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Redemptions and asset liquidations in corporate bond funds

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Non-technical summary

Research Question

Over the past years, the bond fund industry has increasingly shifted its focus on corporate bonds. Against this background, concerns about risks arising from illiquid assets under management in times of stress have come to the fore. With respect to German corporate bond funds, this paper explores to what extent the composition of the shareholder base drives the flow-performance relationship, and to what extent fund managers liquidate their securities to meet redemptions. A special focus is put on the liquidity structure of their bond portfolios.

Contribution

Based on the Bundesbank's investment fund statistics, we construct a unique panel of securities portfolios of corporate bond funds augmented with quotes from Bloomberg and ownership data from the Eurosystem's securities holdings statistics. In the first step, we review the redemption behaviour in institutional-oriented versus retail-based funds as a function of their portfolio liquidity. In the second step, we investigate asset liquidation strategies of fund managers in the presence of redemptions. As a key contribution, we identify differences in the liquidity management along the lines of ownership structures. With a breakdown in phases of low and high macroeconomic uncertainty, we distinguish between sales in a liquidity pecking order style and strategies where the liquidity structure does not change. The resulting sale behaviour can be explained by ownership-related differences in the flow-performance relationship.

Results

Conditional on underperformance, retail-based funds with an illiquid portfolio front-end are found to be more exposed to outflows than illiquid funds primarily owned by institutional investors. Apparently institutional investors are reluctant to withdraw from an illiquid fund because they internalise the fire-sale-driven loss a withdrawal would otherwise inflict on the fund. Within institutional-oriented funds, the flow response to bad performance is only significant if fund assets are sufficiently liquid.

As regards redemptions and asset liquidations in times of high macroeconomic uncertainty, managers of institutional-oriented funds are found to sell bonds in a liquidity pecking order mode, thereby preserving short-term performance. At the same time, our estimations suggest that managers of retail-based funds do not let their portfolio liquidity deteriorate. We interpret this as an attempt to attenuate incentives for illiquidity-induced runs. These differences in sale strategies correspond to ownership-related differences in the vulnerability of illiquid funds.

Nichttechnische Zusammenfassung

Fragestellung

In den vergangenen Jahren haben Rentenfonds ihren Anlageschwerpunkt zunehmend auf Unternehmensanleihen verschoben. Vor diesem Hintergrund rückte die Besorgnis über Risiken aus illiquiden Vermögensanlagen in Stressphasen verstärkt in den Fokus. Die vorliegende Studie untersucht für deutsche Rentenfonds mit einem Schwerpunkt auf Unternehmensanleihen, inwieweit die Zusammensetzung der Investorenbasis die Beziehung von Fondsperformance und Mittelflüssen beeinflusst und wie Fondsmanager Mittelabflüsse durch Wertpapierverkäufe finanzieren. Im Mittelpunkt der Analyse steht die Liquiditätsstruktur ihrer Anleiheportfolien.

Beitrag

Auf der Grundlage der Investmentfondsstatistik der Bundesbank erstellen wir einen speziellen Datensatz mit den Wertpapierportfolien deutscher Unternehmensanleihefonds, verknüpft mit Preisdaten von Bloomberg und Wertpapierhalterdaten der Securities Holdings Statistics des Eurosystems. Im ersten Schritt betrachten wir die Mittelflüsse institutionell orientierter bzw. retailbasierter Fonds in Abhängigkeit von ihrer Portfolioliquidität. Im zweiten Schritt wird untersucht, welche Liquidationsstrategien Fondsmanager wählen, um Anteilsscheinrücknahmen zu finanzieren. Unser wichtigster Beitrag besteht darin, aus dem makroökonomischen Umfeld und aus der Eigentümerstruktur der Fonds resultierende Unterschiede im Liquiditätsmanagement zu identifizieren. Hierfür trennen wir zwischen Verkäufen ohne Einfluss auf die Liquiditätsstruktur und Verkäufen, die einer Liquiditäts-Hackordnung folgen. Die gefundenen Unterschiede können mit den zuvor nachgewiesenen Differenzen im Investorenverhalten institutionell orientierter bzw. retailbasierter Fonds erklärt werden.

Ergebnisse

Bei schlechter Fondsperformance fließen aus illiquiden retail-orientierten Fonds (bezogen auf das liquideste Dezil ihres Portfolios) mehr Mittel ab als aus illiquiden institutionell dominierten Fonds. Offenbar sind institutionelle Investoren weniger gewillt, Mittel aus illiquiden Fonds abzuziehen, weil sie die aus einem Abverkauf andernfalls entstehenden Verluste internalisieren. Infolge schlechter Performance fließen von institutionell orientierten Fonds nur dann Mittel ab, wenn diese hinreichend liquide sind. Mit Blick auf die Liquidationsstrategien zur Finanzierung von Mittelabflüssen in einem Umfeld hoher makroökonomischer Unsicherheit belegen unsere Schätzungen, dass Manager institutionell orientierter Fonds Anleihen in einer Liquiditäts-Hackordnung verkaufen und dadurch ihre Transaktionskosten gering halten. Zugleich lassen die Manager retailbasierter Fonds keine Verschlechterung ihrer Portfolioliquidität zu. Dies lässt sich als Bestreben interpretieren, Anreize zu einem illiquiditätsgetriebenen Run zu reduzieren. Diese Differenzen in den Verkaufsstrategien entsprechen den unterschiedlichen Anfälligkeiten illiquider retailbasierter bzw. institutionell orientierter Fonds.

BUNDESBANK DISCUSSION PAPER NO 11/2019

Redemptions and Asset Liquidations in Corporate Bond Funds*

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Abstract

Mutual funds' exposure to corporate bonds has brought concerns about risks arising from liquidity transformation back to the fore. With a focus on fund asset liquidity and investors, this paper explores the flow-performance relationship and the liquidity management of funds in the presence of net redemptions. We highlight the response of fund liquidity because the vulnerability to outflows is found to depend on asset liquidity and fund ownership. We construct a unique panel of German corporate bond funds by merging data on asset liquidity with information on fund ownership. First, conditional on underperformance, illiquid funds dominated by retail investors are more exposed to outflows than illiquid funds primarily owned by institutional investors. Large investors are reluctant to withdraw most likely because they internalise the fire-sale-driven loss that a withdrawal inflicts on an illiquid fund. Within institutional-oriented funds, the flow response to bad performance is only significant if fund assets are sufficiently liquid. Second, the way that fund managers liquidate their bonds to meet redemptions is found to differ across ownership structures and depends on the degree of macroeconomic uncertainty: in times of high uncertainty, managers of institutional-oriented funds sell bonds in a liquidity pecking order style, thereby preserving short-term performance. At the same time, retail-based funds do not let portfolio liquidity deteriorate – presumably to attenuate incentives for runs.

Keywords: Corporate bond funds, Ownership, Portfolio liquidity, Strategic complementarities
JEL-Classification: G11, G23, G32

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1 Introduction

In the aftermath of the recent financial and sovereign debt crises, the discussion on risks originating from asset-liability mismatches of financial intermediaries has intensified, as have advances to reduce their vulnerability to strategic investor behaviour by installing liquidity risk management frameworks. At the same time, the role of investment funds in securities markets has been growing, and shifts in investment targets have taken place: in an environment of low interest rates, bond funds have increasingly focused on corporate bonds, many of which exhibit a low degree of liquidity.

