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Investor flows and fragility in corporate bond funds[☆]

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ABSTRACT

This paper explores flow patterns in corporate bond mutual funds. We show that corporate bond funds exhibit a concave flow-to-performance relationship: their outflows are sensitive to bad performance more than their inflows are sensitive to good performance. Moreover, corporate bond funds tend to have greater sensitivity of outflows to bad performance when they have more illiquid assets and when the overall market illiquidity is high. These results point to the possibility of fragility in the fast-growing corporate bond market. The illiquidity of corporate bonds may generate a first-mover advantage among investors in corporate bond funds, amplifying their response to bad performance.

1. Introduction

The landscape of the financial industry is constantly changing, as new financial innovation and regulation shift activities across different financial institutions and vehicles. One of the dominant trends of recent years is the growth of assets under management by fixed income mutual funds, i.e., mutual funds investing in corporate or government bonds. Data reported by Feroli, Kashyap, Schoenholtz, and Shin (2014) show that from January 2008 to April 2013, fixed income funds have attracted multiple times more inflows compared to equity, money market, allocation, and other funds combined. Data reported by the

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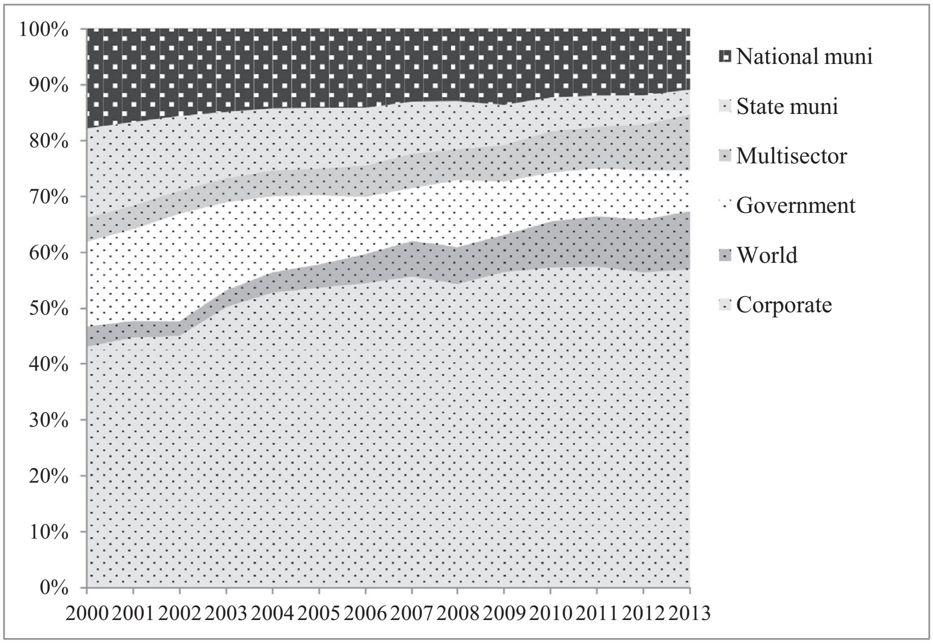

Fig. 1. Distribution of bond fund assets across investment objectives. This figure plots the share in net fund assets for fixed income mutual funds grouped by their investment objectives over the period 2000 to 2013. The source of data is the 2014 Investment Company Institute Fact Book.

Investment Company Institute (ICI 2014) show bond fund assets roughly doubling over this period.[1]

Observing this trend, several commentators have argued that bond funds pose a new threat to financial stability. What will happen when the current trend of loose monetary policy changes or upon increasing concerns of corporate defaults? Will large flows out of bond funds and subsequent sales of assets by these funds destabilize debt markets with potential adverse consequences for the real economy? Feroli, Kashyap, Schoenholtz, and Shin (2014) use evidence from the dynamics of bond funds to show that flows into and out of funds seem to aggravate and be aggravated by changes in bond prices. They conclude that this suggests the potential for instability to come out of this industry.

To get a better understanding of the potential threats to stability posed by bond mutual funds, we need more research on the flows into and out of these funds. By now, there is a large literature on flows in equity mutual funds, as reviewed recently by Christoffersen, Musto, and Wermers (2014). However, as they note, there is little research on flows in bond mutual funds. In this paper, we try to fill the gap. We focus on actively managed corporate bond funds in the period between January 1992 and December 2014. This is because, as we show in Fig. 1, the growth in assets held by these funds has been large relative to other bond funds, and because these funds present a particularly strong concern for stability due to the illiquidity of their assets (corporate bonds).

Fig. 2 shows the total net assets (TNA) and dollar flows of actively managed corporate bond funds in our sample. The total net assets in this segment have been trending up in our sample period, particularly since the onset of the recent financial crisis. As of 2008, there was $649 billion under management. From 2008 to 2014, this figure has almost tripled to more than $1.8 trillion. During the same period, outstanding US corporate bonds have gone up by 44% from $5.42 trillion to $7.83 trillion, according to Securities Industry and Financial Markets Association (SIFMA). Thus, corporate bond mutual fund size has grown significantly as a proportion of outstanding US corporate debt. Such a steady increase in corporate bond fund assets, however, masks increasingly volatile fund flows. For instance, corporate bond funds attracted net inflows of approximately $190 billion in 2009 but experienced net redemptions of nearly $60 billion from existing funds in 2013.

A pervasive result in the empirical literature on equity mutual funds is that the flow-to-performance relation tends to have a convex shape, that is, inflows to equity funds tend to be very sensitive to good past performance, but outflows are overall not that sensitive to bad past performance. Papers documenting this pattern, discussing its origins and consequences include: Ippolito (1992), Brown, Harlow, and Starks (1996), Chevalier and Ellison (1997), Sirri and Tufano (1998), Lynch and Musto (2003), Huang, Wei, and Yan (2007), among others. Considering the context of fragility, a convex flow-to-performance curve suggests that fragility is not a pressing concern. If investors do not rush to take their money out of funds following negative developments, then one should not worry about outflows depressing prices and leading to negative consequences for the real economy.

Our evidence, however, shows that corporate bond funds exhibit quite a different pattern from equity funds when it comes to the sensitivity of flow-to-performance. While we confirm a convex shape for equity funds' flow-to-performance over the period of our study, we show

[1] See Section 2.1 for details on the developments in the bond fund industry.

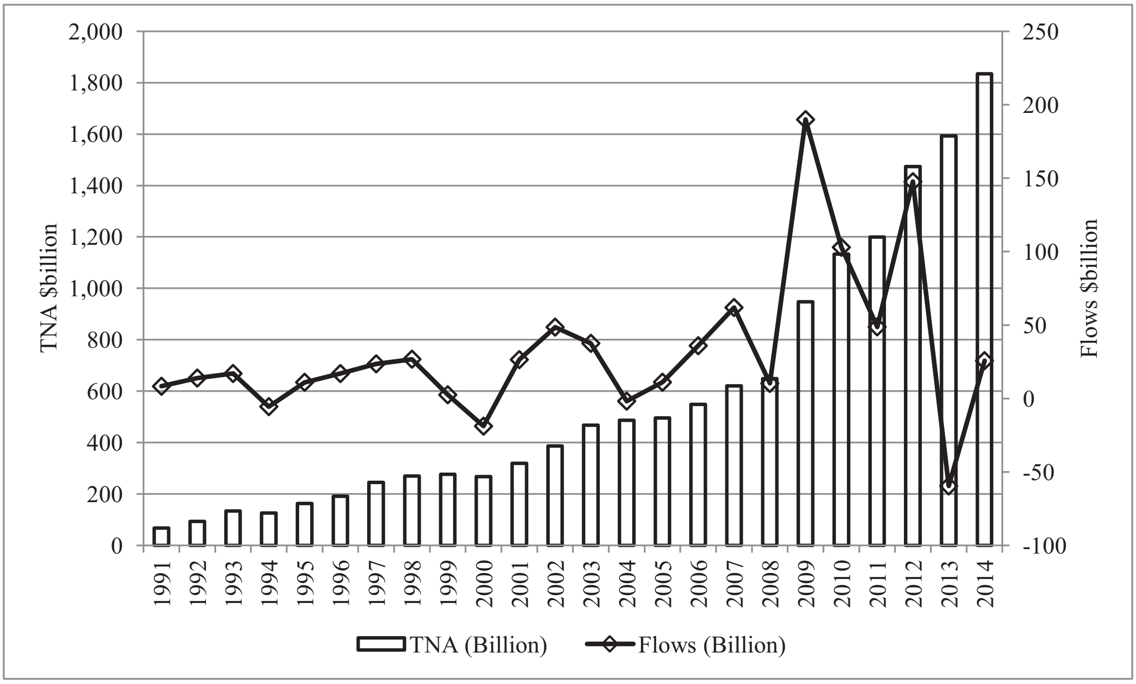

Fig. 2. Total net assets and dollar flows of active corporate bond funds. This figure shows total net assets (TNA) and dollar flows of actively managed corporate bond funds from 1991 to 2014. We exclude index corporate bond funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database.

that during the same time, corporate bond funds exhibit a concave shape: Their outflows are sensitive to bad performance more than their inflows are sensitive to good performance. Moreover, the sensitivity of flows in corporate bond funds in the negative (positive) region is greater (smaller) than that in equity funds.[2] Various subsample analyses within the sample of corporate-bond funds show that the concave flow-performance relation is pervasive across young and old funds, present in periods with high and low aggregate fund flows, and robust to controlling for the fund fixed effect. This is in contrast to findings in the literature on equity mutual funds, where Spiegel and Zhang (2013) show that the convexity is an artifact of heterogeneity and that it disappears within subsamples.

The greater sensitivity of outflows to bad performance in corporate bond funds is consistent with the arguments in Chen, Goldstein, and Jiang (2010). They compare the sensitivity of outflows to bad performance between equity funds that hold illiquid assets and equity funds that hold liquid assets. They show that outflows are more sensitive to bad performance in illiquid funds and relate the result to strategic complementarities and financial fragility. In illiquid funds, outflows impose greater liquidation costs on the fund when readjusting the portfolio. Since portfolio readjustments typically happen in the days after the actual redemption and investors get the net asset value as of the day of redemption, withdrawing money out of the fund leads to negative externalities on other investors who keep their money in the fund. This creates a first-mover advantage in the redemption decision, amplifying the flows out of illiquid funds following bad performance.[3]

Indeed, corporate bond funds tend to hold illiquid assets. Unlike equity, which typically trades many times throughout the day, corporate bonds may not trade for weeks and trading costs in them can be very large. Despite the illiquidity of their holdings, corporate bond funds quote their net asset values and allow investors to redeem their money on a daily basis. As a result, there is a significant mismatch between the illiquidity of the fund's holdings and the liquidity that investors holding the fund receive. The externalities imposed by redeeming investors on those who stay in the fund are expected to be large given this liquidity mismatch. Note that the increase in size of the corporate-bond market could in itself present fragility issues simply because more money is invested in assets that cannot be easily or cheaply liquidated. Our paper shows that this is further exacerbated by mutual funds, which provide more liquidity to those who exit first.

To further support the idea that asset illiquidity creates strategic complementarities among corporate-bond-fund investors in their redemption decisions, we conduct more tests on various dimensions of the data. First, the

[2] These results are obtained under our main specification, where performance is measured relative to the bond market and equity market. As we discuss in the paper, we conduct several robustness tests with different performance measures and find that the flow-performance relationship for corporate bond funds is never convex, whereas for equity funds it is always convex.

[3] Chen, Goldstein, and Jiang (2010) develop a model of runs in the tradition of the global-games literature—e.g., Morris and Shin (1998) and Goldstein and Pauzner (2005)—and show how complementarities will generate this amplification of outflows following bad performance. Such complementarities are in the spirit of the bank-run literature going back to Diamond and Dybvig (1983); albeit they are not as strong as in banks.

liquidation costs imposed on funds due to large outflows are expected to be more severe during periods of higher illiquidity, when bonds trade even less and trading is more costly. We use several measures that are common in the literature to proxy for aggregate illiquidity in the corporate-bond market. These include the Volatility Index (VIX), measuring implied volatilities in stock markets, the TED spread, measuring the difference between the interest rates on interbank loans and on Treasury bills, and a corporate bond illiquidity measure by Dick-Nielsen, Feldhutter, and Lando (2012), measuring illiquidity based on bond trading data. Consistent with our hypothesis, we find that outflows are more sensitive to bad performance of corporate bond funds during periods when the corporate bond market is less liquid.

Second, we show that among corporate bond funds, those with lower asset liquidity tend to experience greater sensitivity of outflows to bad performance. To measure liquidity at the fund level, we use the level of cash holdings, since funds with more cash suffer lower liquidation costs in case of large outflows, and expose their investors to weaker strategic complementarities. As additional measures of fund liquidity, we use a fund's holdings of cash and government bonds, and compute two holding-based liquidity measures using the Roll (1984) measure based on the serial covariance of bond returns and the interquartile price range based on the dispersion of intraday bond prices. We find similar results using these different measures of fund liquidity.

Third, we provide direct evidence for the first-mover advantage, by calculating the impact of outflows on fund returns in funds that hold illiquid assets when the market is less liquid. We find that for funds with illiquid asset holdings, a one standard deviation increase in outflows is associated with a decline in fund returns by 31 to 36 basis points in the same month when the corporate bond market is less liquid. In contrast, for funds with liquid asset holdings, a one standard deviation increase in outflows is associated with a decline in fund returns by only 5 to 7 basis points in the same month when the corporate bond market is liquid. Hence, rational investors should have a greater incentive to take their money out when they think others take their money out in the face of illiquid conditions. As we discuss in the paper, we think the effect of illiquidity estimated here is only a lower bound on the true effect.

