{j,t-1}$			-0.059***				-0.033**	
			(-5.062)				(-2.232)	
$Flow_{j,t} \cdot Roll_{j,t-1}$				-0.105***				-0.029**
				(-4.603)				(-1.960)
$CashRatio_{j,t-1}$		0.756**	0.700**	0.579		0.763**	0.690*	0.545
		(2.364)	(2.077)	(1.543)		(1.986)	(1.669)	(1.161)
$ZTD_{j,t-1}$			-0.129				-0.275	
			(-0.814)				(-1.437)	
$Roll_{j,t-1}$				1.026***				1.365***
				(4.564)				(5.896)
$Issuer \cdot Quarter\ F.E.$	Y	Y	Y	Y	Y	Y	Y	Y
$Lipper \cdot Quarter\ F.E.$	Y	Y	Y	Y	Y	Y	Y	Y
N	1,158,835	1,158,835	969,237	463,328	1,201,134	1,201,134	1,013,876	490,147
Adj. R^2	0.093	0.093	0.093	0.082	0.086	0.086	0.086	0.079
p-value from testing H_0: $\beta_1 = 1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4. Summary Statistics: Treated, Matched Control, and Non-treated Bonds

This table provides the results of difference tests on means and medians across the treated, control, and non-treated bonds and their issuers at the end of last quarters prior to fire-sale quarters. The treated group (*Treated*) is composed of bonds that are exposed to fire sales. The control group (*Control*) is a set of bonds matched to the bonds in the treatment group; a treated bond and its control bond should have the same issuer with identical option features (callable, putable, and sinking fund provisions) and the same credit rating in the last quarter before the fire sale quarter. We also require that differences in time-to-maturity between a treated bond and its control bond be less than one year. If there are multiple control bonds satisfying the aforementioned conditions, we select at most two control bonds with smaller differences in ages. The group of non-treated bonds (*Non-treated*) is composed of all the other bonds held by the low-cash funds in our sample that have never been exposed to fire sales during the sample period. In Panel A, we provide statistics for issuer- and bond-level characteristics and test statistics of mean and median differences. The mean test is a Wilcoxon rank-sum test and the median test is Pearson's chi-squared test. We report z- and χ^2 statistics from the mean and median tests, respectively. N is the number of issuer- or bond-quarters. In Panel B, we provide statistics for monthly returns from four quarters (Q-4) through one quarter (Q-1) prior to the fire sale quarter and also provide test statistics for differences in average and median returns. The variable descriptions are provided in Appendix A. The values in parentheses are p-values. The sample period runs from 2005 Q2 through 2014 Q2.