Among the sources of fragility, liquidity transformation is key. The use of liquid liabilities to finance illiquid investments is at the core of many business models in the financial industry, given that bearing liquidity risk is generally remunerated with a premium. Looking back at the past decade, the intensified search for yield by investors in a low interest rate environment translated into pressure on the fund industry to comply with return expectations. Against this background, managers of bond funds redirected their assets under management towards less liquid but higher yielding debt. Since Bund yields started to decline in 2012, increasing weight has been attached to corporate debt securities. A breakdown of flows by shareholder majority and portfolio liquidity shows that among funds mainly owned by retail investors (retail-based funds), those targeting illiquid corporate bonds became attractive financial vehicles.[1] While the 'illiquidity premium' earned by these funds was reflected in a heightened performance[2], the build-up of liquidity mismatches has fuelled concerns about the risk of disruptions once outflows are triggered. Against this background, the literature has turned its focus to the investigation of run incentives, which are closely linked to the existence of strategic complementarities[3]. On the liability side of mutual funds, such complementarities can emerge when investors redeem their shares because they expect many others to be doing that, too. Investors behave like this because large redemptions imply a higher probability that the fund has to sell illiquid assets at a discount to acquire sufficient liquidity.[4] That is, redemptions are costly when illiquid assets have to be sold – a cost which we approximate by the security-specific bid-ask spread in the present study. In addition, sales of illiquid assets may take time to be executed in the market, while in the absence of gates, redemption requests can occur any

[1] See Figure A1.
[2] The preference for illiquid funds in the form of heightened retail investor flows went hand in hand with an 'illiquidity premium' earned on holding an illiquid fund. See Table A2.
[3] When an agent's action induces one or more rival agents to take the same action, their actions are dubbed strategic complements.
[4] Open-end funds usually promise daily redeemability, where redemptions could be met by reduced cash reserves, increased borrowing, or generating cash through asset sales. With higher redemptions, it becomes more likely that illiquid assets have to be sold. If that happens at discounts *and* at a delay, this drives a wedge between the per-share value paid out to the withdrawer and the per-share value left for those who stay in the fund.

time.[5] Unless being covered by the back-end load fee, the cost of these transactions is borne by investors who stay invested rather than by those who are withdrawing. This outflow and illiquidity-induced loss in the value of claims of remaining shareholders constitutes a negative externality. Funds primarily managing corporate debt securities are of special interest in this regard. Since this target asset class is relatively illiquid, a first mover advantage arising from strategic complementarities is possible. Empirically, these complementarities are identified using the sensitivity of outflows to past performance in the presence of illiquidity. As past performance serves as a signal to withdraw, complementarities tend to accelerate withdrawals, as additional investors may also withdraw just because they fear the negative repercussions of the withdrawals by others. A key concern is that at some point, a spiral of self-reinforcing outflows could unwind, threatening financial stability and potentially affecting the transmission of monetary policy.

Complementary to the existing evidence on illiquidity-induced amplifications of redemptions, the response of fund managers in terms of asset allocations has recently been explored by Jiang, Li and Wang (2017). With respect to asset sale strategies, however, less attention has been paid to the role of fund ownership in interaction in different states of macroeconomic uncertainty.

The question of how open-end funds with a different weight of institutional shareholders cope with outflows is the focus of the present paper. Elevated macroeconomic uncertainty can incentivise funds subject to strategic complementarities to restore their liquid reserves quickly after redemptions have been met. This behaviour would be consistent with an unchanged level of average portfolio liquidity on a monthly basis. We argue that the liquidity response of funds plays an important role because the exposure of a fund to outflows depends, apart from its performance, on asset liquidity and fund ownership. To check this, our first step is to explore the flow-performance relationship of underperforming corporate bond funds. In a second step, we restrict the sample to outflows. While portfolio illiquidity can accelerate outflows and associated losses[6] due to strategic complementarities, we focus on the rebound of outflows on the liquidity composition of the portfolio: if the manager sells the most liquid assets to comply with redemptions, the liquidity status of the portfolio deteriorates. We follow Jiang et al. (2017)

[5] With respect to fund management, this imbalance arises from the fact that the fund share price is usually determined on the day of the redemption, but asset liquidations required to meet that redemption may take longer than that. This time lag can become virulent when the market requires a discount to absorb low-liquid assets, but this discount is not priced in on the day of the redemption. When the fund manager has no other option to meet the redemption but to sell illiquid assets, she or he is forced to sell assets worth more than 100 per cent of the redemption value. The fund then realises a loss, which implies a lower fund share price for all shareholders who stay in the fund. In turn, this cost associated with sales incentivises shareholders to redeem early, which makes an outflow spiral more likely.

[6] See Annex B and Table B1 for corresponding estimation results that corroborate that withdrawals from illiquid funds affect contemporaneous fund performance more intensely than withdrawals from liquid funds: Withdrawals from funds with rather illiquid portfolios entail a return that is by 22 basis points (raw fund return) and 33 basis points (market-adjusted return) lower than the return generated by rather liquid funds. This hints at costly asset liquidations, hence at the presence of an extra first-mover advantage in the form of illiquidity-induced losses.

in dubbing this sale behaviour a *liquidity pecking order style*.[7] It allows managers to preserve short-term performance by keeping transaction costs as low as possible. Of course, in a perfect liquidity pecking order, cash would be drawn on in the first place, as noted by Morris, Shim and Shin (2017), as the use of cash buffers reduces the need to sell assets at fire sale conditions. However, we find that on a monthly basis, the change in cash hardly reflects a buffering of outflows, suggesting that cash is restored within a month or not used at all.[8]

However, the answer on whether or not cash is restored does not necessarily allow inference on whether or not the average asset liquidity of the fund changes. A refined assessment of the liquidity structure of fund assets is especially warranted when the marginal cost of asset liquidation is not flat. For example, the fund's average asset liquidity will worsen when more liquid assets than illiquid assets under management are sold. Opposed to this pecking order style, preserving liquid assets could help attenuate run incentives, but this strategy would weigh on performance, since in the absence of inflows, more illiquid assets have to be liquidated.[9] Against this background, the present study focuses on the liquidity structure of security holdings. Controlling for changes in cash holdings, we shed light on the fundamental trade-off fund managers are confronted with when deciding on which assets to liquidate: when they draw on liquid assets in the first place, they minimise transaction costs and preserve short-term performance. At the same time, this pecking order strategy reduces the portfolio weight of liquid positions, which makes the fund more vulnerable to a future run (too many illiquid assets might jeopardise its viability). Opposed to this deterioration of portfolio liquidity, managers may preserve liquid positions by selling assets in a way to leave average portfolio liquidity unaffected. This improves the longer-term viability by attenuating run incentives, but weighs on short-term performance due to higher transactions costs.