Fourth, to further identify the effect of first-mover advantage on outflows, we use tax-loss selling at the turn of a year as an exogenous reason to redeem, and evaluate how it is amplified due to illiquidity. It is known that tax considerations will cause investors to take their money out of losing funds just before the end of the year. The first-mover advantage studied in our paper implies that these outflows will be amplified by illiquidity. Indeed, we find that, conditional on a fund having bad performance in the past year, funds with more illiquid assets tend to experience larger outflows towards the end of the year.

Fifth, following the model in Chen, Goldstein, and Jiang, (2010), we expect that strategic complementarities will be less important in determining fund outflows if the fund ownership is mostly composed of institutional investors. This is because institutional investors are large and so are more likely to internalize the negative externalities generated by their outflows. Using the fraction of institutional share class as a proxy for the presence of institutional investors, we indeed find that the effect of illiquidity on the sensitivity of outflows to bad performance diminishes when the fund has a large presence of institutional investors.

Sixth, expanding the analysis beyond corporate bond funds, we examine the flow-performance relation for Treasury bond funds and municipal bond funds. Both have similar payoff structures as corporate bond funds, but have different levels of liquidity, whereby Treasury bonds are very liquid, as equity, and municipal bonds are illiquid, as corporate bonds. Consistent with the liquidity theory, we find a convex flow-performance relation for Treasury funds and a concave flow-performance relation for municipal bond funds.

The strategic complementarities and first-mover advantage we discuss here are familiar from the banking context, and recently were on display in the run on money market mutual funds following the collapse of Lehman Brothers.[4] One thing that distinguishes banks and money market funds from other mutual funds (including bond funds) is that the latter have a floating net asset value (NAV), such that investors are not guaranteed to get a fixed amount when they withdraw. Indeed, this feature is often thought to prevent the emergence of strategic complementarities in mutual funds. However, this argument is incomplete. Even with a floating net asset value, the structure of funds gives rise to complementarities and fragility, since investors can take their money out at any trading day based on the most recently updated net asset value, and the consequences of their redemptions will be reflected to a large extent in future net asset values. Hence, investors impose a negative externality on others when they redeem their shares, creating the first-mover advantage. This problem arises mostly when the assets held by the fund are illiquid, which is the case for corporate bond funds.

The potential fragility from fund flows does not necessarily call for regulatory intervention. Funds can take measures to reduce the extent of the first-mover advantage and so reduce the amplification of outflows in illiquid funds. Indeed, we show here that the amplification is reduced when funds hold more liquid assets. Other measures funds can take include putting restrictions on redemptions or factoring the future liquidation costs into the net asset value that investors can take out of the fund. The practice of swing pricing, whereby the net asset value investors can redeem depends on the total flows experienced by the fund, is based on similar logic.[5] Thus far, swing pricing has only been used in some countries outside the US and information about its effectiveness is limited. In October 2016, the US Securities and Exchange Commission (SEC) adopted

[4] For empirical studies of the run on money market funds, see Kacperczyk and Schnabl (2013) and Schmidt, Timmerman, and Wermers (2016).

[5] Hanson, Scharfstein, and Sunderam (2015) discuss some solutions for money market funds, noting that a floating net asset value will not completely solve the problem.

a new rule permitting US open-end mutual funds to use swing pricing. This may change the way open-end mutual funds operate in the US and have interesting implications for future studies.

More broadly, regulators should be aware of the behavior of flows in the mutual fund industry. First, attempts to regulate other players in the financial system are likely to push more activity into mutual funds, potentially increasing their fragility. Indeed, the limitations imposed on banks in providing liquidity transformation have likely contributed to the increased prominence of corporate-bond funds in the provision of this service to investors. Second, if the effect of flows goes beyond the fund itself, e.g., by pushing down bond prices and thereby having a real effect on firms, and is not internalized by the fund, then mutual funds will not fully implement the desired measures.[6] Our paper does not attempt to answer the question of whether outflows in bond funds have significant implications on market prices and/or the real economy. Hence, we do not attempt to address the potential systemic implications of corporate-bond-funds fragility. We do, however, perform one analysis that goes beyond the fund level and examine the flow-performance relation for the aggregate corporate bond fund sector. Interestingly, we find that it is also concave just like at the fund level, exhibiting strong sensitivity of outflows to negative performance. This is in contrast to the equity fund sector, where the flow-performance relation is essentially flat at the aggregate level, as was previously found by Warther (1995). Hence, in corporate-bond funds, there is a possibility of substantial redemptions out of the sector in response to negative aggregate performance.

The remainder of the paper is organized as follows. Section 2 presents the institutional background and hypothesis development. Section 3 presents the data and methodology. Section 4 shows the empirical results. Section 5 concludes.

2. Institutional background and hypothesis development

2.1. Institutional background

As shown in Fig. 1, the share of corporate bond fund assets in the universe of fixed income funds has trended up steadily. Traditional players in the corporate bond market include long-horizon investors such as insurance companies, pension funds, and trusts.[7] In the recent decade, mutual funds have become increasingly important in corporate bond markets. With a total net asset value reaching \$1.8 trillion in 2014 (see Fig. 2), corporate bond funds comprise 57% of all bond fund assets. Adrian, Fleming, Shachar, and Vogt (2015) use Federal Reserve data and estimate that mutual funds own more than 20% of outstanding corporate bonds in 2015. Despite their growing prominence, research on corporate-bond funds has been quite limited.[8] We try to fill the gap in this paper. To make our analysis of flow-performance relation comparable with the literature on equity funds, our paper focuses on actively managed corporate bond mutual funds.[9]

Corporate bond funds are prone to strategic complementarities in redemption decisions among their investors due to the mismatch between the illiquidity of their assets and the liquidity they offer to their investors. Below, we elaborate on four contributing features: infrequent corporate bond trading; uncertain pricing of corporate bonds; high costs associated with investor outflows; and negative externality arising from costly outflows.

First, in contrast to equities which trade frequently on the exchange, corporate bonds trade in the over-the-counter dealer market relatively infrequently. Edwards, Harris, and Piwowar (2007) find that individual bond issues do not trade on 48% of the days in their sample. They find that the average number of daily trades in an issue, conditional on trading, is only 2.4. Bessembinder and Maxwell (2008) suggest that the corporate bond market remains relatively illiquid compared with other bonds. This remains true in recent years. In 2014, corporate bonds comprise a sizeable 20.1% of bonds outstanding in US markets, but account for only a small 3.7% of trading volume, according to figures from SIFMA. In contrast, US Treasury securities represent 32.1% of the US bond market but their trading volume accounts for a lion's share (69.2%) of the trading volume for all bonds.

Second, since corporate bonds trade infrequently, accurate price information of corporate bonds may not be readily available, which leads to ambiguity in their pricing. According to the Investment Company Act of 1940, bonds not traded should be priced at "fair value" made "in good faith." Cici, Gibson, and Merrick (2011) find that in practice, bond fund managers usually comply with this mandate by marking their bond positions at the prices provided by one or more pricing service companies and/or securities dealers. However, there is much ambiguity about the best practice to follow, and so prices that go into the NAV calculation might be stale.

Third, the trading cost associated with outflows can be high for corporate bond funds. Although substantial disagreement exists in the literature, the estimates of trading costs in corporate bonds indicate that they are generally large. For instance, Edwards, Harris, and Piwowar

[6] There is vast evidence on the price pressure imposed by mutual fund outflows (e.g., Coval and Stafford, 2007; Manconi, Massa, and Yasuda, 2012; and Ellul, Jotikasthira, and Lundblad, 2011) and on the real effect of these outflows (e.g., Edmans, Goldstein, and Jiang, 2012; and Hau and Lai, 2013). Gilchrist and Zakrajsek (2012) examine the relation between non-fundamental changes in bond prices and key macroeconomic variables.

[7] As Bessembinder and Maxwell (2008) explain, most bond issues are often absorbed into stable "buy-and-hold" portfolios of insurance companies and pension funds soon after issuance. The reason is that corporate bonds are a favored investment for insurance companies and pension funds, since their long-horizon obligations can be matched reasonably well to the relatively predictable, long-term stream of coupon interest payments from bonds.

[8] Two exceptions are Zhao (2005) and Chen and Qin (2017). However, their focus is quite different, as they do not look at the effects of liquidity and fragility.

[9] Among corporate bond funds, index funds represent a relatively small portion of the sample. At the end of our sample in 2014, there are 45 distinct index corporate bond funds with \$69 billion of assets under management; by comparison, there are 850 distinct active corporate bond funds with \$1.8 trillion of assets under management.

(2007) estimate that the round-trip transaction costs in corporate bonds range from approximately 150 basis points (bps) for the smallest trade size to about three bps for the largest trade size (see also Bessembinder, Maxwell, and Venkataraman, 2006). Bao, Pan, and Wang (2011) use serial covariance in corporate bond returns [essentially the same as the Roll (1984) measure described in Section 4.2.2] to estimate the trading costs and find that the median implied bid-ask spread is 1.50%. These results support the view that it is costly to trade corporate bonds, especially during times of distress or low liquidity.

Finally, the structure of corporate bond funds that hold illiquid assets but provide withdrawal rights to their investors on a daily basis would give rise to payoff complementarities. Like other open-end mutual funds, the costs imposed by investors' liquidation in corporate bond funds are not fully reflected in the price these investors get when they redeem the shares, but are shared by investors who keep their money in the fund. The NAV at which investors can buy and sell their shares in the funds is calculated using the same-day market close prices of the underlying securities, but the trades made by the funds in response to redemptions are most likely to happen after the day of the redemptions. Taking into account that corporate bonds do not trade often, that there is ambiguity on their pricing, and that transaction costs can be large, the externalities imposed by redeeming shareholders on remaining shareholders can be very significant in corporate bond funds. This might create a 'run risk': Investors might have a stronger incentive to redeem their shares just because they expect other investors will do so, and so large redemptions become a self-fulfilling phenomenon. This is related to the well-known bank-run phenomenon, albeit we do not expect it to be as strong in mutual funds as in uninsured banks.

One would expect mutual fund managers to take measures to mitigate these externalities. For instance, on March 3, 2005, the Securities and Exchange Commission voted to adopt a rule concerning voluntary redemption fees, which allows a mutual fund to charge a redemption fee of up to 2% of the amount of the shares redeemed to discourage excessive short-term redemptions. In practice, however, redemption fees do not appear to be very popular among mutual funds, possibly because funds compete to attract investors' money. This is related to the argument in Stein (2005). He studies a model trying to understand why there are so many open-end funds and so few closed-end funds in equilibrium. Because funds compete for investors and because being open-ended can be thought of as a signal of high skill, then an excessive number of open-end funds arises in equilibrium relative to closed-end funds. Similarly, one can think of the decision between being open-end and being closed-end as a spectrum, where high redemption fees move the fund away from being completely open-ended. Then, competition and signaling could generate redemption fees that are too low in equilibrium.

2.2. Hypothesis development

The main hypotheses we have are based on the idea that strategic complementarities exist among investors in corporate bond mutual funds driven by the illiquidity of their assets. When investors redeem their shares, they get the net asset value as of the day of redemption. The fund then has to conduct costly liquidation that hurts the value of the shares for investors who keep their money in the fund. Hence, the expected redemption by some investors increases the incentives of others to redeem. Chen, Goldstein, and Jiang (2010) provide a model which clarifies this point formally. They show how strategic complementarities driven by illiquidity amplify the sensitivity of outflows to bad performance. This model also applies to our context. We now describe the four main hypotheses that follow from the model.

A key distinction between corporate bond funds and equity funds is that the former hold much more illiquid assets. Hence, the strategic complementarities for investors when redeeming shares will be stronger in corporate bond funds than in equity funds. This leads to the first hypothesis.[10]

Hypothesis 1. Corporate bond funds exhibit stronger sensitivity of outflows to bad performance than equity funds, leading to a more concave flow-to-performance relation.

Focusing on corporate bond funds, the same logic should extend to changes in liquidity over time. When illiquidity in the corporate bond market is higher, strategic complementarities among mutual fund investors should strengthen, leading to greater sensitivity of outflows to bad performance. This leads to the second hypothesis.

Hypothesis 2. During periods of higher illiquidity, corporate bond funds exhibit greater sensitivity of outflows to low past performance.

While the previous hypothesis deals with the time series, similar forces are expected to operate in the comparison across different funds. Greater illiquidity at the level of the fund is expected to generate stronger strategic complementarities among investors when deciding to redeem their shares. Funds with more liquid assets will not have to bear high costs liquidating their positions on short notice to meet redemption requests, mitigating the negative externalities following redemptions. Funds may thus choose to hold more liquidity to alleviate the tendency of investors to run. This leads to the third hypothesis.

Hypothesis 3. Corporate bond funds with more illiquid assets exhibit greater sensitivity of outflows to low past performance.