Panel A: Characteristics of Issuers, Bonds, and Mutual Fund Holders of the Bonds

	Summary Statistics			Test of Difference			
				Treated vs. Non-treated		Treated vs. Control	
	Treated	Non-treated	Control	Mean Test	Median Test	Mean Test	Median Test
	Mean	Mean	Mean	z	χ^2	z	χ^2
	[Median]	[Median]	[Median]	(P-value)	(P-value)	(P-value)	(P-value)
Issuer-level characteristics	(*N*=433)	(*N*=37,888)					
Market Size ($MM)	44,200	11,090		13.91	117.55		
	[18,205]	[3,965]		(0.00)	(0.00)		
Leverage	0.35	0.31		3.91	4.98		
	[0.31]	[0.29]		(0.00)	(0.03)		
#(Bonds)	31.66	4.58		32.82	530.57		
	[22.00]	[2.00]		(0.00)	(0.00)		
Bond-level characteristics	(*N*=473)	(*N*=110,300)	(*N*=639)				
Rating	11.78	12.36	12.08	-3.03	2.13	-1.30	2.24
	[12.00]	[13.00]	[13.00]	(0.00)	(0.14)	(0.19)	(0.13)
Roll	0.0091	0.0112	0.0096	-3.54	11.22	-0.68	0.00
	[0.0062]	[0.0074]	[0.0063]	(0.00)	(0.00)	(0.49)	(0.97)
ZTD	19.70	56.98	23.55	-22.10	383.07	-1.72	1.93
	[10.94]	[60.32]	[13.85]	(0.00)	(0.00)	(0.09)	(0.16)
TTM (Year)	7.42	7.72	6.77	-2.62	3.07	-2.70	5.31
	[5.95]	[5.30]	[5.02]	(0.01)	(0.08)	(0.01)	(0.02)
Age (Year)	2.36	4.32	2.66	-11.94	114.24	-1.79	0.13
	[1.83]	[3.04]	[1.87]	(0.00)	(0.00)	(0.07)	(0.72)
Amtout ($MM)	1160	574	956	19.25	242.14	3.68	4.77
	[1,000]	[400]	[750]	(0.00)	(0.00)	(0.00)	(0.03)
Mutual fund characteristics							
TNA ($MM)	2690	3000	3310	-2.73	22.97	-1.53	0.94
	[2,450]	[2,000]	[2,580]	(0.01)	(0.00)	(0.13)	(0.33)
#(CB Held by MF)	257.86	241.42	260.90	4.63	23.02	-0.39	0.00
	[264.20]	[246.67]	[265.20]	(0.00)	(0.00)	(0.70)	(1.00)
CashRatio (%)	9.46	8.35	10.06	4.96	22.97	-1.32	0.24
	[9.61]	[7.78]	[9.87]	(0.00)	(0.00)	(0.19)	(0.63)

Panel B: Monthly Returns of Treated and Control Bonds						
	Summary Statistics				Test of Difference	
					Treated vs. Control	
	Treated		Control		Mean Test	Median Test
Quarters Prior to Event Q(0)	*N*	Mean [Median]	*N*	Mean [Median]	z (P-value)	χ^2 (P-value)
Q(-1)	1,073	0.86	1,380	0.86	0.65	0.99
		[0.61]		[0.53]	(0.52)	(0.32)
Q(-2)	910	0.77	1,175	0.74	0.68	0.59
		[0.64]		[0.56]	(0.50)	(0.44)
Q(-3)	809	0.57	1,058	0.46	0.65	0.00
		[0.53]		[0.53]	(0.52)	(0.98)
Q(-4)	704	0.56	898	0.58	-0.24	0.00
		[0.59]		[0.59]	(0.81)	(0.96)
Q(-4) through Q(-1)	3,496	0.71	4,511	0.68	0.93	1.05
		[0.60]		[0.55]	(0.35)	(0.31)

Table 5. Difference-in-Differences Regressions of Bond Returns

This table provides the estimation results of difference-in-differences regressions. Panel A reports the results from the following model:

$$R_{i,t} = \alpha + \sum_{n=-1}^{2} \beta_n Q(n)_{i,t} \cdot Treat_i + \sum_{n=-1}^{2} \gamma_n Q(n)_{i,t} + \varepsilon_{i,t}$$

where $R_{i,t}$ is monthly returns (in percentage) on bond i during month t. $Treat_i$ is an indicator variable for a treated bond. $Q(n)_{i,t}$ is a quarterly event dummy variable, which is one if month *t* is belong to n^{th} quarter from the fire-sales quarter of bond i (or its matched treated bond). For bond i in the control group, for example, $Q(-1)_{i,t}$ is one if month *t* belongs to the quarter before the fire-sale quarter of the treated bond matched to bond *i*. For bond *i* in the treated group, $Q(-1)_{i,t}$ is one if month *t* belongs to the quarter before the fire-sale quarter of bond i. As control variables, we include logged time-to-maturity, *TTM*; zero trading days of the previous quarter, *ZTD*; log bond age, *Age*; and log amount outstanding, *Amtout*. We also include both bond fixed effects and issuer-times-month fixed effects. In Columns (1) and (2), treated bonds are held by low-cash funds (cash holdings less than 5% of their assets). In Columns (3) and (4), we redefine treated bonds using only bonds that are held by high-cash funds (cash holdings greater than 5%). The sample period for the treatment is 2005 Q2 through 2014 Q2. Panel B reports the regression specification employing monthly event dummy variables $M(n)_{i,t}$ instead of quarterly event dummies:

$$R_{i,t} = \alpha + \sum_{n=-3}^{3} \beta_n M(n)_{i,t} \cdot Treat_i + \sum_{n=-3}^{3} \gamma_n M(n)_{i,t} + \varepsilon_{i,t}$$

where $M(n)_{i,t}$ is defined similarly to its definition for Panel A. Specifically, $M(n)_{i,t}$ is a dummy variable which is one if month *t* is belong to n^{th} month from the end of fire-sales quarter. To save space, constant estimates are not reported. Shaded rows represent difference-in-differences coefficient estimates during the fire sale quarter. The values in parentheses are t-statistics using standard errors two-way clustered at the issuer and month levels. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Regressions Using Quarterly Event Dummies				
			High Cash Funds Only	
	(1)	(2)	(3)	(4)
$Q(-1)_{i,t} \cdot Treat_i$	-0.039	-0.040	-0.005	-0.004
	(-0.726)	(-0.729)	(-0.122)	(-0.090)
$Q(0)_{i,t} \cdot Treat_i$	-0.118**	-0.118**	0.022	0.025
	(-2.330)	(-2.315)	(0.871)	(0.936)
$Q(1)_{i,t} \cdot Treat_i$	0.114**	0.114**	0.023	0.023
	(2.100)	(2.137)	(0.762)	(0.737)
$Q(2)_{i,t} \cdot Treat_i$	-0.014	-0.017	0.027	0.023
	(-0.284)	(-0.344)	(1.016)	(0.885)
$Q(-1)_{i,t}$	-0.031	-0.029	-0.038	-0.039
	(-0.975)	(-0.826)	(-0.710)	(-0.731)
$Q(0)_{i,t}$	0.078**	0.081*	-0.050	-0.050
	(2.010)	(1.807)	(-1.264)	(-1.287)
$Q(1)_{i,t}$	-0.008	-0.002	-0.006	-0.005
	(-0.192)	(-0.034)	(-0.154)	(-0.115)
$Q(2)_{i,t}$	-0.026	-0.018	-0.043	-0.037
	(-0.625)	(-0.462)	(-1.041)	(-0.932)
TTM		0.383		0.258
		(0.572)		(0.854)
ZTD		0.002*		0.001*
		(1.646)		(1.922)
Age		0.215		0.181
		(0.610)		(1.203)
Amtout		-0.006		0.018
		(-0.291)		(0.114)
Bond FE	Y	Y	Y	Y
Issuer · Month FE	Y	Y	Y	Y
N	15,703	15,703	24,355	24,355
Adj. R^2	0.894	0.894	0.894	0.894