With a focus on funds' ownership structures, this paper addresses two questions: First, when does the liquidity transformation of funds translate into an intensified flow-performance relationship, given that portfolio illiquidity increases outflow-induced losses? The second question is: Does ownership affect the way in which fund managers meet redemptions? We contribute to the literature by identifying novel aspects of corporate bond funds' liquidation strategies. When redemptions are to be met, the investor base is shown to be pivotal for the sale

[7] A *liquidity pecking order style* is defined as selling first relatively liquid assets to meet outflows leaving the fund with more illiquid assets after experiencing outflows. Jiang, Li and Wang (2017) use this notion to describe that apart from cash, liquid assets are drawn on before illiquid asset holdings are sold to meet redemptions. This notion has also been employed by Morris, Shim and Shin (2017), but with respect to the role of cash: In their setting, a pecking order simply describes a behaviour where fund managers draw on cash first, meaning that they do not start to sell assets unless they run out of cash.

[8] The limited use of cash buffers is confirmed by regressing the change in cash holdings on flows (not reported here to save space): While a robust increase of cash holdings is found in response to net inflows, the reduction of cash holdings in response to net redemptions meets only a minor part of it.

[9] This view is emphasised by Jiang et al. (2017), which is challenged by Zeng (2017) who argues that restoring cash can be a source of fragility.

strategy chosen by corporate bond funds. This aspect is not covered in depth in the literature.[10] The Investment Fund Statistics of the Bundesbank provides a well suited empirical database at the monthly frequency to investigate this issue.

In a first step, we look at the determinants of outflow amplifications. In this regard, we review the role of the shareholder base that is emphasised in the literature. We investigate the conditions under which past underperformance on the asset side translates into stress on the funding side: to what extent do funds that are catering predominantly institutional investors mitigate panic-driven outflows that emerge when assets under management are illiquid? A theoretical argument is that in contrast to atomistic retail investors who can benefit from withdrawing fast, large institutional investors are aware that their decision to withdraw is likely to be pivotal for fund performance and their own return. Institutional investors who hold a non-atomistic share in a fund internalise at least some of the costs they inflict on the fund when withdrawing. This implies that their decision is less dependent on their expectation about withdrawals of others, i.e. less driven by panic. Instead, negative externalities arising from strategic complementarities are more likely in retail-based funds where investors hold small fractions: once others are expected to withdraw, a first move at the expense of others will pay off. To detect such amplifications in the flow-performance relationship, we regress the net flows of underperforming[11] funds a) on the past return, b) on a liquidity indicator variable which is one for funds with a front-end[12] bid-ask spread below its cross-section median in month *t*, c) an institutional ownership indicator which is one for funds of which more than 50% of the shares were held by non-retail investors in the current period, and d) on the interactions of those explanatory variables. We control for fund-specific characteristics as well as macroeconomic influences.

As a result, the fund's liquidity and ownership structure play a key role in the extent to which past returns affect net redemptions: The performance sensitivity is significant for funds owned predominately by retail investors – where significance is highest for funds with an illiquid portfolio front-end. On the contrary, withdrawals from illiquid funds under institutional control do not respond significantly to bad past performance. These ownership-related disparities point to an illiquidity-induced cost of redemptions, which makes investors in institutional-oriented funds stay but shareholders of retail-based funds withdraw (Hypothesis 1).[13] More precisely, the external cost of redemptions appears to be mutualised in retail-based funds, while it is more likely to be internalised in funds under institutional control. This internalisation implies that

[10] The empirical work of Jiang et al. (2017), who analyse state-contingent asset allocations of corporate bond funds that face redemptions, takes account of the fraction of fund assets held by retail investors as a control, but does not explore the role of the funds' ownership structure in further detail.

[11] Here, we restrict the sample to funds with a negative lagged market-adjusted return. The derivation of the market-adjusted return used here is described in Annex A.

[12] In this paper, the top liquid decile of assets under management is dubbed the front-end of the fund. The fund classification thus is based on the ranking of the 10% most liquid assets in the previous period.

[13] Hypothesis 1 states that among underperforming retail-based funds, funds with high asset liquidation costs face more significant withdrawals than liquid funds. Among underperforming funds primarily held by institutional investors, the contrary is true.

fragility is less a concern for illiquid institutional-oriented funds, as bad past returns do not entail withdrawals. In the absence of illiquidity-induced redemptions costs, however, this reluctance of investors disappears; there is no reason to hesitate to withdraw. We detect this pattern in liquid funds that are significantly responding to bad past performance.

The first hypothesis we formulate states that in funds with an illiquid portfolio front-end, the vulnerability to outflows depends on the composition of the fund's shareholder base. This can be interpreted as a reflection of an exposure to strategic complementarities that is high in retail-based funds but low in institutional-oriented funds. This ownership-related disparity corresponds to the resulting flow-performance patterns of existing empirical studies that differentiate along the lines of dominating shareholder group. These results help us interpret the liquidation strategies of funds that we explore in the following step.

In a second step, we ask how the liquidity structure of fund portfolios is affected by net redemptions. In the absence of sufficient inflows and under the premise of keeping cash and leverage unchanged, the fund manager makes a decision on which assets to liquidate. To explore whether the most liquid securities are sold in the first place, two regression approaches are applied:

i) In the first one, we investigate the determinants of the fund's average portfolio liquidity. We do so since changes in portfolio liquidity can be affected by contemporaneous redemptions. This effect is captured separately for liquid and illiquid funds, using an indicator variable for the liquidity status of the fund. Here, we control for changes in the fund's cash holdings, its leverage ratio, and changes in market liquidity of the underlying assets.[14] The results of our first approach show that higher withdrawals from institutional-oriented funds classified as illiquid go hand in hand with a decline in the liquidity of the remaining portfolio. This outflow-induced deterioration of portfolio liquidity can be interpreted as a reflection of asset sales in a *liquidity pecking order style*. By contrast, the effect of contemporaneous withdrawals from retail-based funds on portfolio liquidity remains insignificant, pointing to liquidations on a *pro-rata* basis.

ii) In a second approach, we estimate a logistic model of the fund's propensity to sell a bond at the fund-security-month level as a function of redemptions, bond liquidity and the shareholder base. With reference to Jiang et al. (2017), we test whether asset sales are carried out in a liquidity pecking order, but we put a special focus on differences in ownership structures in tranquil times and in phases of heightened aggregate uncertainty.[15] Controlling for changes in cash holdings and other fund and bond-specific characteristics, the institutional share and macroeconomic uncertainty are found to govern the impact of redemptions on the liquidity structure. In phases of high uncertainty, institutional-oriented funds keep transaction costs low and preserve their performance by selling bonds in a liquidity pecking order style. We also

[14] We do so because at least two different factors can influence the liquidity status of a fund's security portfolio: one is asset reallocations, which is at the core of our analysis. The second is a changing market liquidity of the assets under management. To identify the impact of the first one, we have to control for the second one.

[15] Similar to Jiang et al. (2017), we define phases of high aggregate uncertainty with reference to the level of implied stock market uncertainty. Our criterion is a VDAX exceeding its 75th percentile over time.

show that the higher the institutional share, the more accentuated the pecking order, hence a sale of liquid bonds becomes more likely to meet redemptions.