Finally, we expect strategic complementarities to be weaker in funds that are held mostly by institutional investors. These investors are large and hold a large proportion of the funds' assets; hence, they internalize the liquidation cost and are less prone to strategic complementarities. Other investors, knowing that the institutional investors provide strategic stability, are also less inclined to

[10] In a different context, Getmansky (2012) shows that hedge funds feature greater sensitivity of flows to performance on the downside than on the upside. But, this is most likely due to the restrictions that prevent new investors from coming into the funds.

withdraw. This point is made formally in the model of Chen, Goldstein, and Jiang (2010). This leads to the last hypothesis.

Hypothesis 4. The effect of illiquidity on the sensitivity of outflows to bad performance is weaker in funds that are held mostly by institutional investors.

Our empirical tests will focus on these hypotheses and also provide robustness tests to check whether illiquidity is indeed an important force in amplifying withdrawals out of mutual funds and creating 'run' dynamics. We now describe the data and empirical measurements.

3. Sample construction and empirical measurements

3.1. Sample construction

Data on corporate bond funds come from the Center for Research in Security Prices (CRSP). Our sample period is January 1992 to December 2014. Prior to 1991, there are few corporate bond funds in the CRSP database. Since we use one year of data to estimate the alpha of individual bond funds, our flow-performance tests start from January 1992. A bond fund typically issues several share classes with different bundles of expense ratios, management fees, front-end and/or back-end sales charges (loads), minimum investment requirements, and restrictions on investor types to attract investors with different wealth levels, investment horizons, and investment mandates. Since these fund share-level characteristics can influence the investment and redemption decisions of mutual fund investors, we use individual fund share classes as our unit of observation.

We select corporate bond funds based on the objective codes provided by CRSP.[11] In the paper, we use Lipper objective codes as a measure of style of a corporate bond fund. We require at least one year of fund history before a fund is included in our sample and exclude index corporate bond funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Our final sample includes 4679 unique fund share classes and 1660 unique corporate bond funds. To compare the behavior of investors in corporate bond funds and equity funds, we follow Jiang and Zheng (2015) to select the sample of equity funds.

3.2. Measurement of flow and performance

The key variables in our empirical analyses are mutual fund flows and performance. As a standard practice, we impute net fund flows from the total net assets of each fund share class between consecutive points in time and the interim net fund return. Specifically, flow for fund k in month t is defined as:

$$Flow_{k,t} = \frac{TNA_{k,t} - TNA_{k,t-1}(1 + R_{k,t})}{TNA_{k,t-1}},$$

where $R_{k,t}$ is the return of fund k during month t, and $TNA_{k,t}$ is the total net asset value at the end of month t. To mitigate the influence of outliers (a standard practice in the literature), fund flows are winsorized at the 1% and 99% levels.

To measure performance of corporate bond funds, we estimate a bond fund's average alpha in the past year by performing rolling-window time-series regressions for each fund using the past 12 months of data. One issue that merits discussion is the benchmark relative to which performance is measured. Given the scarcity of studies on the investment and redemption decisions of corporate bond fund investors, we resort to both theory and prior studies on flows and performance of equity funds for guidance. Our primary performance measure is fund *Alpha*, which is the intercept from a regression of excess corporate bond fund returns on excess aggregate bond market and aggregate stock market returns. We use the Vanguard Total Bond Market Index Fund return and CRSP value-weighted market return to proxy for aggregate bond and stock market returns.

Several reasons prompt the choice of this simple measure of fund *Alpha*. First, a positive (negative) intercept from this regression for a given mutual fund over a particular period indicates that investors holding passive stock and bond market portfolios would have improved their mean-variance performance had they tilted their portfolios towards (away from) the fund. Therefore, the measured *Alpha* can, a priori, be an important determinant of the investment and redemption decisions of bond fund investors if they expect future alphas to be persistent. Second, a growing number of studies find that alpha from the Capital Asset Pricing Model (CAPM) drives flows into and out of equity mutual funds, and the explanatory power of CAPM alpha for fund flows is higher than alternative, multifactor models (see Berk and Van Binsbergen, 2016; Barber, Huang, and Odean, 2016). Although for equity funds it may be reasonable to approximate the wealth portfolio using the aggregate stock market return following the spirit of CAPM, for corporate bond funds, it seems natural to include both bond and stock markets to approximate fluctuations in the wealth portfolio.[12] Third, from an asset pricing perspective, a growing literature establishes common risk factors driving both stock and bond returns (e.g., Fama and French, 1993; Koijen, Lustig, and Van Nieuwerburg, 2017). Therefore, it is reasonable to adjust for the exposures to bond and stock market risks when computing corporate bond fund alpha.

[11] Specifically, to be classified as a corporate bond fund, a mutual fund must have a (1) Lipper objective code in the set ('A','BBB', 'HY', 'SII', 'SID', 'IID'), or (2) Strategic Insight objective code in the set ('CGN', 'CHQ', 'CHY', 'CIM', 'CMQ', 'CPR', 'CSM'), or (3) Wiesenberger objective code in the set ('CBD', 'CHY'), or (4) 'IC' as the first two characters of the CRSP objective code.

[12] Earlier tests of CAPM approximate returns on the wealth portfolio using the value-weighted returns to stock and bond markets (e.g., Friend, Westerfield, and Granito, 1978). Since our objective is not to literally test if the aggregate wealth portfolio is mean-variance efficient, and for the benefit of mitigating measurement errors in the relative value of stocks and bonds, we adopt a more flexible approach of including both stock and bond market returns in the regression. Another advantage of our approach is that it allows individual funds to have different exposures to stock and bond markets.

Given that there is no established consensus on measuring performance for corporate bond funds, we consider several robustness tests with different measures of performance. First, instead of using both stock and bond market factors, we use a more parsimonious, one-factor model with the aggregate bond market return to compute the corporate bond fund alpha. Second, to improve the precision of beta estimates, we first estimate fund beta using the past two or three years of return data, and then compute the alpha of the bond fund over the next month. Third, we use fund returns in excess of the cross-sectional average of all corporate bond fund returns as an alternative measure of fund performance. Fourth, we use raw fund returns in excess of the risk-free rates. The results of these robustness tests, unreported to conserve space, show that our main findings are robust to the choice of performance measure.

3.3. Measurement of liquidity

Our empirical analysis incorporates both aggregate and fund-level measures of liquidity. We use three measures of the aggregate corporate bond market liquidity. First, Bao, Pan, and Wang (2011) find that increase in the aggregate stock market volatility, as proxied by the VIX index, strongly and positively impacts the illiquidity of corporate bonds. We therefore use the VIX index (from the Chicago Board Options Exchange (CBOE)) as one measure of aggregate corporate bond illiquidity. Second, Brunnermeier and Pedersen (2009) show that asset market liquidity co-moves with the funding liquidity of financial institutions that supply liquidity to asset markets. We use the TED spread (difference between the three-month London Interbank Offered Rate (LIBOR) and the three-month Treasury-bill interest rate, from the St. Louis Fed data) to capture funding liquidity to financial institutions, which in turn determines the liquidity of corporate bond markets. Third, we use the index of aggregate corporate bond market illiquidity proposed by Dick-Nielsen, Feldhutter, and Lando (DFL, 2012). Since the DFL index is estimated using the TRACE (Trade Reporting and Compliance Engine) data, it has a shorter history, starting from July 2002 to June 2013. It shares an 86% correlation coefficient with VIX. We use these three aggregate liquidity measures to capture the periods when liquidity in the corporate bond market evaporates, strengthening the concern of fund investors about the negative externality arising from other investors' redemption decisions.

Concerning the liquidity of assets held by individual corporate bond funds, as a first approximation, we use a fund's cash holdings (the fraction of fund assets held in cash). To accommodate redemption requests from clients, fund managers may have multiple means, e.g., disposal of undesired holdings, selling liquid assets, using the proceeds from new clients (inflows), and loans from financial markets or other institutions such as the fund family. When faced with large, abrupt net redemptions, however, cash provides fund managers with the most reliable source of liquidity (see Chernenko and Sunderam, 2016). Moreover, while adverse market events (e.g., the failure of Lehman Brothers) can render the liquidity of previously liquid financial assets (e.g., shares of money market funds) suddenly illiquid, the liquidity of cash is largely insulated from these movements. These considerations prompt us to use the pre-determined level of cash holdings to proxy for the liquidity of a fund's assets, which, according to our hypothesis, will influence the redemption decisions of fund investors.

Of course, the level of cash holdings can reflect fund managers' anticipation of the fund's foreseeable liquidity needs, and therefore could be endogenous, which may reverse the direction of causality. This concern of endogeneity, however, implies that conditional on poor past performance, funds with higher cash holdings should experience large subsequent redemptions, due to fund managers' anticipation effect. This predicted direction is opposite to that of our hypothesis and, if relevant, could potentially bias us against finding evidence that supports our hypothesis. In addition to the level of cash holdings, we use the holdings of cash and government bonds from the CRSP mutual fund database as another proxy for liquidity of the funds' holdings. As a second measure of cash, we also collect cash holdings data for corporate bond mutual funds from the SEC N-SAR filings.[13]

Finally, we also estimate the fund holdings-based liquidity based on the corporate bonds held by the fund. For this, we use the TRACE data which is a publicly available data set that contains corporate bond transactions-level data. We average the daily liquidity over each month to create two monthly liquidity measures (Roll and interquartile range) for each bond. We merge the CRSP funds' bond holdings with the monthly bond liquidity measures, and then aggregate over each corporate bond fund's bond holdings to create fund-level liquidity measures.

3.4. Summary statistics

Table 1 presents the summary statistics for the funds in our sample from January 1992 to December 2014. Over this sample period, active corporate funds record returns of 0.42% and an inflow of 0.82% per month on average. The median fund age is 6.89 years. On average these funds have annual expense of 1.04% and approximately 29% of them charge rear-end loads. The funds hold 3.5% of their assets in cash on average, but the cash holding practices vary substantially across funds with a standard deviation of 10%. The top 1% of funds holds as much as 46.7% of their assets in cash, while the bottom 1% has negative cash holding (i.e., leverage) of 36.72%. Fewer than 20% of the funds have negative cash holdings. On average, 23% of the fund share-classes are institutional.

4. Results

4.1. Flow-performance relation for corporate bond funds

In this section, we report that outflows are more sensitive to underperformance of corporate bond funds

[13] The paper by Chernenko and Sunderam (2016) uses this source as well.

Table 1
Summary statistics.
This table shows the summary statistics for characteristics of active corporate bond funds in our sample from January 1992 to December 2014. We report the mean (Mean), standard deviation (Std dev), 1st percentile (P1), 5th percentile (P5), etc., as well as the total number of observation (N). Flow (%) is the percentage fund flow in a given month, Fund return (%) is the monthly net fund return in per cent, Log(TNA) is the natural log of total net assets (TNA), Log(age) is the natural log of fund age in years since its inception in the CRSP database, Expense (%) is fund expense ratio in percent, Rear load is an indicator variable that equals one if the fund share charges rear loads and zero otherwise, Cash holdings is the proportion of fund assets held in cash in percent, Institutional is an indicator variable that equals one if it is an institutional share class, and zero otherwise. The unit of observation is share class-month. The sample includes 4679 unique fund share classes and 1660 unique funds. We exclude index corporate bond funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance ($^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, respectively).

	Mean	Std dev	P1	P5	P10	P20	P30	P40	P50	P60	P70	P80	P90	P95	P99	N
Flow (%)	0.82	8.79	−23.83	−7.27	−4.26	−2.27	−1.33	−0.72	−0.20	0.34	1.15	2.54	5.87	11.13	44.09	326,035
Fund return (%)	0.42	1.86	−4.90	−1.93	−1.03	−0.38	0.00	0.25	0.47	0.72	0.99	1.34	1.91	2.54	5.17	326,036
Log(TNA)	3.88	2.38	−2.30	−0.51	0.64	1.97	2.84	3.51	4.08	4.64	5.22	5.89	6.72	7.39	8.79	326,076
Log(age)	1.90	0.76	0.22	0.61	0.85	1.20	1.49	1.72	1.93	2.14	2.35	2.58	2.85	3.08	3.56	326,871
Expense (%)	1.04	0.48	0.14	0.40	0.50	0.63	0.74	0.82	0.93	1.05	1.26	1.57	1.77	1.90	2.13	326,035
Rear load	0.29	0.46	0	0	0	0	0	0	0	0	0	1	1	1	1	326,871
Cash holdings (%)	3.50	10.04	−36.72	−10.52	−2.54	0.00	1.08	1.97	2.81	3.81	5.00	6.90	11.40	18.31	46.69	326,035
Institutional	0.23	0.42	0	0	0	0	0	0	0	0	0	1	1	1	1	326,871

than are inflows to outperformance. To begin, we follow Chevalier and Ellison (1997) and Robinson (1988) to estimate a semi-parametric regression of fund flows on past fund performance, where the relation between fund flows and performance has a flexible functional form. Our semi-parametric regression is specified as follows:

$$Flow_{i,t} = \alpha + f\ (Alpha_{i,t-12\to t-1}) + \gamma Controls_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where $Flow_{i,t}$ is corporate bond fund i's net flow in month t, and $Alpha_{i,t-12\to t-1}$ is fund i's alpha estimated as the intercept from a regression of excess fund returns on excess aggregate bond market and aggregate stock market returns in the past one year. $Controls_{i,t}$ includes a number of fund characteristics: Lagged flow (the fund's net flow in month $t-1$), Log(TNA) (the natural log of fund assets), Log(age) (the natural log of fund age in years), Expense (the fund's expense ratio), and Rear load (an indicator variable equal to one if the fund charges back-end loads and zero otherwise). To compare our results with the literature on equity funds, we also estimate the same regression for stock funds in the same period. To make the results comparable between the corporate bond funds and stock funds, we use the same two-factor model to estimate equity fund alpha. The results, however, are similar if we use a one-factor model including only the aggregate stock market return to estimate alpha for equity mutual funds.