Panel B: Regressions Using Monthly Event Dummies				
			High Cash Funds Only	
	(1)	(2)	(3)	(4)
$M(-3)_{i,t} \cdot Treat_i$	-0.045	-0.046	-0.060	-0.057
	(-0.471)	(-0.477)	(-1.043)	(-0.986)
$M(-2)_{i,t} \cdot Treat_i$	0.040	0.042	0.015	0.015
	(0.462)	(0.485)	(0.398)	(0.402)
$M(-1)_{i,t} \cdot Treat_i$	-0.117	-0.116	0.016	0.019
	(-1.268)	(-1.268)	(0.303)	(0.370)
$M(0)_{i,t} \cdot Treat_i$	-0.256**	-0.255**	0.009	0.015
	(-2.541)	(-2.329)	(0.231)	(0.373)
$M(1)_{i,t} \cdot Treat_i$	0.295***	0.295***	0.070	0.065
	(2.673)	(2.603)	(1.445)	(1.327)
$M(2)_{i,t} \cdot Treat_i$	0.016	0.016	-0.038	-0.040
	(0.137)	(0.136)	(-0.757)	(-0.796)
$M(3)_{i,t} \cdot Treat_i$	0.104	0.104	0.021	0.021
	(1.378)	(1.420)	(0.653)	(0.643)
$M(-3)_{i,t}$	0.027	0.030	-0.013	-0.012
	(0.396)	(0.426)	(-0.158)	(-0.143)
$M(-2)_{i,t}$	0.052	0.048	-0.112	-0.110
	(0.565)	(0.510)	(-1.600)	(-1.577)
$M(-1)_{i,t}$	0.018	0.014	0.020	0.023
	(0.124)	(0.097)	(0.204)	(0.235)
$M(0)_{i,t}$	0.197**	0.194*	-0.001	0.002
	(2.091)	(1.792)	(-0.023)	(0.029)
$M(1)_{i,t}$	-0.130	-0.137	-0.095*	-0.087
	(-1.308)	(-1.321)	(-1.676)	(-1.460)
$M(2)_{i,t}$	0.094	0.088	0.070	0.077
	(0.708)	(0.691)	(1.163)	(1.256)
$M(3)_{i,t}$	0.029	0.024	0.051	0.060
	(0.316)	(0.268)	(0.591)	(0.710)
Controls	N	Y	N	Y
Bond FE	Y	Y	Y	Y
Issuer · Month FE	Y	Y	Y	Y
N	13,150	13,150	20,613	20,613
Adj. R^2	0.885	0.885	0.894	0.894

Table 6. Cumulative Return Differences between Treated Bonds and Matched Control Bonds

This table provides cumulative return differences between treated and matched control bonds from $M(-3)$, a month before the fire sale quarter, through $M(3)$, three months after the fire sale quarter. The return differences during $M(n)$ are calculated using difference-in-difference estimates (i.e., coefficient estimates on $M(n) \cdot Treat_i$) obtained from Columns (2) and (4) of Table 5 Panel B. Shaded rows represent the fire-sale quarter. The values in parentheses are t-statistics using standard errors two-way clustered at the issuer and month levels. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

			High Cash Funds Only	
	Cumulative Return Differences	t-statistic	Cumulative Return Differences	t-statistic
M(-3)	-0.046	(0.477)	-0.057	(0.986)
M(-2)	-0.004	(0.054)	-0.042	(0.755)
M(-1)	-0.074	(1.018)	0.035	(0.293)
M(0)	-0.329**	(2.213)	0.049	(0.089)
M(1)	-0.034	(0.519)	0.115	(0.578)
M(2)	-0.017	(0.265)	0.075	(0.141)
M(3)	0.087	(0.163)	0.096	(0.269)

Table 7. Difference-in-Differences Regressions: Triple Interactions with Arbitrage Cost Proxies

This table provides the estimation results of difference-in-differences regressions using triple interactions with dummy variables for arbitrage costs:

$$R_{i,t} = \alpha + \sum_{n=-3}^{3} \beta_n M(n)_{i,t} \cdot Treat_i \cdot D_i + \sum_{n=-3}^{3} \gamma_n M(n)_{i,t} \cdot Treat_i + \sum_{n=-3}^{3} \eta_n M(n)_{i,t} \cdot D_i + \sum_{n=-3}^{3} \nu_n M(n)_{i,t} + Treat_i \cdot D_i + D_i + \epsilon_{i,t}$$