By contrast, retail-based funds are found to avoid a deterioration of portfolio liquidity. They comply with outflows in a way where the sale probability of a liquid bond is equal to that of an illiquid bond. This is an indication that these funds prefer *pro-rata* sales in times of high macroeconomic uncertainty. Preserving portfolio liquidity then seems to dominate the negative effect on short-term performance. This can be seen as an attempt to avoid incentives for illiquidity-induced outflows. In conformity with Hypothesis 1, their attempt to safeguard longer-term viability can be explained by the vulnerability to outflows that might otherwise result from extensive illiquid asset holdings.[16]

Our analysis suggests: given the trade-off between preserving short-term performance on the one side and preserving portfolio liquidity on the other, institutionally owned and retail-based funds choose different strategies when they are confronted with redemptions in times of high aggregate uncertainty. These differences are most pronounced when funds have an illiquid front-end (Hypothesis 2). The uneven pattern of liquidity management reflects the different extent to which these funds are exposed to strategic complementarities.

This paper uses data on funds domiciled in Germany from the Bundesbank's Investment Fund Statistics. To approximate the liquidity status of a fund, we merge security-specific bid-ask spreads derived from Bloomberg data with granular data on funds' security holdings to derive a holdings-weighted average bid-ask-spread, one of which comprises the entire fund portfolio, whereas a second measure refers to its top liquid decile, i.e. the bid-ask spread of the ten per cent most liquid asset holdings in each portfolio. We introduce the second measure because we expect it to contain important information given that fund managers aim at balancing liquid and illiquid asset holdings as a function of expected future redemptions. More precisely, we use the top decile measure to distinguish a liquid class of funds from an illiquid class in each month under review. Using this measure to classify funds relies on the assumption that in distress the top liquid assets are most important to meet redemptions.[17] Moreover, to identify funds that are predominately held by institutional investors and those of which the majority of issued shares is owned by retail investors, we rely on data taken from the Securities Holdings Statistics (SHS) of the Eurosystem.

The remainder of the paper is structured as follows: Section 2 reviews the related literature and develops our hypotheses. Data issues and the sample construction are described in Section 3, including the derivation of our measures of portfolio liquidity and the concept of fund

[16] This view is further supported by adding the first difference of the average portfolio bid-ask spread as an explanatory factor (Regression (1b)): According to Table 3, columns 2 and 4, increasing portfolio illiquidity prompts investors to withdraw from underperforming retail-based funds, but not at all from institutional-oriented funds.

[17] The historical flow distribution suggests that the bulk of redemptions can be covered by this 'front-end' of the fund's total asset holdings. The corresponding holdings-weighted (top decile) bid-ask spread thus serves as a proxy of the minimum cost at which fund managers could meet the bulk of redemptions.

performance used in this study. Section 4 presents the estimation approaches and empirical results. Section 5 concludes.

2 Related literature and hypothesis development

Strategic complementarities arising from liquidity transformation have been referred to as a source of a self-reinforcing asset meltdown in times of stress. This literature goes back to the familiar bank run model of Diamond and Dybvig (1983) where the liquidity mismatch between assets and liabilities creates fragility of banks. Notwithstanding, this problem has been acknowledged to exist in shadow banking and unlevered institutions as well.[18] With respect to mutual funds, there have been advances in the global game literature to model the behaviour of fund shareholders depending on the action of others. At its core stands the question of the origins of outflow spirals and asset selloffs as a result of negative externalities. To model the mutualisation of redemption costs as a function of the fund's liquidity position, threshold global game mechanisms have been applied in various forms. Liu and Mello (2011) formalize the interplay of the flow decision of investors and optimal cash holdings of otherwise illiquid funds: apart from a benchmark optimisation without the possibility of a run, they focus on optimal cash when a run is possible. Accordingly, if more than a critical mass of fundamentally motivated outflows materializes and assets must be sold at a discount, a run is triggered as redemptions become the dominant strategy. In their model, fund managers choose a cash level depending on the distribution of outflows and the risk of a run. Zeng (2017) presents another model of cash management: he points out that the objective to restore cash holdings can, by itself, become a source of fragility: funds invested in illiquid assets rebuild cash buffers by selling illiquid assets, which can in turn be responsible for the run behaviour of shareholders. In a similar vein, Morris et al. (2017) present a model of investor runs with ex-ante liquidations, i.e. before redemptions take place. They derive conditions for an optimal amount of asset liquidations to build up a cash buffer. Presuming a shift in asset illiquidity over time, they show that cash optimisation may imply cash hoarding (through costly fire sales) in order to be prepared for future redemptions.[19] According to their evidence, cash hoarding is common among US bond mutual funds especially when they are less liquid.

Chen, Goldstein and Jiang (2010) use a global game approach to model a run from illiquid funds depending on a signal on fund performance. Moreover, they add a novel ingredient by modelling the differential behaviour of small investors and a large investor: whether or not strategic withdrawals occur is traced back to the size of the large investors: If large enough, their propensity to realise costly withdrawals is reduced. Chen et al. (2010) consider the liquidity of assets under management. They argue that strategic behaviour of mutual fund

[18] See Gorton and Pennacchi (1990) and Chen, Goldstein and Jiang (2010), for example.

[19] According to Morris et al. (2017), the decision to sell assets today to pre-emptively build up cash reserves points to a trade-off. On the one side, selling illiquid assets imply fire sale costs. On the other hand, hoarding cash could help avoid selling assets at a potentially even higher discount when redemptions have to be met in the future.

shareholders can arise when fund share prices do not immediately reflect the full impact of outflow-induced asset sales. Conditional on costly asset liquidations to meet redemptions, a run is modelled as a response to investors' expected payoff, which is assumed to depend on past performance for outside investors and on the threshold of a noisy signal on the fund return received by inside investors.[20] An important take-away of their analysis is that the fund flow depends on fund performance *and* on the liquidity of the fund's assets. A second result is that apart from asset liquidity, the fund's ownership structure determines whether or not strategic complements are likely to occur: Chen et al. (2010) claim that not all shareholders respond in the same way to poor performance. It is the combination of retail ownership and asset illiquidity that creates a first-mover advantage among fund investors – i.e. shareholders expect to be better off by withdrawing early. Here, retail investors are assumed to be aware of liquidation costs arising from mutually reinforcing redemptions, but they are small enough not to bear this redemption cost if they move early. They are predicted to withdraw if they receive a signal that makes them believe that prices will go down because other shareholders are going to withdraw. Their 'benefit' consists in a redemption price which does not yet reflect subsequent sale-induced losses. This redemption cost is thus a negative externality. The resulting damage to the portfolio value would consequently be borne by the remaining shareholders. In their model, small retail shareholders are too small to coordinate their actions. Hence they will not internalise the cost their redemptions inflict on the fund, whereas large institutional investors are predicted to internalise this cost when they dominate the shareholder base, because outflow-induced losses would ultimately hit themselves.[21] Therefore in illiquid funds the resulting flow decisions are predicted to differ across ownership groups. Empirically, Chen et al. (2010) find for US equity mutual funds that illiquid retail-oriented funds are more affected by illiquidity-driven redemption costs than illiquid institutional-oriented funds.

Similar to this analysis, ownership has been identified to play a role in US corporate bond funds too. Goldstein, Jiang and Ng (2017) conclude that illiquidity of corporate bonds can amplify outflows in states of underperformance, but this is less to in institutional-oriented funds. The findings of Wang (2015) are in line with the first result in Goldstein et al. (2017), but his view on institutional investors is different: he suggests that institutional-oriented funds are more vulnerable to the effect of illiquidity on flows than retail-based funds.[22] This ambiguity boils down to the question whether or not institutional investors play a stabilising role when liquidation costs are high. With a focus on portfolio liquidity, our first hypothesis explores the flow-performance relationship in retail-based versus institutional-oriented corporate bond funds. Our results are supportive of Goldstein et al. (2017) rather than Wang (2015):

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[20] See the theoretical mutual fund model presented by Chen et al. (2010). In their model, the threshold of staying invested is a function of asset illiquidity and of past fund performance.