Fig. 3 shows the results. Among underperforming funds, the response of outflows to a decline in the alpha of corporate bond funds is highly sensitive, in contrast to the low sensitivity of flows out of equity funds to a decrease in their alpha. Among outperforming funds, however, investors tend to reward winning equity funds by allocating disproportionally more money to their managers, but show only a tepid response to the performance of winning corporate bond funds. These results provide initial support for Hypothesis 1 that corporate bond funds exhibit a stronger sensitivity to underperformance than equity funds.

Due to the flexible functional specification, the semi-parametric approach has relatively low statistical power. To formally test Hypothesis 1, we perform the following parametric regression that captures a potential nonlinearity in the flow-performance relation:

$$\begin{aligned} Flow_{i,t} = {} & \alpha + \beta_1 Alpha_{i,t-12\to t-1} \\ & + \beta_2 Alpha_{i,t-12\to t-1} \times I(Alpha_{i,t-12\to t-1} < 0) \\ & + \beta_3 I(Alpha_{i,t-12\to t-1} < 0) + \gamma Controls_{i,t} + \varepsilon_{i,t}, \end{aligned} \quad (2)$$

where $I\ (Alpha_{i,t-12\to t-1} < 0)$ is an indicator variable equal to one if the fund achieves a negative alpha in the past year and zero otherwise, and the dependent and other independent variables are defined as in Eq. (1). To control for the aggregate flows into and out of the corporate bond fund sector, we include the month fixed effect. To allow for intertemporal dependence of regression residuals at the level of fund share class, we cluster standard errors by fund share class.

Table 2 shows the results. We find a concave flow-performance relation for corporate bond funds: the sensitivity of flows out of corporate bond funds to bad performance is much higher than that of flows into those funds to good performance. The slope coefficient for *Alpha* is 0.238, and the slope coefficient for *Alpha* interacted with the negative alpha dummy is 0.621 and is statistically significant. In other words, the sensitivity of outflows to negative alpha is 0.859 (= 0.238 + 0.621), which is 3.6 times that of the sensitivity of inflows to positive alpha (0.238).

Such a concave flow-performance relation for corporate bond funds is different from the convex flow-performance relation documented in the stock fund literature. In the second column, we confirm the existence of such a convex flow-performance relation for stock funds during our sample period. For stock funds with positive alpha, a 1% increase in alpha is associated with 0.994% increase in fund flows. But for stock funds with negative alpha, a 1% decrease in alpha is associated with a 0.419% (= 0.994−0.575) decrease in fund flows. The sensitivity of outflows to negative alpha is therefore 58% lower than that of inflows to positive alpha, which implies a convex flow-performance relation for stock funds.

In the context of fragility, the effect of outflows is particularly important. The sensitivity of outflows in corporate bond funds to decreases in alpha (0.859%) is approximately twice that of equity funds (0.419%). We also find that the difference between the two coefficients on the negative

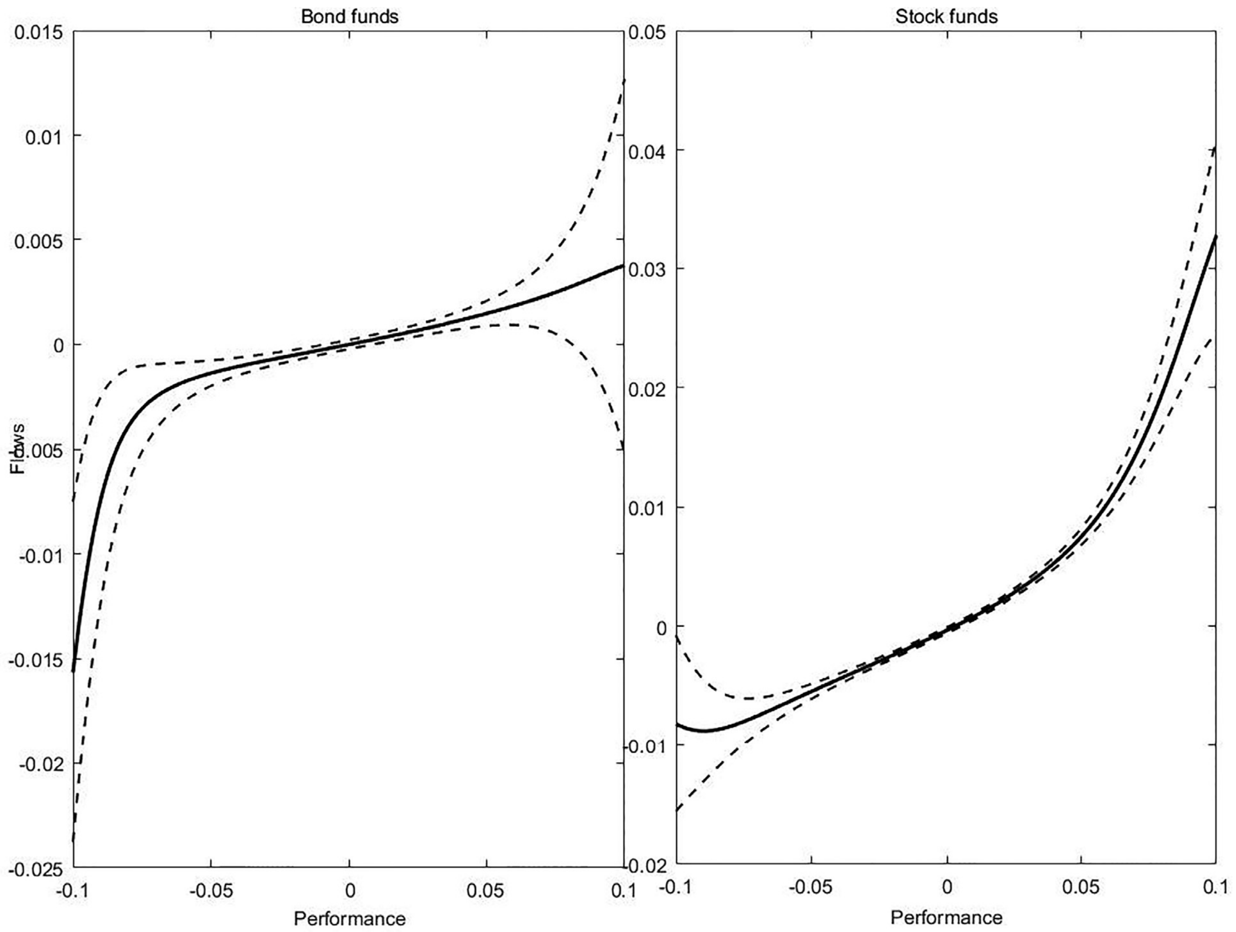

Fig. 3. Flow-performance relations for individual corporate bond funds. This figure shows the flow-performance relation for corporate bond funds and stock funds using a semi-parametric regressing of monthly fund flows on past fund alpha and fund characteristics including fund size, fund age, expenses, back-end loads, and lagged flows. The estimation uses the method developed by Robinson (1988) and applied in Chevalier and Ellison (1997). The dotted lines represent the 90% confidence intervals.

alpha indicator variable is statistically significant at the 1% level when we run a regression that pools the corporate bond and equity funds together.

So far, our results are based on the performance measure of alpha calculated using a two-factor model, i.e., fund alpha is measured as the intercept from a regression of excess corporate bond fund returns on excess Vanguard Total Bond Market Index Fund returns and excess CRSP value-weighted stock market returns. Despite the reasons outlined previously that lead us to favor this proxy for corporate bond fund alpha, we also construct alternative measures of fund performance: alpha from a one-factor model with the aggregate bond market return, alpha based on predetermined fund betas, style-adjusted fund returns, and fund returns in excess of the risk-free rate. These results, unreported to conserve space, show that the flow-performance relation for corporate bond funds is either concave or linear, but never convex. In contrast, equity funds consistently exhibit a convex flow-performance relation in all specifications. These results lend support to our Hypothesis 1.

Recently, Spiegel and Zhang (2013) suggest that the heterogeneity among equity funds may lead to a spurious convex flow-performance relation. In the spirit of their analysis, Table 3 reports results on various subsamples to check whether this is also a concern for our results on corporate bond funds. We examine if the flow-performance relation is pervasive across young and old funds (funds with below- and above-median fund age, respectively), present in periods with low and high aggregate fund flows (months with below- and above-median aggregate corporate bond fund flows, respectively), and robust to controlling for fund fixed effects. The dependent and independent variables in the regressions are as defined in Eq. (2).

Columns 1 and 2 of Table 3 indicate that the higher sensitivity of outflows to underperformance than inflows to outperformance is robust across both young and old funds. On average, flows are more sensitive to past performance for young funds than for old funds, which is consistent with Chevalier and Ellison (1997). The additional sensitivity of outflows to underperformance relative to that of inflows to outperformance is also quantitatively

Table 2
Flow-performance relations: corporate bond funds versus stock funds.
This table shows flow-performance relations for active corporate bond funds and stock funds from January 1992 to December 2014. It indicates the asymmetry in investor responses to outperformance and underperformance (positive versus negative alpha). Column 1 shows the results for corporate bond funds, while column 2 shows the results for stock funds. Flow is the proportional fund flow in a given month, Alpha is the average monthly alpha for a given fund in the past year, Log(TNA) is the natural log of total net assets, Log(age) is the natural log of fund age in years since its inception in the CRSP database, Expense is fund expense ratio, Rear load is an indicator variable that equals one if the fund share charges rear loads and zero otherwise. For all funds, alpha is the intercept from a regression of excess fund returns on excess aggregate bond market and aggregate stock market returns. We use the Vanguard Total Bond Market Index Fund return and CRSP value-weighted market return to proxy for aggregate bond and stock market returns. The unit of observations is share class-month. We include month fixed effects and cluster standard errors by fund share class. We exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, respectively).

	(1) Corporate bond funds	(2) Stock funds
Alpha	0.238***	0.994***
	(2.71)	(34.23)
Alpha × (Alpha < 0)	0.621***	−0.575***
	(4.34)	(−14.70)
Alpha < 0	−0.00979***	−0.00723***
	(−18.45)	(−25.06)
Lagged flow	0.152***	0.118***
	(21.47)	(29.90)
Log(TNA)	0.000728***	0.000459***
	(5.74)	(5.46)
Log(age)	−0.0157***	−0.0183***
	(−32.08)	(−70.95)
Expense	−0.200***	−0.0522
	(−2.59)	(−0.77)
Rear load	−0.00280***	−0.134***
	(−3.68)	(−5.51)
Observations	307,242	1578,506
Adj. R^2	0.0646	0.0583

larger and statistically stronger for young funds than for old funds. Columns 3 and 4 show that the shape of the flow-performance relation is similar in periods with high and low aggregate corporate bond fund flows. Columns 5 and 6 show that the stronger response of outflows to underperformance is robust to controlling for the fund share-class fixed effect.[14] These results suggest that the shape of the flow-performance relation in corporate-bond funds that we report in this paper should not be spurious, as suggested by Spiegel and Zhang (2013) in the context of equity funds.

4.2. Illiquidity and sensitivity of redemptions to poor performance

4.2.1. Illiquidity of corporate bond markets

According to Hypothesis 2, the sensitivity of outflows to negative performance in corporate-bond funds will be exacerbated in periods when the corporate-bond market is illiquid and the first-mover advantage in redemptions is stronger. To test this hypothesis, we perform the following regression:

$$\begin{aligned} Flow_{i,t} &= \alpha + \beta_1 Alpha_{i,t-12\to t-1} + \beta_2 Alpha_{i,t-12\to t-1} \\ &\quad \times IlliqPeriod_{i,t} + \beta_3 IlliqPeriod_{i,t} + \gamma Controls_{i,t} \\ &\quad + \beta_3 IlliqPeriod_{i,t} + \gamma Controls_{i,t} + \varepsilon_{i,t}, \\ &\quad \forall\, Alpha_{i,t-12\to t-1} < 0, \end{aligned} \tag{3}$$

where $Flow_{i,t}$ is fund i's net flow in month t, $Alpha_{i,t-12\to t-1}$ is fund i's alpha in the past one year, $IlliqPeriod_t$ is an indicator variable that equals one if the particular illiquid period proxy is above the sample mean and zero otherwise, and $Controls_{i,t}$ remains the same as before. We use three proxies to capture illiquid periods in the corporate bond market, which are based on the VIX, TED spread, and DFL Illiquidity index. For this test, we conduct regressions based on the subsample of funds with negative alpha.