where $R_{i,t}$ is monthly returns (in percentage) on bond i during month t. D_i is a dummy variable for arbitrage cost proxies. In Columns (1) and (2), D_i is one if the volatility of return differences between the treated-control pair of bond i is above than the 20th percentile and zero otherwise. We measure the volatility of return differences by using 12-month returns from five quarters through two quarters before a fire sale. We require at least four observations of monthly returns to calculate the volatility. In Columns (3) and (4), D_i is one if amounts outstanding of control bonds of treated bond i is below the 20th percentile and zero otherwise. In Columns (5) and (6), D_i is one if the treated–control bond pairs are high-yield rated bonds. $Treat_i$ is an indicator variable for a treated bond. $M(n)_{i,t}$ is a monthly event dummy variable, which is one if month t is the n^{th} month from the last month of the fire-sales quarter of a bond i (or its matched treated bond). As control variables, we include logged time-to-maturity, *TTM*; zero trading days of the previous quarter, *ZTD*; log bond age, *Age*; and log amount outstanding, *Amtout*. We also include both bond fixed effects and issuer-times-month fixed effects. Fire-sale quarters span from 2005 Q2 through 2014 Q2. We include in the regressions monthly observations of the treated bonds and their matched control bonds from four quarters prior to the fire-sale quarter through one quarter after. To save space, we report coefficient estimates only on the triple interactions (β_n) and omit other coefficients. Shaded rows represent coefficient estimates for fire-sale quarters. The values in parentheses are t-statistics using standard errors two-way clustered at the issuer and month levels. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Volatility of Return Differences		Amount Outstanding of Control Bonds		High Yields vs. Investment Grades	
	(1)	(2)	(3)	(4)	(5)	(6)
$M(-3)_{i,t} \cdot Treat_i \cdot D_i$	0.283	0.280	-0.191	-0.198	0.032	0.033
	(1.167)	(1.131)	(-0.630)	(-0.650)	(0.149)	(0.153)
$M(-2)_{i,t} \cdot Treat_i \cdot D_i$	0.145	0.139	0.058	0.049	0.206	0.206
	(0.268)	(0.258)	(0.267)	(0.226)	(1.021)	(1.025)
$M(-1)_{i,t} \cdot Treat_i \cdot D_i$	-0.922*	-0.928*	-0.041	-0.053	-0.269	-0.269
	(-1.745)	(-1.757)	(-0.188)	(-0.241)	(-1.165)	(-1.161)
$M(0)_{i,t} \cdot Treat_i \cdot D_i$	-0.826	-0.835	-1.115*	-1.128*	-0.579**	-0.577**
	(-1.139)	(-1.122)	(-1.803)	(-1.797)	(-2.325)	(-2.282)
$M(1)_{i,t} \cdot Treat_i \cdot D_i$	0.866	0.854	0.182	0.170	0.260	0.262
	(0.975)	(0.958)	(0.416)	(0.387)	(1.032)	(1.012)
$M(2)_{i,t} \cdot Treat_i \cdot D_i$	-0.369	-0.382	0.188	0.173	-0.107	-0.109
	(-0.509)	(-0.515)	(0.613)	(0.549)	(-0.395)	(-0.396)
$M(3)_{i,t} \cdot Treat_i \cdot D_i$	0.104	0.089	-0.017	-0.032	0.223	0.226
	(0.380)	(0.323)	(-0.088)	(-0.165)	(1.617)	(1.572)
$Controls$	N	Y	N	Y	N	Y
$Bond\ FE$	Y	Y	Y	Y	Y	Y
$Issuer \cdot Month\ FE$	Y	Y	Y	Y	Y	Y
N	9,575	9,575	13,150	13,150	13,150	13,150
Adj. R^2	0.891	0.891	0.885	0.885	0.885	0.885

Table 8. Weekly Abnormal Returns on Fire-Sale Portfolio around the Taper Tantrum in 2013