[21] Although their global game model refers to the presence of one large investor, Chen et al. (2010) claim that their results hold in a framework of multiple large investors if a cooperative equilibrium is played. This case is considered relevant as large shareholders tend to coordinate their actions with each other.

[22] Wang trace this result back to institutional investors being more sophisticated than retail investors, which should make flows of the former more sensitive to market information and poor fund performance. See Wang (2015).

Hypothesis 1: *Within funds with an illiquid portfolio front-end, retail-based funds are vulnerable to outflows in response to bad performance, whereas funds under institutional control remain unaffected. Within institutional-oriented funds, the flow response is only significant if the front-end of assets under management is sufficiently liquid.*

Our first set of regressions deals with the causes that make investors realise a certain amount of outflows. In the flow-performance relationship at the fund level, we detect a mutualisation of redemption costs by controlling for ownership and liquidity. Similar to Chen et al. (2010), who predict that the degree of retail orientation determines the extent to which illiquid funds are exposed to outflows, our results are conditional on past underperformance. We claim that, conditional on illiquid portfolios under management, a first-mover advantage is present in retail-based funds, but not in funds in the hands of institutional investors, given that the latter coordinate more easily. Thus in the latter case, shareholders refrain from withdrawing in response to past underperformance to avoid implied extra costs. The picture is diametrically opposite in liquid funds, however: the significant exposure to outflows found for institutional-oriented funds can be explained by negligible redemption costs combined with greater sophistication of investors.

As regards asset liquidation necessary to meet redemptions, a number of studies focus on cash optimisation models when asset liquidation is costly. A commonality of these models is the implicit assumption that marginal liquidation costs are flat in redemptions. To date, corresponding models where asset sales are carried out in a liquidity pecking order style do not exist. The latter would require marginal liquidation costs to increase in redemptions.

On empirical grounds, Jiang, Li and Wang (2017) test for the presence of a liquidity pecking order by estimating the probability of a bond sale as a function of its liquidity. They find that in the presence of outflows, a pecking order style of asset sales prevails in tranquil phases, whereas asset liquidations are carried out on a pro-rata basis in phases of high aggregate uncertainty. These authors interpret the latter strategy as an attempt to attenuate run incentives. However, they leave open whether or not this pattern holds for different groups of fund shareholders. To our knowledge, the ownership issue has not been taken into account in the literature on the liquidity management[23] of open-end funds so far. Therefore we aim at clarifying the influence of institutional versus retail ownership on asset liquidation strategies in a pecking order style as opposed to a pro-rata style. Motivated by our previous findings on the vulnerability of corporate bond funds (Hypothesis 1), our second hypothesis highlights the role of ownership structures in selling securities:

[23] Here, we use the notion of liquidity management to describe the way in which fund managers meet redemption requests. This includes the issue of portfolio liquidity *and* the issue of security liquidations.

Hypothesis 2: *In times of elevated aggregate uncertainty, managers of institutional-oriented funds sell bonds in a liquidity pecking order style, thereby preserving short-term performance. At the same time, retail-based funds do not let portfolio liquidity deteriorate – presumably to attenuate incentives for illiquidity-induced runs.*

Accordingly, it is stated that ownership-related disparities affect the behaviour of fund managers who meet redemptions. We claim that managers of retail-based funds avoid a meltdown of the liquid part of their securities portfolio when they have to meet redemptions in times of high volatility. With respect to funds with an illiquid front-end, such liquidations consistent with a pro-rata style[24] can be explained by the heightened vulnerability of retail-based funds compared to institutional-oriented funds (Hypothesis 1). This differential in vulnerability may prompt managers of retail-based funds to limit the incentives for an illiquidity-driven run in times of high uncertainty. At the same time, we find that managers of funds under institutional control liquidate assets in a pecking order style. Given their previously detected non-vulnerability of illiquid institutional-oriented funds, a further deterioration in portfolio liquidity does not seem to be a problem when outflows have to be met. This allows this group of funds to direct the focus on keeping transaction costs low rather than preserving liquidity.

3 Data and descriptive statistics

Our dataset consists of all open-end bond funds in the Bundesbank Investment Fund Statistics, where the share of corporate bonds in the bond portfolio exceeds 50 per cent.[25] The common accessibility by retail *and* institutional investors makes open-end funds particularly interesting in terms of heterogeneous investor strategies and resulting flow patterns. We construct a unique sample that covers 80 months from November 2009 to June 2016.[26] It consists of 5,612 reports for 159 corporate bond fund share classes, referring to 697,971 reported security holdings positions. The sample comprises both active funds as well as funds that were liquidated, taken over or merged in the period under review. However, funds subject to a closure or merger are disregarded once the remaining lifetime falls below six months. For our panel estimations of the flow decision of investors (Section 4.1), we use the fund share class as a cross-sectional unit.[27] To estimate the asset liquidation decision of fund managers (Section 4.2), we restrict the sample

[24] To be exact, the analysis is based on quarterly or monthly end-of-period snapshots, a strategy dubbed a ‘pro-rata strategy’ would eventually cover two cases: one is no change in liquid assets, the other is a fast restoring of liquid assets after redemptions have been met by selling liquid assets.

[25] For the purpose of the present study, we exclude specialised funds which are reserved to institutional investors. For details on the Investment Fund Statistics, see Dötsch, Flory and Schönberg (2017).

[26] Granular holdings data on a fund-month-security level had not been collected at the Bundesbank before September 2009. In September 2009, a refined reporting requirement was implemented in the Bundesbank Investment Fund Statistics. Since then, investment funds domiciled in Germany report their full security holdings at a monthly frequency.

[27] In line with Goldstein et al. (2017), we choose the share class level as our cross-sectional unit to estimate the flow-performance relationship, because the redemption decisions of fund shareholders may depend on share class-specific features. A fund can issue different share classes with separate fee structures which may be targeted at different types of investors. Hence the ownership structure can differ

to funds with one single share class. On the liability side, we add quarterly data about the shareholder base for each panel unit. We do so to assess the degree to which strategic complementarities depend on ownership structures. Information on the securities holdings sectors of corporate bond funds is obtained from the Securities Holdings Statistics of the Eurosystem.[28] We distinguish the retail (private households) sector and the sum of all institutional sectors in the euro area and use this information as follows: first, we add the institutional share and the retail share of each fund share class k at each quarter q to our dataset. To approximate the institutional share, we divide the institutional shareholdings in the euro area by the total holdings of euro area sectors:[29]

$$Inst_{k,q} = \frac{Institutional\ holdings\ in\ EMU_{k,q}}{Total\ holdings\ by\ EMU\ residents_{k,q}}$$

We interpolate $Inst_{k,q}$ linearly between quarter q-1 and quarter q to obtain a time series for each panel unit k at the monthly level, $Inst_{k,t}$. We use this variable to classify corporate bond funds under review into institutional-oriented funds ($Inst_{k,t} > 0.5$) and retail-based funds ($Inst_{k,t} < 0.5$) at a given month t.