Table 4 Panel A shows that the high sensitivity of investor redemptions to poor fund performance is driven mostly by periods when the corporate bond market is illiquid based on these three proxies. In particular, during liquid periods with low VIX, the effect of performance on flows essentially disappears for underperforming funds. But, during illiquid periods with high VIX, a 1% decrease in alpha is associated with 0.622% incremental outflows. Similarly, for the TED spread and the DFL index, during liquid periods, there is a relatively flat relation between funds' flows and past performance. During illiquid periods with a high TED spread or high DFL index, a 1% decrease in alpha is associated with a 0.628% and 0.666% increase in outflows, respectively. The difference in the sensitivity of flows to past alpha between high and low liquidity periods is statistically significant in all the three cases.[15]

It is possible that the illiquidity indicators are essentially financial crisis period indicators. To explore this possibility, in Panel B, we examine bond market liquidity measures during crisis and non-crisis periods. To capture the period of crisis, we follow Fahlenbrach, Prilmeier, and Stulz (2012) in constructing a Crisis dummy variable that includes the Long-Term Capital Management crisis (August to December 1998) and the recent financial crisis (July 2007 to December 2008) in our sample. We find that all three bond market illiquidity variables are significant in their effect on flow-performance sensitivity in both crisis and non-crisis periods. We do find that during the crisis

[14] In Column 6, we leave out the control variable of lagged flow since it may be correlated with the residual in a fund share-class fixed effect setting. The results in Columns 5 and 6 remain similar with or without the lagged flow variable.

[15] An interesting observation about Panel A of Table 4 is that the effect of illiquid period on net flows is positive. This reflects the flight to safety phenomenon, whereby money flows from equity to bond markets when measures like the VIX and TED spread are high; see Baele, Bekaert, Inghelbrecht, and Wei (2015). As a result of this, the average net flows for a negative-alpha fund are positive in illiquid periods. Of course, our effect is coming from funds with lower performance, which see net outflows (over half of the negative-alpha funds have net outflows in illiquid periods). Our empirical investigation still includes all funds below alpha=0, as this is the most natural cutoff ex ante without imposing what we learn from the data on where net outflows start occurring. Note also that the effect of strategic complementarities is expected to start showing up when investors fear there might be net outflows, and this will clearly happen at a higher alpha than the one where net outflows are actually realized.

Table 3
Subsamples of corporate bond funds.
This table shows flow-performance relations for subgroups of active corporate bond funds from January 1992 to December 2014. It indicates that the asymmetry in investor responses to outperformance and underperformance (positive versus negative alpha) is pervasive across young and old funds, present in periods with both aggregate inflows and outflows, and robust to controlling for the fund share class fixed effect. The variables are defined as in Table 2. Columns 1 to 4 report results for young, old, low flows and high Flows funds respectively. Young and old funds correspond to the funds whose age falls below- and above-median, respectively. High and low flows correspond to periods with aggregate corporate bond fund flows above- and below-median, respectively. Columns 5 and 6 report regression results with fund fixed effects. The unit of observation is share class-month. We include month fixed effects and cluster standard errors by fund share class. We exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, respectively).

	(1) Young	(2) Old	(3) Low flows	(4) High flows	(5) Fund fixed effects	(6) Fund fixed effects
Alpha	0.411***	0.0630	0.0193	0.299***	0.166*	0.190*
	(2.58)	(0.72)	(0.15)	(2.94)	(1.85)	(1.93)
Alpha × (Alpha < 0)	1.046***	0.534***	0.860***	0.531***	0.658***	0.734***
	(4.23)	(4.04)	(4.14)	(3.68)	(4.51)	(4.52)
(Alpha < 0)	−0.0118***	−0.00717***	−0.00977***	−0.0104***	−0.00971***	−0.0106***
	(−12.87)	(−13.51)	(−14.97)	(−14.20)	(−17.11)	(−17.03)
Lagged flow	0.153***	0.136***	0.123***	0.177***	0.0951***	
	(17.53)	(14.20)	(15.02)	(19.53)	(13.33)	
Log(TNA)	0.000222	0.00120***	0.000317**	0.00121***	0.00506***	0.00562***
	(1.21)	(7.22)	(2.18)	(6.74)	(13.26)	(14.16)
Log(age)	−0.0208***	−0.00788***	−0.0148***	−0.0168***	−0.0349***	−0.0386***
	(−19.37)	(−11.73)	(−27.84)	(−26.24)	(−26.39)	(−27.05)
Expense	0.232*	−0.578***	−0.511***	0.129	1.639***	1.811***
	(1.93)	(−6.46)	(−6.13)	(1.26)	(7.11)	(7.13)
Rear load	−0.00299**	−0.00193**	−0.00322***	−0.00238**	0.00202**	0.00222**
	(−2.41)	(−2.38)	(−4.00)	(−2.33)	(2.05)	(2.04)
Observations	145,739	161,503	163,258	143,984	307,242	307,590
Adj. R^2	0.0566	0.0507	0.0503	0.0695	0.101	0.0930

periods, investor redemptions are more sensitive to fund underperformance, which brings up concerns for large outflows during fragile financial markets.

Overall, we find that corporate bond funds have a higher outflow-to-poor-performance sensitivity during periods when the corporate bond market is less liquid. This evidence supports the idea of strategic complementarities in redemptions that are aggravated by the illiquidity of the corporate bond market.

4.2.2. Illiquidity of fund assets

Next, we test Hypothesis 3 by exploring the impact of asset liquidity on the flow-performance relation for corporate bond funds. To measure asset liquidity at the fund level, we use five different measures. We start with a fund's cash balances. Specifically, using CRSP data, we measure a fund's most recent level of cash holdings prior to month t, to ensure that the level of cash holdings is not simply the outcome of flows in month t and that the information on cash holdings is available to fund investors. Second, also using CRSP, we measure a fund's cash and government bond holdings as an alternative measure of asset liquidity. Third, we measure a fund's holdings of cash and cash equivalents, collected from the SEC N-SAR filings. In particular, from the semi-annual N-SAR forms for all corporate bond mutual funds available through the Electronic Data Gathering, Analysis, and Retrieval (EDGAR) website, we extract their holdings of cash (item 74A), repurchase agreements (item 74B), and short-term debt other than repurchase agreements (item 74C). We sum up these three items as a measure of cash holdings. For each of the three cash-related measures of asset liquidity, we construct a corresponding indicator variable for illiquid funds, *Illiq-Fund*, which equals one if the fund has cash holdings lower than the average fund in the same style and zero otherwise. These style adjustments control for the possibility that the level of cash holdings may be systematically different across corporate bond funds with different investment styles and reduce the influence of potential outliers.

The fourth and fifth measures are based on the illiquidity of individual corporate bonds held by corporate bond funds. We use two measures of corporate bond illiquidity: the Roll (1984) measure and the interquartile range of bond prices. The Roll measure captures the serial covariance of intraday bond returns and is commonly used in the bond literature as a proxy for the bid-ask spread. Intuitively, bond prices bounce back and forth between the bid and ask prices, and hence higher bid-ask spreads would lead to higher negative covariance between consecutive returns. We collect intraday transaction data from TRACE for all corporate bonds and compute the Roll measure for each bond, following Dick-Nielsen, Feldhutter, and Lando (2012):

$$Roll_j = 2\sqrt{-\mathrm{cov}(r_j,r_{j-1})}, \quad if\ cov(r_j, r_{j-1}) < 0;$$
$$= 0, \quad if \quad cov(r_j, r_{j-1}) \geq 0.$$

To compute a daily Roll measure for individual corporate bonds, we require at least four transactions on a given trading day.[16] The monthly Roll measure for each bond is

[16] As robustness checks, we relax the data requirement in creating the Roll measures. First, we only require a bond to trade three times a day (instead of four times a day) and recalculate the Roll measure. Second, we require a bond to trade only three times within the same week. We then recalculate this Roll measure on a weekly basis based on the observed trading prices. Our main results remain similar.

Table 4
Flow-performance relations of underperforming corporate bond funds during illiquid periods.

This table shows time-varying flow-performance relations for active corporate bond funds with negative alpha from January 1992 to December 2014. The fund characteristics are defined as in Table 2. In Panel A, we use three indicator variables to capture illiquid period (IlliqPeriod) of corporate bond markets, high VIX, high TED, and high DFL. IlliqPeriod equals one if the corresponding time-series variable is above the sample average. VIX is the CBOE's VIX index, TED is the difference between the three-month London Interbank Offered Rate (LIBOR) and the three-month T-bill interest rate, and DFL is the corporate bond market illiquidity index proposed by Dick-Nielsen et al. (2012). Columns 1, 2, and 3 report results for VIX, TED and DFL, respectively in both panels. In Panel B, we also include interaction variables of illiquid period and crisis. To capture the period of crisis, we follow Fahlenbrach et al. (2012) in constructing a dummy variable Crisis that includes the Long-Term Capital Management crisis (August to December 1998) and the recent financial crisis (July 2007 to December 2008) in our sample. The unit of observation is share class-month. We cluster standard errors by fund share class, and exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance ($^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, respectively).

Panel A: Different illiquid period proxies

Alpha < 0	(1) VIX	(2) TED	(3) DFL
Alpha	−0.131	−0.121	−0.746***
	(−0.77)	(−1.11)	(−3.22)
Alpha × IlliqPeriod	0.753***	0.749***	1.412***
	(3.89)	(5.37)	(5.21)
IlliqPeriod	0.00690***	0.00148**	0.00745***
	(9.81)	(2.44)	(8.11)
Lagged flow	0.121***	0.123***	0.152***
	(15.37)	(15.47)	(14.90)
Log(TNA)	0.000552***	0.000558***	0.000533***
	(3.78)	(3.82)	(2.98)
Log(age)	−0.0134***	−0.0136***	−0.0124***
	(−26.78)	(−26.70)	(−17.88)
Expense	−0.175**	−0.185**	−0.284**
	(−1.98)	(−2.10)	(−2.45)
Rear load	−0.00294***	−0.00285***	−0.00611***
	(−3.40)	(−3.29)	(−5.87)
Observations	171,006	171,006	100,215
Adj. R^2	0.0339	0.0330	0.0429

Panel B: Illiquidity and crisis periods

Alpha < 0	(1) VIX	(2) TED	(3) DFL
Alpha	−0.212	−0.122	−0.797***
	(−1.24)	(−1.12)	(−3.44)
Alpha × IlliqPeriod	0.668***	0.567***	1.203***
	(3.65)	(4.05)	(4.82)
Alpha × Crisis	0.401***	0.355***	0.409***
	(3.05)	(2.71)	(3.05)
IlliqPeriod	0.00691***	0.000465	0.00920***
	(9.61)	(0.75)	(9.59)
Crisis	−0.000463	0.00269***	−0.00415***
	(−0.50)	(2.90)	(−4.12)
Lagged flow	0.121***	0.122***	0.152***
	(15.36)	(15.46)	(14.83)
Log(TNA)	0.000519***	0.000569***	0.000498***
	(3.55)	(3.88)	(2.78)
Log(age)	−0.0133***	−0.0137***	−0.0123***
	(−26.44)	(−26.54)	(−17.65)
Expense	−0.199**	−0.188**	−0.310***
	(−2.24)	(−2.13)	(−2.67)
Rear load	−0.00280***	−0.00297***	−0.00578***
	(−3.22)	(−3.41)	(−5.53)
Observations	171,006	171,006	100,215
Adj. R^2	0.0340	0.0331	0.0434

the median of the daily Roll measure within the month. In each month, we aggregate the bond-level Roll measure into a fund-level Roll measure by taking value-weighted averages using the fund's bond holdings, where the weights are based on the fraction of fund assets invested in the bond. This fund-level Roll measure is our fourth measure of bond fund asset illiquidity.

The fifth measure is based on the interquartile range of the prices of corporate bonds held by bond funds. The intuition of this measure is that in the corporate bond market, a large fraction of intraday bond price volatility is driven by the bid-ask spread (see, e.g., Pu, 2009; Han and Zhou, 2016; and Schestag, Schuster, and Uhrig-Homburg, 2016). As a result, corporate bonds with a larger bid-ask spread tend to have more dispersed transaction prices on a given day. To estimate the interquartile range, we follow Schestag, Schuster, and Uhrig-Homburg (2016), using transactions data from TRACE. Specifically, for each corporate bond, we divide the difference between the 75th percentile and 25th percentile of intraday prices on day t by the average trade price of that day to obtain the daily interquartile range. We compute the daily interquartile range with at least three observations and calculate the monthly measure as the mean of the daily measures. We then calculate the value-weighted average of interquartile range for each corporate bond fund to obtain our fifth measure of fund-level asset liquidity.

To mitigate the concern that corporate bond funds holding more illiquid bonds may choose to hold more cash as a liquidity buffer, we construct the indicator variable *IlliqFund* that combines information on holdings of illiquid corporate bonds and cash. Specifically, *IlliqFund* equals one if the fund has below-average style-adjusted cash holdings and above-average holdings of illiquid corporate bonds based on the Roll measure (or the interquartile range), and zero if the fund has above-average cash holdings and below-average holdings of illiquid corporate bonds. Otherwise, the observation is excluded.

As N-SAR data start in 2003, and the coverage for government bond holdings data in CRSP improve significantly after 2003, we use data from 2003 to 2014 as our baseline sample for the tests of Hypothesis 3.[17] For the two bond holdings-based measures, we merge the TRACE data with the CRSP mutual fund holdings data. To obtain sufficient data coverage, we further limit the data sample for bond holdings-based analyses to the period 2008 to 2014 for these two measures.

To test Hypothesis 3, we use the following regression specification:

$$\begin{aligned} Flow_{i,t} &= \alpha + \beta_1 Alpha_{i,t-12\to t-1} + \beta_2 Alpha_{i,t-12\to t-1} \\ &\quad \times IlliqFund_{i,t} + \beta_3 IlliqFund_{i,t} + \gamma Controls_{i,t} \\ &\quad + \varepsilon_{i,t}, \quad \forall\, Alpha_{i,t-12\to t-1} < 0, \end{aligned} \tag{4}$$

where $Flow_{i,t}$ is fund i's net flow in month t, $Alpha_{i,t-12\to t-1}$ is fund i's alpha in the past one year.