This table provides weekly average abnormal returns (in percentages) on two value-weighted corporate bond portfolios (low-cash and high-cash portfolios) sorted on price pressure. The low-cash portfolio consists of fire-sale bonds from 2013 Q2 as defined in Section 4.1 using low-cash (<5%) funds. The high-cash portfolio is defined similarly using high-cash funds instead of low-cash funds. We report weekly average abnormal returns (*E[R]*) from April 12 through July 19. The weekly returns on bonds are calculated based on prices obtained from TRACE using the last daily price within 2 days of the end of each week. The abnormal returns are estimated following the matching-portfolio approach (by rating and maturity) of Bessembinder et al. (2009). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Low Cash		High Cash	
Year 2013	E[R] (%)	t-statistic	E[R] (%)	t-statistic
April 12	-0.038	(-0.37)	-0.003	(-0.04)
April 19	0.095	(1.18)	-0.032	(-0.65)
April 26	-0.026	(-0.23)	-0.020	(-0.38)
May 3	0.030	(0.21)	-0.054	(-0.91)
May 10	-0.264***	(-2.88)	0.013	(0.22)
May 17	-0.150	(-1.09)	0.071	(1.04)
May 24	-0.063	(-0.53)	-0.101	(-1.13)
May 31	-0.131	(-0.99)	-0.026	(-0.41)
June 7	-0.106	(-0.90)	0.126	(1.75)
June 14	0.011	(0.05)	-0.052	(-0.55)
June 21	0.296**	(1.89)	0.092	(1.13)
June 28	0.071	(0.54)	0.015	(0.17)
July 5	0.380	(1.46)	-0.112	(-1.18)
July 12	0.011	(0.08)	-0.112	(-1.23)
July 19	-0.103	(-1.05)	0.032	(0.54)

Table 9. Fire Sale Effects on New Bond Offering Yields During the Taper Tantrum

This table provides the estimation results of following regressions.

$$Y_{i,j,t} = \alpha + \beta_1 Event_t \cdot Treat_i + \beta_2 Treat_i + \epsilon_{i,t}$$

$$Y_{i,j,t} = \alpha + \beta_1 Event_t \cdot Treat_i \cdot M_{i,j,t} + \beta_2 Event_t \cdot Treat_i + \beta_3 Event_t \cdot M_{i,j,t} + \beta_4 M_{i,j,t} \cdot Treat_i + \beta_5 M_{i,j,t} + \beta_6 Treat_i + \epsilon_{i,t}$$

where $Y_{i,j,t}$ is offering yields (in percentages) of bond i issued by firm j at month t. $Event_t$ is a dummy variable that equals one if the issuing date is between May 1, 2013 and June 31, 2013 and zero otherwise. $Treat_i$ is a time-invariant dummy variable for bond i issued by firm j indicating that pre-existing bonds of firm j are held by low-cash (<5% of total net assets) funds with outflows at the bottom 30% from May through June 2013. In Columns (5) through (8), $Treat_i$ is defined similarly using high-cash (>=5%) funds. $M_{i,j,t}$ equals one if the issuer of bond i has outstanding bonds maturing within one month from the issuance of bond i. As control variables, we include logged amount outstanding of the newly issued bond i, a dummy variable indicating private placement, and four dummy variables indicating separate option features such as convertible, call, put, and sinking provision. We also include rating-times-month, time-to-maturity-times-month, and industry fixed effects. Specifically, we use the S&P issue-rating and times to maturity groups of 0-to-3 year, 3-to-5 year, 5-to-7 year, 7-to-9 year, 9-to-11 year, 11-to-15 year, 15-to-20 year, 20-to-30 year, and 30+-year bins. To be included in the sample, a firm should have at least one outstanding bond held by our sample funds. We exclude bond issues with no issue ratings available. To save space, we report only the coefficient estimates of the interactions of interest (β_1 and β_2) and omit other coefficient estimates. The sample period runs from February 1, 2013 through June 30, 2013. The values in parentheses are t-statistics using standard errors two-way clustered at the issue-rating and issuer levels. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Low Cash Funds				High Cash Funds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Event_t \cdot Treatment_i$	0.330**	0.351***	0.249**	0.308**	0.005	-0.062	0.059	-0.063
	(2.426)	(3.098)	(1.982)	(2.400)	(0.052)	(-0.493)	(0.620)	(-0.425)
$Event_t \cdot Treatment_i \cdot M_{i,j,t}$			0.909***	0.530*			-0.677	-0.074
			(2.834)	(1.720)			(-1.325)	(-0.089)
Controls	N	Y	N	Y	N	Y	N	Y
Rating · Month FE	Y	Y	Y	Y	Y	Y	Y	Y
TTM · Month FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	N	Y	N	Y	N	Y	N	Y
N	502	502	502	502	502	502	502	502
Adj. R^2	0.821	0.876	0.822	0.875	0.819	0.875	0.819	0.874