On the asset side of the fund, price and liquidity information are added to each security under management. Moreover, we augment this dataset by adding fund and security-specific (issuer and instrument-specific) information. We obtain it from two sources, namely the Eurosystem's Centralised Securities Database (CSDB[30]) and Bloomberg. The liquidity data we apply are monthly averages derived from daily bid-ask spreads.[31] We derive averages of the daily security-specific liquidity information at the monthly level. Taking account of the portfolio structure of each fund, we then condense it further at the fund level to approximate the liquidity status of each securities portfolio under review.

Our starting point is to acknowledge that fund managers transform liquid liabilities into assets at *different degrees* of liquidity. To date, analyses of the impact of asset liquidity on mutual fund flows have not taken into consideration measures of the liquidity *structure* of fund portfolios,

across fund share classes within one managing fund. Among the 159 share classes of corporate bond funds under review, 96 are funds with one single share class (dubbed 'single funds'); the remainder refers to multiple fund share classes which are subordinated to a managing fund.

[28] For details on the Securities Holdings Statistics, see Bade, Flory, Gomolka and Schönberg (2017).

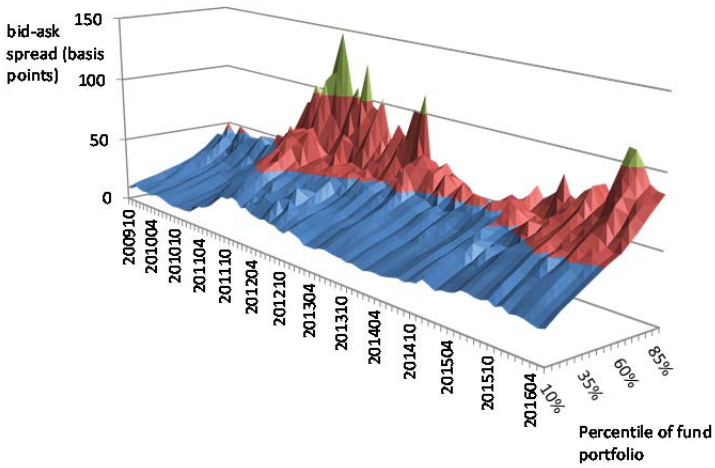
[29] Institutional shareholdings from *non*-EMU residents are not identified in the Securities Holdings Statistics of the Eurosystem. Since non-EMU residents tend to hold a negligible part of German bond fund shares, we take $Inst_{k,q}$ as a proxy of the true value. A retail share is derived in analogy.

[30] CSDB data are obtained from the Deutsche Bundesbank Research Data and Service Centre.

[31] Daily quotes for a security are calculated as the difference between the Bloomberg ask price and bid price divided by its mid-market price. For each security, monthly averages are derived from daily quotes. For a minor part of all monthly fund-security observations, no monthly quotes could be derived: For these reports, we carry out a similarity analysis, in which securities are classified along a range of criteria. Corresponding to its classification, each security where a monthly quote is missing is attributed the average bid-ask spread of the class to which the security belongs.

and the impact of flows on these measures of fund portfolios has not been focused on. For the purpose of this study, we rely on quoted bid-ask spreads of single securities under management to reflect the cost to liquidate it at different portfolio percentiles.[32] We focus on this indicator in an attempt to capture, to the extent that security information is covered by Bloomberg, the full range of security positions held by the fund.[33] Where no Bloomberg information is available at the security level, we assume that it takes the average value of the asset class the security belongs to.[34] Figure 1 depicts the liquidity structure for corporate bond funds over time.

Figure 1: Liquidity structure of corporate bond fund portfolios



Notes: Bid-ask spreads are calculated at a daily level as the ask price of a security less its bid price divided by its mid-market price. A value of 100 basis points corresponds to a price bid-ask spread of one per cent. At a fund-month-security level, monthly mean bid-ask spreads are taken into account for 689 131 fund positions, of which 569 043 positions refer to observed bid-ask spreads, and the remaining positions refer to missing values. Here, we rely on bid-ask spread proxies derived from asset class-specific averages. On this basis, a liquidity structure is derived for each fund in each month. Figure 1 depicts cross-section averages of bid-ask spreads for selected percentiles (10%, 20%,…, 90%) of the liquidity structure at each point in time.

For each point in time, cross-section averages of nine bid-ask spread percentiles are depicted. This illustrates that it matters *which* assets are sold: if the most liquid assets are liquidated, more illiquid assets will remain. Given that the bid-ask spread is a valid measure of liquidation costs, this would imply that potential cost of future liquidations will rise. Moreover, Figure 1 points to a considerable variation of the liquidity structure over time. Signs of market stress in the form of an illiquidity peak are observable in 2011 and at the end of the sample period.

Two liquidity measures are used to assess the role of asset liquidity in corporate bond funds.

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[32] Quoted bid-ask spread indicates the difference between the indicative prices at which a security can be bought and sold at one point in time, but there are no trading volumes associated with this spread.

[33] A range of liquidity indicators has been proposed in the literature to measure liquidity in bond markets. For an overview of liquidity measures in bond markets, see Schestag, Schuster and Uhrig-Homburg (2016).

[34] We use monthly averages derived from daily Bloomberg bid and ask price histories at the security level.

Our first measure is the holdings-weighted average bid-ask spread of the entire securities portfolio, where each security position held by fund *k* is weighted using its holdings value. This holdings-weighted bid-ask spread serves as a proxy for the cost to liquidate the entire securities portfolio of fund *k*. It captures all quotes available for securities under management[35]:

$$BAS_{k,t}^{pf} = \sum_{i} \frac{q_{k,i,t} \cdot price_{i,t} \cdot bas_{i,t}}{\sum_{i} q_{k,i,t} \cdot price_{i,t}}$$

Since the portfolio of fund *k* comprises a set of securities quoted at different bid-ask spreads, our measure of portfolio liquidity is a weighted average of the liquidity of all securities under management. $bas_{i,t}$ denotes the monthly average of daily bid-ask spreads $bas_{i,d}$ of security *i* observed in month *t*.[36] The weight attached to each security-specific bid-ask spread $bas_{i,t}$ is given by the holdings value $q_{k,i,t} \cdot prc_{i,t}$, where $q_{k,i,t}$ denotes the nominal value held by fund *k* in security *i*, and $prc_{i,t}$ denotes its price at time *t*. This makes clear that changes in $BAS_{k,t}^{pf}$ are not only driven by changes in the market liquidity of the underlying assets, but also by changes in the fund-specific weighting. In turn, this weighting is under the influence of asset reallocations (changes in $q_{k,i,t}$) and changes in security prices $price_{i,t}$ that determine the value of security holdings.