[17] In the previous version of our paper, we use the CRSP cash holdings for our full sample from 1992 to 2014 to test the effect of asset liquidity on the sensitivity of outflows to underperformance of corporate bond funds. The results provide a similar support to Hypothesis 3.

Table 5
Flow-performance relations of underperforming corporate bond funds with illiquid assets.
This table shows flow-performance relations for active corporate bond funds with negative alpha from July 2003 to December 2014. We use five indicator variables to capture an illiquid fund, IlliqFund. For Columns 1, 2, and 3, IlliqFund is an indicator variable equal to one if the fund has cash, cash and government bond holdings, and holdings of cash, short-term securities, and repos reported in the fund's N-SAR filings below the average fund in the same style and zero otherwise, respectively. For Column 4 and 5, IlliqFund is an indicator variable equal to one if the fund has below-average style-adjusted cash holdings and above-average holdings of illiquid corporate bonds based on the Roll measure (interquartile range), and zero if the fund has above-average cash holdings and below-average holdings of illiquid corporate bonds. Other variables are defined as follows: Flow is the proportional fund flow in a given month, Alpha is the intercept from a regression of excess corporate bond fund returns on excess aggregate bond market and aggregate stock market returns, Log(TNA) is the natural log of total net assets (TNA), Log(age) is the natural log of fund age in years since its inception in the CRSP database, Expense is the fund expense ratio, Rear load is an indicator variable that equals one if the fund share charges rear loads and zero otherwise. We use the Vanguard Total Bond Market Index Fund return and CRSP value-weighted market return to proxy for aggregate bond and stock market returns. The unit of observation is share class-month. We include month fixed effects and cluster standard errors by fund share class. We exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, respectively).

Alpha < 0	Low cash	Low (cash + Government bonds)	Low N-SAR cash	Illiquid holdings (Roll)	Illiquid holdings (interquartile range)
Alpha	0.554***	0.567***	0.631***	0.688***	0.662***
	(6.42)	(6.17)	(6.09)	(3.20)	(3.16)
Alpha × IlliqFund	0.814***	0.647***	0.767***	1.305***	1.174***
	(3.21)	(2.74)	(3.82)	(3.02)	(2.82)
IlliqFund	−0.000288	0.00113	0.00211*	0.00472***	0.00435***
	(−0.38)	(1.51)	(1.73)	(2.89)	(2.74)
Lagged flow	0.131***	0.132***	0.121***	0.180***	0.179***
	(12.50)	(12.52)	(7.15)	(10.67)	(11.11)
Log(TNA)	0.000561***	0.000555***	0.000470*	0.000831***	0.000928***
	(3.18)	(3.15)	(1.80)	(2.58)	(2.86)
Log(age)	−0.0140***	−0.0140***	−0.0142***	−0.0153***	−0.0157***
	(−20.26)	(−20.22)	(−14.61)	(−12.59)	(−12.95)
Expense	−0.443***	−0.449***	−0.521***	−0.0281	−0.0158
	(−3.99)	(−4.02)	(−3.10)	(−0.14)	(−0.08)
Rear load	−0.00485***	−0.00482***	−0.00221	−0.00474**	−0.00482**
	(−4.78)	(−4.74)	(−1.45)	(−2.49)	(−2.50)
Observations	108,745	108,745	49,759	25,389	25,370
Adj. R^2	0.0500	0.0498	0.0473	0.0732	0.0750

Across specifications, $IlliqFund_{i,t}$ is an indicator variable for an illiquid fund based on each of the five measures described previously, and $Controls_{i,t}$ includes the same set of control variables as in the earlier tables. We conduct regressions based on the subsample of funds with negative alpha.

Table 5 shows the results. Column 1 presents the results where we include the interaction term between low cash holdings and the performance variable. For funds with high cash holdings, a 1% decrease in alpha results in a 0.554% increase in outflows. In contrast, for funds with low cash holdings, a 1% decrease in alpha results in a 1.368% (=0.554+0.814%) increase in outflows. Hence, among illiquid funds, more negative fund alpha results in significantly greater outflows. Column 2 confirms the results when we include Treasury bond holdings along with cash as a measure of a bond fund's liquidity. Column 3 shows similar results with low cash holdings obtained from N-SAR filings.

Next we examine the results for funds with more illiquid bond holdings. Column 4 shows that bond funds with more illiquid corporate bond holdings based on the Roll measure tend to have higher sensitivity of outflows to bad performance than their more liquid peers. Column 5 demonstrates the same effect for funds with more illiquid corporate bond holdings based on the interquartile range.

In summary, we show that corporate bond funds with lower asset liquidity tend to experience greater sensitivity of outflows to bad performance. Consistent with Hypothesis 3, the evidence supports the idea that asset illiquidity exacerbates strategic complementarities among corporate-bond-fund investors in their redemption decisions.

4.2.3. Illiquidity of fund assets during illiquid periods

Building on the preceding results, we now examine whether the sensitivity of outflows to underperformance of corporate bond funds is particularly high for illiquid corporate bond funds during illiquid time periods. We estimate the following regression involving the three-way interaction including fund performance, illiquid time period dummy, and illiquid fund dummy:

$$\begin{aligned} Flow_{i,t} &= \alpha + \beta_1 Alpha_{i,t-12\to t-1} + \beta_2 Alpha_{i,t-12\to t-1} \\ &\times IlliqPeriod_t \times IlliqFund_{i,t} + \beta_3 Alpha_{i,t-12\to t-1} \\ &\times IlliqPeriod_t + \beta_4 Alpha_{i,t-12\to t-1} \times IlliqFund_{i,t} \\ &+ \gamma Controls_{i,t} + \varepsilon_{i,t}, \forall\ Alpha_{i,t-12\to t-1} < 0, \qquad (5) \end{aligned}$$

where we include the three-way interaction of $Alpha_{i,t-12\to t-1}$, $IlliqPeriod_t$, and $IlliqFund_{i,t}$. The dependent and other independent variables are defined as in Eqs. (3) and (4).

Table 6 shows the result. As conjectured, we find that the high sensitivity of investor redemptions to poor fund performance is particularly severe for illiquid funds during periods when the corporate bond market is less liquid. The slope coefficient for the three-way interaction of fund performance, illiquid period, and illiquid fund is positive and statistically significant at the 1% level. The economic magnitude is also large. For instance, for funds with

Table 6
Flow-performance relations of underperforming corporate bond funds with illiquid assets during illiquid periods.

This table shows the effect of illiquid corporate bond markets and illiquid corporate bond fund assets on the flow-performance relation for underperforming funds with negative alpha from July 2003 to December 2014. Columns 1, 2, and 3 report results for VIX, TED, and DFL, respectively. Flow is the proportional flow for a given fund in month *t*. IlliqFund is an indicator variable equal to one if the fund has cash and government bond holdings below the average fund in the same style and zero otherwise. Other variables are defined as in Table 4. The unit of observation is share class-month. We cluster standard errors by fund share class. We exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, respectively).

Alpha < 0	(1) VIX	(2) TED	(3) DFL
Alpha	0.345	−0.394	0.00548
	(1.22)	(−1.03)	(0.01)
Alpha × IlliqPeriod × IlliqFund	2.705***	1.410**	2.191***
	(6.38)	(2.51)	(4.00)
Alpha × IlliqPeriod	0.159	0.921**	0.517
	(0.52)	(2.35)	(1.23)
Alpha × IlliqFund	−1.765***	−0.564	−1.377***
	(−5.12)	(−1.37)	(−2.87)
IlliqPeriod × IlliqFund	0.00339**	−0.000202	0.00292*
	(2.09)	(−0.13)	(1.67)
IlliqPeriod	0.00689***	0.00710***	0.00625***
	(5.65)	(5.97)	(4.65)
IlliqFund	−0.00213***	−0.000331	−0.00220**
	(−2.60)	(−0.39)	(−2.30)
Lagged flow	0.138***	0.138***	0.150***
	(12.99)	(13.01)	(14.12)
Log(TNA)	0.000607***	0.000582***	0.000555***
	(3.51)	(3.37)	(2.99)
Log(age)	−0.0132***	−0.0130***	−0.0125***
	(−19.59)	(−19.34)	(−17.17)
Expense	−0.497***	−0.506***	−0.371***
	(−4.43)	(−4.52)	(−3.05)
Rear load	−0.00570***	−0.00580***	−0.00667***
	(−5.71)	(−5.79)	(−6.22)
Observations	108,745	108,745	94,640
Adj. R^2	0.0411	0.0406	0.0431

below-average cash and government bond holdings during illiquid periods with high VIX, a 1% decrease in fund alpha is associated with a 1.444% (=0.345+2.705+0.159–1.765%) increase in outflows.

4.3. Tax-loss selling and outflows from illiquid funds

US tax laws offer incentives for investors to take their money out of losing funds before the end of the year to offset potential tax liability. Thus, tax-loss selling at year-end provides investors incentives to redeem that are unrelated to other motives (e.g., investors' learning from past fund performance). This provides an interesting natural experiment to study how illiquidity amplifies investor redemption incentives. The idea is that if the underperformance of corporate bond funds induces tax-motivated redemptions from certain investors, the payoff of remaining shareholders would be adversely influenced since they have to partially bear the redemption-related liquidation costs. The resulting strategic complementarities will be aggravated if the corporate bond fund holds illiquid assets. As a result, the response of redemptions to underperformance can be particularly strong before the end of the year for corporate bond funds holding illiquid assets.

To exploit tax-loss selling as an exogenous event that aggravates the first-mover advantage in investor redemptions, we test whether the difference in the outflow-underperformance sensitivity between liquid and illiquid funds is stronger before the end of the year. This is a difference-in-differences approach. In Fig. 4, we examine the seasonality in aggregate flows of corporate bond funds with negative alpha. It shows that flows out of underperforming corporate bond funds tend to be particularly large in November and December. The finding that large flows out of underperforming corporate bond funds tend to start in November is consistent with the idea that the anticipation of tax-motivated selling in December, which is associated with costly asset liquidation, provides incentives for certain fund investors to take money out earlier in November. We therefore use an indicator variable *YearEnd* that equals one for November or December and zero otherwise, to capture the turn of the year.[18]

To identify the impact of tax-loss selling, we estimate the following regression:

$$\begin{aligned}Flow_{i,t} = \alpha &+ \beta_1 Alpha_{i,t-12\to t-1} + \beta_2 Alpha_{i,t-12\to t-1}\\ &\times IlliqFund_t \times YearEnd_t + \beta_3 Alpha_{i,t-12\to t-1}\\ &\times IlliqFund_{i,t} + \beta_4 Alpha_{i,t-12\to t-1} \times YearEnd_t\\ &+ \gamma Controls_{i,t} + \varepsilon_{i,t}, \forall\ Alpha_{i,t-12\to t-1} < 0, \quad (6)\end{aligned}$$

where we include $Alpha_{i,t-12\to t-1}$, $YearEnd_t$, $IlliqFund_{i,t}$, and the pairwise and three-way interactions of the three variables together with the control variables in the regression. Table 7 shows that among underperforming corporate bond funds, illiquid funds tend to experience larger outflows during the turn of a year than their liquid peers. As a placebo test, we perform similar analyses for outperforming corporate bond funds but find no such effects. Our results remain similar whether we use holdings of cash or cash plus government bonds as cash proxies.

4.4. Direct evidence of first-mover advantage

We have presented evidence consistent with the presence of payoff complementarities in driving the redemption decisions of mutual fund investors when the funds hold illiquid assets and/or in illiquid times. We now provide more direct evidence of the gains for investors from redeeming before others in these circumstances. In particular, we estimate the impact of outflows on fund returns and how this is affected by illiquidity. A higher effect of outflows on returns implies that investors lose more if they stay in the fund when others redeem. The approach is similar in spirit to Amihud (2002) which gauges the effect of investor order flows on stock returns.

[18] When we define the end of the year only as December, we find a weaker but still consistent effect of liquidity on investor redemptions. We attribute the stronger result based on November and December to the inclusion of early redemptions occurring in November, which increases the power of our tests.

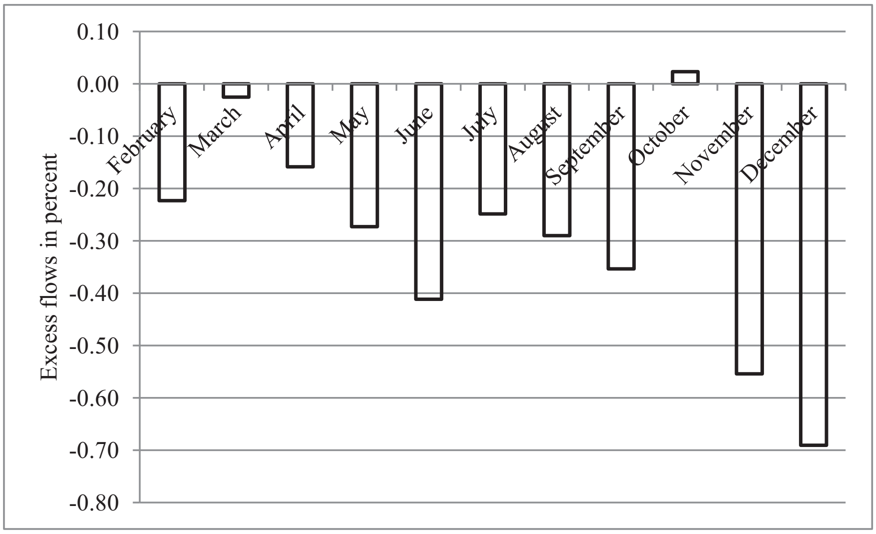

Fig. 4. Seasonality of monthly flows for underperforming corporate bond funds. This figure plots the slope coefficients for eleven dummy variables that capture February to December, respectively, for our sample of corporate bond funds with negative alpha in the past year during the period from July 2003 to December 2014. The dependent variable is monthly percentage flows of corporate bond funds. With standard errors clustered across funds, the coefficients for November and December are statistically significant with *t*-statistics of −4.92 and −6.45, respectively.