Table A-1. Flow–Performance Relationship in Corporate Bond Funds

This table provides results of the regression of quarterly mutual fund flows on lagged flows and lagged fund returns. We report both Fama-MacBeth regressions and pooled OLS using quarterly observations. We run the regressions for both corporate bond funds (CB) and equity funds from 2002 Q3 through 2014 Q4. We construct equity fund samples by following Huang, Sialm, and Zhang (2011). The dependent variable is the quarterly flow to a mutual fund. The independent variables are lagged flows and lagged returns up to the previous 8 quarters. To save space, we omit estimates for the constant. In the Fama-Macbeth regressions, we use Newey-West standard errors with eight lags and the reported R^2 are the average values of R^2 from the first-stage cross-sectional regressions. In the Pooled OLS estimations, we use Lipper-code-times-quarter fixed effects and standard errors clustered at the fund level. The R^2 for the Pooled OLS estimations are the adjusted R-squares. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Fama-MacBeth		Pooled	
	CB	Equity	CB	Equity
	(1)	(2)	(3)	(4)
Flow(t-1)	0.282***	0.265***	0.304***	0.268***
	(13.056)	(17.346)	(10.375)	(23.033)
Flow(t-2)	0.126***	0.116***	0.107***	0.131***
	(3.264)	(5.561)	(5.566)	(15.997)
Flow(t-3)	0.055***	0.071***	0.058***	0.066***
	(2.940)	(11.321)	(3.784)	(8.868)
Flow(t-4)	0.055***	0.056***	0.046***	0.061***
	(5.869)	(7.693)	(3.953)	(7.268)
Flow(t-5)	0.008	0.018**	0.004	0.014*
	(0.745)	(2.115)	(0.405)	(1.863)
Flow(t-6)	0.028*	0.032***	0.028*	0.034***
	(1.685)	(3.887)	(1.709)	(4.592)
Flow(t-7)	0.032***	0.014***	0.021*	0.015**
	(4.087)	(2.746)	(1.825)	(2.353)
Flow(t-8)	0.025**	0.018***	0.022	0.021***
	(2.221)	(3.632)	(1.548)	(4.693)
Return(t-1)	0.810***	0.370***	0.562***	0.247***
	(5.224)	(6.694)	(4.425)	(18.045)
Return(t-2)	0.621***	0.132***	0.374***	0.114***
	(3.786)	(5.857)	(4.584)	(9.708)
Return(t-3)	0.397**	0.065***	0.151*	0.054***
	(2.064)	(3.219)	(1.673)	(4.895)
Return(t-4)	0.222	0.076***	0.269***	0.061***
	(0.925)	(3.207)	(3.601)	(5.967)
Return(t-5)	0.251*	-0.006	0.212***	0.020**
	(1.767)	(-0.407)	(2.721)	(2.354)
Return(t-6)	-0.004	0.020	0.078	0.024***
	(-0.029)	(0.660)	(1.454)	(2.692)
Return(t-7)	-0.060	0.011	0.187***	-0.019**
	(-0.347)	(0.787)	(2.811)	(-2.102)
Return(t-8)	-0.132	0.012	-0.015	-0.022***
	(-0.743)	(0.673)	(-0.272)	(-2.775)
N	8,895	98,618	8,895	98,618
R^2	0.333	0.293	0.302	0.255