Since a fund holds securities at different degrees of liquidity, we construct a second measure that captures the bid-ask spread of the 10 per cent most liquid assets under management. We use this 'front-end' of the fund's asset holdings sheet to approximate the cost at which fund managers should be able to meet the bulk of redemptions if they pursue a sale strategy in a liquidity pecking order style (i.e. selling top liquid securities first). Apart from drawing on cash holdings, this fraction should constitute a 'first line of defence' to meet redemptions. Given the lack of other security-specific liquidity data, its average bid-ask spread serves as a proxy for the transaction cost to liquidate security holdings worth 10% of total net assets. We use this boundary because the outflow history of German bond funds between November 2009 and mid-2016 documents that the bulk (95%) of all monthly outflow events does not exceed 10 per cent of total net assets managed by the fund in the preceding period. The holdings-weighted average bid-ask spread of the top liquid decile of the fund securities portfolio reads:

$$BAS_{k,t}^{top} = \sum_{i(t)} \frac{q_{k,i,t} \cdot price_{i,t} \cdot bas_{i,t} \cdot D_{i,k,t}^{top}}{\sum_{i(t)} q_{k,i,t} \cdot price_{i,t} \cdot D_{i,k,t}^{top}} \quad where \; D_{i,k,t}^{top} = \begin{cases} 0 \; if \; bas_{i,t} > bas_{k,t}^{p10} \\ 1 \; if \; bas_{i,t} \leq bas_{k,t}^{p10} \end{cases}$$

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[35] Regarding the availability of security bid and ask prices we rely on Bloomberg data.

[36] At the security level, monthly average bid-ask spreads, $bas_{i,t}$, are derived from daily quotes: $bas_{i,t} = \sum_{d} bas_{i,d}^{Bloomberg} / N_{i,t}$. The daily quote $bas_{i,d}^{Bloomberg}$ is derived from Bloomberg bid prices and ask prices: $bas_{i,d}^{Bloomberg} = \frac{ask_{i,d} - bid_{i,d}}{(ask_{i,d} + bid_{i,d})/2}$. The term $q_{k,i,t} \cdot price_{i,t}$ denotes the position value of security *i* held by fund *k* in month *t* with a nominal volume $q_{k,i,t}$. $N_{i,t}$ is the number of days in month *t* for which quotes are available for security *i*.

where $bas_{k,t}^{p10}$ denotes the monthly bid-ask spread of the marginal security at the 10% percentile of all security holdings of fund k in month t. Securities quoted at bid-ask spreads above this threshold $bas_{k,t}^{p10}$, i.e. where $D_{i,k,t}^{top} = 0$, are excluded from the calculation of this measure. The rationale for the inclusion of this measure is that the liquidity status of the *entire* securities portfolio may not necessarily reflect sufficiently well the ability of a fund to meet redemptions. Presuming that managers want to be prepared to meet a redemption shock at limited costs – to send a corresponding signal to their investors – managers may choose to hold part of their assets in liquid assets or cash reserves. Holding liquid securities can help to mitigate the risk of strategic, illiquidity-induced withdrawals. Thus the manager may prefer a steep liquidity structure of her or his portfolio. The combination of a liquid front-end with otherwise illiquid assets allows her or him to meet two objectives at once: ensuring profitability and being prepared for a given redemption risk at the same time.

Table 1: Summary statistics

				percentiles	
Corporate bond funds	Mean	Std.dev.	p25	Median	p75
Fund share class level (5,612 monthly observations)					
Flow (Net flow as a percentage of lagged TNA)	+0.2	5.7	-1.2	0	+1.3
Holdings-weighted portfolio bid-ask spread (basis points)	56	32	34	52	72
Holdings-weighted bid-ask spread of top liquid portfolio decile (basis points)	21	17	10	18	28
Share of stressed securities[1]	19.1	19.6	4.8	12.3	26.5
Share of debt securities with a residual maturity beyond five years (% of total security holdings)	40.5	25.2	21.6	43.9	58.9
Cash holdings (% of TNA)	2.6	3.6	0.5	1.3	3.1
Leverage (% of TNA)	0.1	1.2	0	0	0
Raw fund return (% per month)	+0.32	1.15	-0.19	+0.27	+0.92
Market-adjusted fund return (% per month)	0.00	0.90	-0.47	0.0	+0.38
Load fee[2] (%)	2.0	1.7	0.0	2.5	3.0
Age of the fund (years)	7.7	6.7	2.9	5.6	11.0
Share of institutional investors[3] in total shareholdings (%)	61.0	36.4	25.1	72.5	96.7
Debt securities under management (689,131 monthly observations)					
Price bid-ask spread (basis points)	58	45	30	50	77
Return (%)	+0.42	4.16	-0.18	+0.34	+1.20
Residual maturity (years)	6.8	8.4	2.9	5.0	7.3
Amount outstanding (€bn)	1.0	1.9	0.5	0.7	1.0

Notes: Sample refers to the period from November 2009 to June 2016 and comprises funds where more than 50% of securities under management is held in corporate debt. 1) The *share of stressed securities* is defined as the ratio of stressed security holdings in relation to the total security holdings of a fund. A security is assumed to be under stress when its bid-ask spread lies beyond the 75th percentile of all observations for this security in the sample period (See Section 4.2 for further explanations). 2) The load fee of a fund is defined as the differential between the purchase price and the redemption price of a fund share divided by its redemption price. 3) Investors resident in the euro area.

Hence to test the robustness of what we find for the overall portfolio bid-ask spread, we include the front-end bid-ask spread to assess the preparedness and resilience of funds to withstand adverse market movements. Based on this front-end liquidity measure, we classify corporate bond funds in a segment of liquid funds and a segment of illiquid funds: for each month under review, a fund is classified as illiquid if its top decile portfolio liquidity, $BAS_{k,t}^{top}$, exceeds its contemporaneous cross-section median, and classified as liquid otherwise.

When evaluating the performance of mutual funds, investors might reasonably base their decisions on a number of different return measures. For reasons of simplicity, we concentrate on the absolute (raw) fund return and the *market-adjusted* return, which is a simple but nonetheless meaningful measure. The latter is defined as the difference between the raw fund return and a relevant benchmark. Since a benchmark is not always made available by the fund, we construct benchmarks based on the market return of the asset classes targeted by a fund. We assume that managers of actively managed funds attempt to beat a weighted market return (benchmark proxy), taking into account fund-specific portfolio weights. As outlined in Annex A, we derive a fund-specific benchmark proxy from observed asset-class specific market returns multiplied by the portfolio weights a fund attaches to the respective asset classes. We then calculate the market-adjusted fund return as the difference between the benchmark return and the raw fund return.

Table 2: Portfolio composition of corporate bond funds

Weight of asset class…	*Retail-based funds*		*Institutional-oriented funds*	
	Liquid funds	*Illiquid funds*	*Liquid funds*	*Illiquid funds*
…in per cent of the top decile value:				
Corporate bonds	49%	81%	54%	78%
Government bonds	26%	4%	23%	2%
…in per cent of the total portfolio value:				
Corporate bonds	76%	88%	82%	87%
Government bonds	5%	3%	5%	1%
Cash holdings (in % of TNA)	2.6%	1.8%	3.0%	1.9%

Notes: Sample comprises inflows and outflows. It extends from November 2009 to June 2016 comprising 5,612 monthly observations for funds where more than 50% of securities under management is held in corporate debt. A fund is dubbed as *retail-based* (*institutional-oriented*) if institutional investors hold less than (more than) 50% of total shareholdings. Funds are classified as *liquid* if the holdings-weighted top decile bid-ask spread is below its cross-section median in month *t*, and as *illiquid* otherwise.