Table 7
Tax-loss selling and outflows from illiquid corporate bond funds.

This table uses the turn of a year which tends to be associated with tax-loss selling as an exogenous event to identify the effect of liquidity on outflows from underperforming funds from July 2003 to December 2014 in columns 1 and 3. We use an indicator variable that equals one for November or December and zero otherwise to capture the turn of the year. IlliqFund is an indicator variable equal to one if the fund has cash (column 1) or cash and government bond holdings (column 3) lower than the average fund in the same style, and zero otherwise. Other variables are as defined in Table 5. As a placebo test, we perform similar analyses for funds with positive alpha in columns 2 and 4. Stars denote standard statistical significance (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, respectively).

	Low cash		Low (Cash + Government bonds)	
	Alpha < 0	Alpha > = 0	Alpha < 0	Alpha > = 0
Alpha	0.357***	0.502***	0.400***	0.516***
	(5.56)	(3.25)	(6.08)	(3.21)
Alpha × IlliqFund × YearEnd	1.001***	−0.139	1.386***	−0.152
	(2.76)	(−0.63)	(3.64)	(−0.63)
Alpha × IlliqFund	−0.383*	−0.106	−0.637***	−0.144
	(−1.90)	(−0.63)	(−3.26)	(−0.79)
IlliqFund × YearEnd	0.000206	0.000722	0.000568	0.00200
	(0.15)	(0.45)	(0.42)	(1.16)
Alpha × YearEnd	0.0955	−0.292	0.0178	−0.288
	(0.87)	(−1.59)	(0.17)	(−1.41)
YearEnd	−0.00325***	−0.000545	−0.00309***	−0.00136
	(−3.41)	(−0.47)	(−3.24)	(−0.99)
IlliqFund	−0.00340***	−0.00407***	−0.00129*	−0.00315***
	(−4.50)	(−4.63)	(−1.71)	(−3.34)
Lagged flow	0.139***	0.203***	0.140***	0.203***
	(13.14)	(19.07)	(13.18)	(19.11)
Log(TNA)	0.000623***	0.000202	0.000598***	0.000183
	(3.58)	(1.03)	(3.44)	(0.93)
Log(age)	−0.0130***	−0.0154***	−0.0130***	−0.0154***
	(−19.27)	(−22.33)	(−19.15)	(−22.12)
Expense	−0.486***	−0.772***	−0.493***	−0.773***
	(−4.36)	(−6.94)	(−4.40)	(−6.90)
Rear load	−0.00549***	−0.00426***	−0.00556***	−0.00442***
	(−5.48)	(−4.09)	(−5.53)	(−4.23)
Observations	108,745	105,288	108,745	105,288
Adj. R^2	0.0400	0.0696	0.0398	0.0693

Table 8
Impact of flows on returns to underperforming corporate bond funds: evidence of first-mover advantage.

This table shows the impact of fund flows on contemporaneous returns for underperforming funds with negative alpha from July 2003 to December 2014. Flow is the proportional flow for a given fund in month *t*. IlliqFund is an indicator variable equal to one if the fund has cash and government bond holdings below the average fund in the same style and zero otherwise. Other variables are defined as in Table 4. Columns 1, 2, and 3 report results for VIX, TED, and DFL, respectively. The unit of observation is share class-month. We cluster standard errors by fund share class. We exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance ($^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$, respectively).

Alpha < 0	(1) VIX	(2) TED	(3) DFL
Flow	0.00559***	0.00774***	0.00532***
	(6.01)	(4.95)	(5.72)
Flow × IlliqPeriod × IlliqFund	0.0127***	0.0135***	0.0146***
	(3.13)	(3.12)	(3.36)
Flow × IlliqPeriod	0.0167***	0.0114***	0.0180***
	(6.57)	(4.00)	(6.74)
Flow × IlliqFund	0.00310**	0.00273	0.00249*
	(2.51)	(1.49)	(1.93)
IlliqPeriod × IlliqFund	−0.00175***	−4.74e−05	−0.00116***
	(−5.25)	(−0.16)	(−3.46)
IlliqPeriod	−0.00238***	−0.00213***	−0.00370***
	(−9.20)	(−10.62)	(−14.58)
IlliqFund	0.000897***	0.000475***	0.000817***
	(8.25)	(4.76)	(7.06)
Past alpha	0.657***	0.687***	0.638***
	(7.52)	(8.75)	(7.02)
Lagged flow	0.00367***	0.00314***	0.00450***
	(5.37)	(4.64)	(5.94)
Log(TNA)	0.000175***	0.000187***	0.000192***
	(5.96)	(6.59)	(5.75)
Log(age)	0.000239***	0.000157*	0.000339***
	(2.59)	(1.78)	(3.11)
Expense	0.0273	0.0357**	0.0564***
	(1.54)	(2.10)	(2.80)
Rear Load	−0.000264	−0.000196	−0.000938***
	(−1.56)	(−1.19)	(−5.00)
Observations	108,745	108,745	94,640
Adj. R^2	0.0467	0.0416	0.0519

In particular, we perform the following regression:

$$R_{i,t} = \alpha + \beta_1 Flow_{i,t} + \beta_2 Flow_{i,t} \times IlliqPeriod_t \times IlliqFund_{i,t} + \beta_3 Flow_{i,t} \times IlliqPeriod_t + \beta_4 Flow_{i,t} \times IlliqFund_{i,t} + \gamma Controls_{i,t} + \varepsilon_{i,t}, \quad \forall\, Alpha_{i,t-12\rightarrow t-1} < 0, \tag{7}$$

where $R_{i,t}$ and $Flow_{i,t}$ denote fund *i*'s net return and flow in month *t*, respectively, $IlliqPeriod_t$ is an indicator variable equal to one if the particular illiquidity proxy (the VIX, TED spread, and DFL index) is above the sample mean and zero otherwise, and *IlliqFund* is an indicator variable equal to one if the fund has cash and government bond holdings below the average fund in the same style and zero otherwise. We include $Flow_{i,t}$, $IlliqPeriod_t$, $IlliqFund_t$, and the pairwise and three-way interactions of the three variables in the regression. The other variables are defined as earlier.

Table 8 presents the results. The slope coefficients for fund flows measure the impact of flows on contemporaneous fund returns. In particular, β_2 is an estimate of the three-way interaction coefficient for how fund flow affects returns for an illiquid fund during illiquid times. Table 8 reports positive and highly significant coefficient estimates for β_2 across the three proxies of illiquid corporate bond markets. These results suggest that the incentive to redeem shares in month *t* after observing fund underperformance during the period from $t-12$ to $t-1$ is especially strong for illiquid funds when the corporate bond market is less liquid.

The sum of the four beta coefficients $\beta_1+\beta_2+\beta_3+\beta_4$ represents the impact of flows on returns to illiquid corporate bond funds when the corporate bond market is illiquid. To get a sense of the magnitude of the overall impact of fund flows on fund returns, a one standard deviation (8.79%) increase in flows out of an illiquid corporate bond fund in a given month is associated with a decline in fund returns by 33, 31, and 36 basis points in the same month when the corporate bond market is less liquid as measured by the VIX, TED spread, and DFL index, respectively. Since part of fund flows in month *t* may result from fund returns in month *t* (intra-month response of fund investors to fund performance) and fund managers may engage in costly trades in month $t+1$ to partially accommodate redemption requests received in month *t*, these measures tend to underestimate the negative impact of outflows on fund performance. We therefore view our estimates as providing a lower bound on the adverse impact of outflows on fund performance, which generates incentives for investors to run. Hence, the overall effect is quite sizable.

4.5. The effect of large investors

Turning to Hypothesis 4, strategic complementarities should be less important in determining fund outflows if the fund ownership is mostly composed of institutional investors. The reason is that large institutional investors hold larger positions in the funds and so they are more likely to internalize the negative externalities generated by their outflows. Hence, they serve to reduce coordination problems that lead to runs on funds. For funds with large investors, we expect the effect of illiquidity on the flow-performance relation to be mitigated.

In Table 9, we examine the effect of complementarities in the case of institutional investors. Following Chen, Goldstein, and Jiang (2010), we classify bond funds into institutional-oriented funds and retail-oriented funds. A fund is classified as an institutional-oriented (retail-oriented) fund if more than 80% (less than 20%) of fund assets are owned through institutional share class. We acknowledge that this classification might be a noisy way to capture actual institutional ownership, but it is the best proxy we are aware of given available data.

Panel A of Table 9 shows that the effect of asset illiquidity on the sensitivity of outflows to bad performance is not statistically significant among institutional-oriented funds but statistically significant among retail-oriented funds. The first two specifications show the results for institutional-oriented funds. The coefficient of interest is the interaction term between alpha and low cash. The presence of strategic complementarity implies that illiquid funds would have higher sensitivity of fund flows to underperformance, hence a larger coefficient in the interaction term. However, the dominance of institutional investors would serve as a constraining force and reduce

Table 9

Institutional investors and the impact of liquidity on outflows of underperforming corporate bond funds.

This table shows how the presence of large institutional investors influences the impact of liquidity on the outflows of corporate bond funds with negative alpha. Panel A shows the effect of fund liquidity, i.e., their cash holdings. Columns 1 and 2 report results for Institutional-oriented funds and columns 3 and 4 report results for retail-oriented funds. Panel B shows the effect of liquidity in the corporate bond market. Columns 1, 2, and 3 report results for Institutional-oriented funds. Columns 4, 5, and 6 report results for retail-oriented funds using VIX, TED, and DFL to capture illiquid period of corporate bond markets. A fund is classified as an institutional-oriented (retail-oriented) fund if more than 80% (less than 20%) of fund assets are owned by institutional investors through institutional share class. Flow is the proportional fund flow in a given month, Alpha is the intercept from a regression of excess corporate bond fund returns on excess aggregate bond market and aggregate stock market returns, Low cash is an indicator variable equal to one if the fund has cash holdings below the average fund in the same style and zero otherwise, Inst is an indicator variable equal to one if the fund class is an institutional share class and zero otherwise, Log(TNA) is the natural log of total net assets (TNA), Log(age) is the natural log of fund age in years since its inception in the CRSP database, Expense is fund expense ratio, Rear load is an indicator variable that equals one if the fund share charges rear loads and zero otherwise. We use the Vanguard Total Bond Market Index Fund return and CRSP value-weighted market return to proxy for aggregate bond and stock market returns. The unit of observation is share class-month. We include month fixed effects and cluster standard errors by fund share class. We exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance ($^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, respectively).

Panel A: Liquidity of corporate bond funds

Alpha < 0	Institutional-oriented funds		Retail-oriented funds	
	(1)	(2)	(3)	(4)
Alpha	2.056***	2.042***	0.958**	1.024**
	(3.61)	(3.58)	(2.28)	(2.44)
Alpha × Low cash	−0.906	−0.898	1.268***	1.236***
	(−1.17)	(−1.17)	(2.90)	(2.83)
Low cash	−0.00304	−0.00301	−0.000683	−0.00100
	(−1.57)	(−1.56)	(−0.52)	(−0.76)
Lagged flow	0.108***	0.108***	0.106***	0.105***
	(5.35)	(5.34)	(4.86)	(4.82)
Log(TNA)	0.000324	0.000391	0.000489	0.000822**
	(0.89)	(1.03)	(1.40)	(2.22)
Log(age)	−0.0163***	−0.0164***	−0.0132***	−0.0124***
	(−9.70)	(−9.58)	(−10.57)	(−9.96)
Expense	0.0469	−0.0168	−0.543***	−0.331*
	(0.14)	(−0.05)	(−3.02)	(−1.81)
Rear load	−0.00340	−0.00352	−0.00639***	−0.00619***
	(−1.21)	(−1.25)	(−4.11)	(−3.99)
Inst		−0.00123		0.00766***
		(−0.48)		(4.03)
Observations	19,331	19,331	37,367	37,367
Adj. R^2	0.0398	0.0398	0.0490	0.0500

Panel B: Liquidity of corporate bond markets

Alpha < 0	Institutional-oriented			Retail-oriented		
	(1) VIX	(2) TED	(3) DFL	(4) VIX	(5) TED	(6) DFL
Alpha	1.207	0.680	0.817	0.473	0.527	0.682*
	(1.40)	(1.16)	(1.09)	(1.04)	(1.26)	(1.71)
Alpha × IlliqPeriod	0.478	1.715**	0.801	1.996***	2.443***	1.704***
	(0.68)	(2.24)	(1.22)	(3.38)	(3.80)	(3.09)
IlliqPeriod	−0.0104	−0.0287	−0.0550*	0.0180	0.0238***	0.0181
	(−0.46)	(−1.36)	(−1.87)	(1.26)	(3.59)	(1.26)
Lagged flow	0.108***	0.108***	0.116***	0.106***	0.106***	0.126***
	(5.35)	(5.33)	(5.43)	(4.86)	(4.84)	(6.01)
Log(TNA)	0.000282	0.000240	0.000630	0.000466	0.000466	0.000376
	(0.78)	(0.66)	(1.60)	(1.33)	(1.34)	(1.02)
Log(age)	−0.0162***	−0.0161***	−0.0152***	−0.0133***	−0.0133***	−0.0133***
	(−9.61)	(−9.57)	(−8.74)	(−10.54)	(−10.57)	(−10.11)
Expense	0.00547	−0.0268	0.120	−0.564***	−0.555***	−0.483**
	(0.02)	(−0.08)	(0.34)	(−3.15)	(−3.10)	(−2.48)
Rear load	−0.00346	−0.00315	−0.00318	−0.00659***	−0.00652***	−0.00693***
	(−1.23)	(−1.12)	(−1.08)	(−4.19)	(−4.17)	(−4.22)
Observations	19,331	19,331	16,514	37,367	37,367	32,600
Adj. R^2	0.0397	0.0401	0.0407	0.0489	0.0492	0.0529

such an effect. The results indicate that, indeed, among institutional-oriented funds, the sensitivity of fund flows to low past performance has no significant relation to the asset liquidity (cash holdings) of corporate bond funds. The coefficient on the interaction term between alpha and low cash is statistically insignificant in both specifications (1) and (2) with different control variables.

When we turn to the last two specifications (3) and (4) which show the results for retail-oriented funds, the effect is very different from that of the institutional-oriented funds. In such cases, the sensitivity of outflows to low performance is significantly larger for low-cash, illiquid funds. The coefficient for the interaction between alpha and low cash is positive and statistically significant for both specifications. Hence, consistent with Hypothesis 4, we find that the effect of asset illiquidity on the sensitivity of outflows to bad performance diminishes when the fund is held mostly by institutional investors. For retail-oriented funds where coordination failures are more likely to be a problem, the sensitivity of outflows to bad performance is substantially exacerbated when the fund's cash holdings fall below average.

Note that we observe larger coefficients on alpha for institutional-oriented funds than for retail-oriented funds. This result points to other forces that may lead to the greater sensitivity of institutional investors to past performance. Institutional investors may have more resources to monitor the performance of their investments, and are more tuned in to news about past performance, reacting to it more strongly. This is consistent with evidence in Schmidt, Timmerman, and Wermers (2016). This does not contradict our hypothesis and the evidence highlighted above. Institutional investors react more strongly to past performance because they monitor more, but their reaction to past performance is less affected by the illiquidity of the assets because they are less affected by strategic complementarities.

Panel B of Table 9 shows how the illiquidity of corporate bond markets impacts the sensitivity of outflows to bad performance for institutional- and retail-oriented funds. Throughout the three proxies for the periods when corporate bond markets are illiquid, retail-oriented funds tend to experience more severe outflows when fund performance declines than their institutional-oriented counterparts.

The results in this subsection point to another measure that can reduce the fragility in fund outflows: concentrated fund ownership. Internalizing the externality, large shareholders reduce the sensitivity of outflows to bad performance. The retail-oriented funds, however, can still create significant problems, as retail investors are more affected by strategic complementarities and rush to the exit.

4.6. Treasury and municipal bond funds

So far in the paper, we have focused on corporate bond funds. As a comparison, in this subsection, we examine the flow-performance relations for Treasury and municipal bond funds. Treasury bonds are traded in more liquid secondary markets than are muni bonds (Harris, 2015). Due to the enhanced liquidity, we would expect the force of strategic complementarity to be weaker for Treasury bond funds, and thus the flow-performance relation for Treasury bond funds to be less concave than for muni bond funds.

We estimate the flow-performance relation for Treasury and municipal bond funds in Table 10. The results indicate that, similar to equity funds, Treasury bond funds tend to exhibit a convex flow-performance relation; but similar to corporate bond funds, muni bond funds tend to exhibit a concave flow-performance relation. Column 1 shows a negative and statistically significant coefficient for *Alpha* × *(Alpha* < 0*)* among Treasury bond funds, which indicates that outflows are less sensitive to underperformance than are inflows to outperformance. Column 2 shows a positive and statistically significant coefficient for *Alpha* × *(Alpha* < 0*)* among municipal bond funds, which indicates that outflows are more sensitive to underperformance than are inflows to outperformance. These results provide further support for the role of liquidity in driving the redemption decisions of mutual fund investors.

One alternative explanation for the greater concavity of the flow-performance relation for corporate bond funds than for equity funds is that investors in corporate bond funds may perceive corporate bonds as an asset class with limited upside potential but large downside risk. Perhaps as a result, their investment decisions may be more sensitive to underperformance of corporate bond funds. The results on Treasury funds provide some evidence against this hypothesis, since Treasuries have a payoff structure similar to corporate bonds with limited upside potential.[19] In-

Table 10
Flow-performance relations for Treasury and muni bond funds.
This table shows flow-performance relations for Treasury and muni bond funds from December 2000 to December 2014 (when the two samples overlap). Column 1 shows the results for Treasury bond funds, while column 2 shows the results for municipal bond funds. Flow is the proportional fund flow in a given month, Alpha is the average monthly alpha for a given fund in the past year, Log(TNA) is the natural log of total net assets, Log(age) is the natural log of fund age in years since its inception in the CRSP database, Expense is the fund expense ratio, and Rear load is an indicator variable that equals one if the fund share charges rear loads and zero otherwise. For all funds, alpha is the intercept from a regression of excess fund returns on excess aggregate bond market and aggregate stock market returns. We use the Vanguard Total Bond Market Index Fund return and CRSP value-weighted market return to proxy for aggregate bond and stock market returns. The unit of observation is share class-month. We include month fixed effects and cluster standard errors by fund share class. We exclude index funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database. Stars denote standard statistical significance ($^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, respectively).

	(1) Treasury bond funds	(2) Muni bond funds
Alpha	2.432***	0.186**
	(3.65)	(2.05)
Alpha × (Alpha < 0)	−2.062**	0.711***
	(−2.24)	(4.75)
Alpha < 0	−0.00509***	−0.00657***
	(−3.97)	(−16.27)
Lagged flow	0.109***	0.204***
	(6.20)	(26.51)
Log(TNA)	0.000489*	0.00117***
	(1.78)	(10.75)
Log(age)	−0.0171***	−0.0138***
	(−16.32)	(−35.89)
Expense	−0.282*	−0.373***
	(−1.65)	(−5.44)
Rear load	−0.00442**	−0.000973*
	(−2.40)	(−1.87)
Observations	79,594	288,373
Adj. R^2	0.0825	0.126

[19] One additional problem with this explanation is that equity returns are negatively skewed, but equity mutual funds tend to exhibit a convex flow-performance relation.

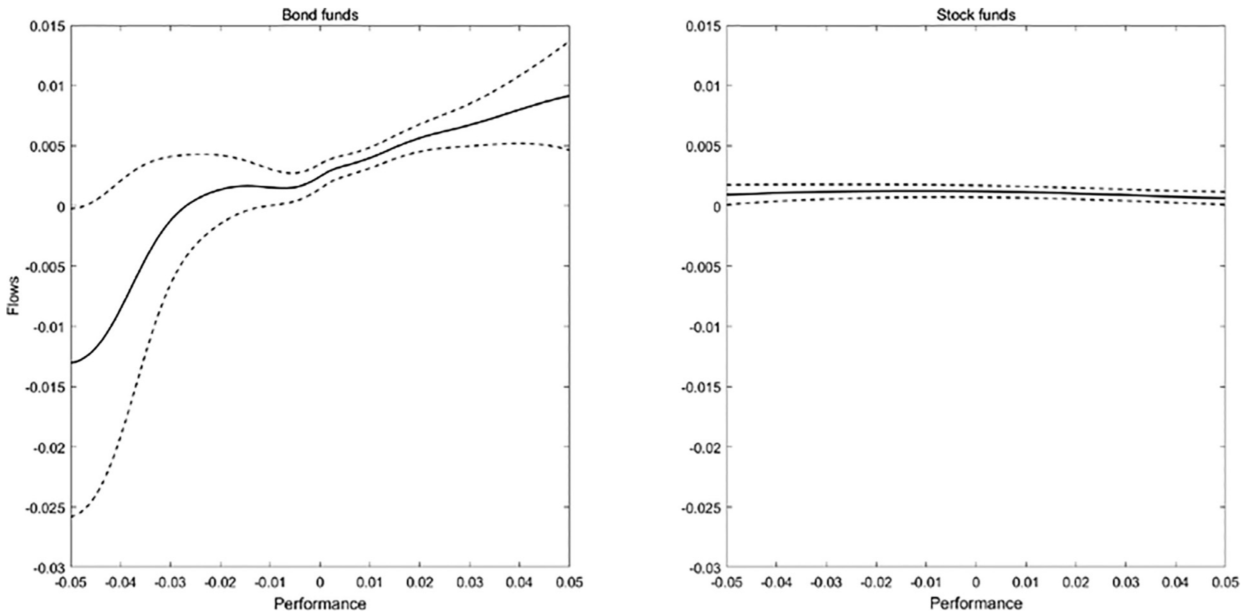

Fig. 5. Flow performance relations for aggregate corporate bond funds. This figure shows the flow-performance relation for aggregate corporate bond funds and stock funds using a semi-parametric regressing of monthly fund flows on past fund returns and lagged fund flows. The estimation uses the method developed by Robinson (1988) and applied in Chevalier and Ellison (1997). The dotted lines represent the 90% confidence intervals.

stead, they are consistent with the idea that liquidity of the assets held by the funds drives the asymmetric flow-performance relation. In addition, it should be noted that the alternative explanation based on the payoff structure will have a hard time explaining the various evidence presented so far concerning the effect of market liquidity, fund liquidity, investor clientele, etc. on the sensitivity of flow-to-performance in corporate bond funds.

4.7. Aggregate corporate bond fund flows

So far, we analyzed the flows into and out of individual funds and their interaction with performance, liquidity, investor clientele, and so on. As we discussed, we think the collection of results is mostly consistent with a first-mover advantage amplifying redemptions out of mutual funds following bad performance in case of illiquidity. From a policy point of view, one would like to know the behavior and consequences of aggregate corporate bond fund flows. Now we examine aggregate flow-performance relation for corporate bond funds as a sector, using equity funds as a comparison. The goal is to assess if the fund-level flow-performance relation reported previously may be washed out in the process of aggregation. Specifically, we perform semi-parametric regressions of aggregate fund flows in a given month on fund returns in the previous month with lagged fund flows as a control variable.

Fig. 5 shows that the aggregate redemption decision by corporate bond fund investors is more sensitive to lower past corporate bond fund returns than is the aggregate purchase decision to higher past corporate bond fund returns. Hence, the concavity in the flow–performance relationship for corporate bond funds is maintained in the aggregate. For equity funds, however, aggregate fund flows have no significant relations to past aggregate fund returns, after we control for the persistence in fund flows. This finding is similar to Warther (1995), who finds no evidence to support feedback trading by equity mutual fund investors in aggregate.

Overall, it appears that investors tend to leave the corporate bond fund sector as a whole when its performance declines, and so there is a concern for the effect on prices overall. This is different from the behavior of the equity fund sector where investors just shift money across funds in response to past performance but there are no significant shifts into and out of the sector.

5. Conclusion

Corporate bond funds have grown substantially in recent years. They hold a large fraction of corporate bonds outstanding in the US, and play an important role in the financing of firms' investments and operations. Despite their importance in the marketplace, there is very little research to date studying their flow patterns. We provide such a study in this paper and show that the familiar convex relationship between flows and performance in equity funds does not hold in corporate bond funds. The relationship in corporate bond funds is much more concave, indicating stronger sensitivity of outflows to poor performance.

We also show that the sensitivity of outflows to bad performance in corporate bond funds is much stronger in times of aggregate illiquidity and among funds that hold more illiquid assets. Moreover, the effect of illiquidity on the sensitivity of outflows to bad performance is driven mostly by retail-oriented funds and not by institutional-oriented funds.

These findings are all consistent with the presence of payoff complementarities among corporate-bond-fund investors driven by the illiquidity of their assets. Investors know that the redemption by others will impose liquidation costs on the fund that will reduce the return for those staying in the fund, and so there is a tendency to redeem with others, which acts to amplify the effect of negative performance on outflows.

Funds can take different measures to alleviate the amplification of outflows. These include holding a cash buffer, putting restrictions on redemptions, or changing the formula for net asset value calculation in the case of redemptions. Regulators should also be aware of the pattern of outflows in corporate bond funds in thinking about the stability of the financial system as a whole and in cases where there are externalities from funds to market prices and real economic activity. These issues call for more research in the future.

Additional research is also needed to understand the differences in fragility across different financial institutions and investment vehicles. A case in point is Exchange Traded Funds (ETFs), whose investment in corporate bonds increased tremendously in recent years. ETFs have a different model and do not allow investors to redeem their shares like in open-end funds. Hence, the first-mover advantage created by the open-end funds should not exist in ETFs. However, the process by which investors trade ETF shares and authorized participants create and redeem shares might lead to other channels of fragility when the underlying asset is illiquid.

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