While the raw return of corporate bond funds has a mean of 0.3% per month in the entire sample, the market-adjusted return has a mean of 0% (See Table 1). Net flows are positive on average (+0.2% of total net assets at the end of the previous month), but show a considerable standard deviation (5.7%). The mean liquidity measures for the securities portfolio are 56 basis points for the holdings-weighted portfolio bid-ask spread and 21 basis points for the holdings-weighted bid-ask spread of its top decile. A security where the bid-ask spread exceeds the 75th percentile of its time series is taken into account in the category of stressed securities. On average, a portfolio share of 19% consists of such securities. Cash holdings amount, on average, to 2.6% of lagged total net assets. Leverage is rarely used by corporate bond funds. As regards the ownership structure of corporate bond funds, institutional investors hold more than 60% of the fund value on average.

As regards the composition of the securities portfolio, Table 2 shows the shares held in corporate and government bonds. We report these shares separately for funds classified as retail-based funds and institutional-oriented funds, respectively. Moreover, we break the sample down by portfolio liquidity in each month under review.[37] Unsurprisingly, corporate bonds have a larger weight in funds categorised as illiquid, while government bonds play a larger role in liquid funds. Moreover, funds with rather illiquid securities under management hold cash in markedly lower quantities than funds with more liquid securities under management. Hence funds with illiquid securities under management exhibit a rather poor overall liquidity status, whereas the contrary is the case for funds with liquid securities.

4 Empirical Results

Before carrying out our regressions to test hypothesis 1 on the run behaviour of investors, and hypothesis 2 on how fund managers respond to it, outliers are eliminated for all variables under review to ensure that our results are not driven by single outlier observations. Observations of each explanatory variable are winsorised at the 1% and the 99% percentile.

4.1 Flow-performance relationship at the fund level

Hypothesis 1: *Within funds with an illiquid portfolio front-end, retail-based funds are vulnerable to outflows in response to bad performance, whereas funds under institutional control remain unaffected. Within institutional-oriented funds, the flow response is only significant if the front-end of assets under management is sufficiently liquid.*

Hypothesis 1 examines the role of portfolio liquidity and the ownership structure for the flow-performance relationship of corporate bond funds. To detect the presence of an ownership-dependent amplification mechanism, we carry out panel regressions relating monthly flows to our measures of fund performance, controlling for liquidity classes and ownership structures. For each fund category, we estimate how the fund flow responds to past performance at the fund share class level:

$$(1a)\quad Flow_{k,t} = \gamma_1 R_{k,t-1} + \gamma_2 R_{k,t-1} \cdot INST_{DUMMY\,k,t-1} + \gamma_3 R_{k,t-1} \cdot LIQ_{k,t-1} + \gamma_4 R_{k,t-1} \cdot LIQ_{k,t-1} \cdot INST_{DUMMY\,k,t-1} + \gamma_5 LIQ_{k,t-1} + \gamma_6 \cdot INST_{DUMMY\,k,t-1} + \gamma_7 INST_{DUMMY\,k,t-1} \cdot LIQ_{k,t-1} + \beta_1 Flow_{k,t-1} + \lambda X_{k,t} + \tau_t + \mu_k + \varepsilon_{k,t} \quad | \, R_{k,t-1} < 0$$

[37] Referring to the entire securities portfolio of a fund, a fund is classified as illiquid (liquid) if the holdings-weighted bid-ask spread of the entire portfolio in month *t* exceeds (is below) its cross-section median (across all funds under review) in month *t*. Referring to the top liquid decile of the fund securities portfolio, funds are classified as illiquid (liquid) if the holdings-weighted top decile bid-ask spread of the portfolio in month *t* exceeds (is below) its cross-section median (across all funds under review) in month *t*.

$$(1b) \quad Flow_{k,t} = \kappa_1 \, \Delta BAS_{k,t}^{pf} + \kappa_2 \, \Delta BAS_{k,t}^{pf} \cdot INST_{DUMMY\,k,t-1}$$
$$+ \gamma_1 R_{k,t-1} + \gamma_2 R_{k,t-1} \cdot INST_{DUMMY\,k,t-1} + \gamma_3 R_{k,t-1} \cdot LIQ_{k,t-1}$$
$$+ \gamma_4 \, R_{k,t-1} \cdot LIQ_{k,t-1} \cdot INST_{DUMMY\,k,t-1} + \gamma_5 \, LIQ_{k,t-1} + \gamma_6 \cdot INST_{DUMMY\,k,t-1}$$
$$+ \gamma_7 INST_{DUMMY\,k,t-1} \cdot LIQ_{k,t-1} + \beta_1 \, Flow_{k,t-1} + \lambda X_{k,t} + \tau_t + \mu_k + \varepsilon_{k,t} \quad | \, R_{k,t-1} < 0$$

Here, the indicator variable $INST_{DUMMY\,k,t-1}$ takes the value of one if the shareholder majority of the fund is owned by institutional investors in month *t-1* (corresponding to $Inst_{k,t} > 0.5$), and zero otherwise. μ_k denotes the fixed fund effect, and τ_t denotes the month fixed effect. The performance variable is $R_{k,t-1}$ represents the lagged raw fund return and the lagged market-adjusted return in alternative specifications (see Table 3). We categorise funds in liquidity segments at each point in time. The indicator variable $LIQ_{k,t-1}$ is introduced to differentiate between funds whose securities portfolios are classified as liquid in the previous month ($LIQ_{k,t-1} = 1$), and illiquid funds ($LIQ_{k,t-1} = 0$):

$$LIQ_{k,t-1} = \begin{cases} 0 \;\; if \;\; BAS_{k,t-1}^{top} > median_{t-1}\left(BAS_{k,t-1}^{top}\right) \\ 1 \;\; if \;\; BAS_{k,t-1}^{top} \leq median_{t-1}\left(BAS_{k,t-1}^{top}\right) \end{cases}$$

As outlined beforehand in section 3, we classify funds in a segment of liquid funds and a segment of illiquid funds according to our front-end liquidity measure, $BAS_{k,t}^{top}$: In a given month *t*, a corporate bond fund is classified as liquid if its holdings-weighted top decile portfolio liquidity is below its contemporaneous cross-section median, and classified as illiquid otherwise.

Since we are interested in withdrawal patterns in a first stage, we limit our dataset to observed underperformance. In Table 3, the coefficient γ_1 denotes the feedback coefficient to past performance of illiquid retail-based funds. The coefficient γ_2 denotes the increment of institutional-oriented funds over retail-based funds, so the linear combination $\gamma_1 + \gamma_2$ represents the response of illiquid institutional-oriented funds. Correspondingly, the linear combination $\gamma_1 + \gamma_3$ denotes the response of liquid retail-based funds, and $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4$ represents the response of liquid institutional-oriented funds. The variable vector $X_{k,t}$ represents a set of fund-specific control variables, which are the log age of the fund, its size (log of total net assets), and the load fee charged by the fund. Table 3 reports a consistently positive coefficient γ_1 for illiquid retail-based funds and consistently positive responses $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4$ for institutional-oriented funds with a liquid portfolio front-end – though less significant than γ_1. This can be interpreted as follows: When past performance deteriorates (i.e. $R_{k,t-1}$ becomes more negative), flows are predicted to decrease, i.e. redemptions are predicted to increase. Instead, the responses for institutional-oriented funds classified as illiquid are insignificant ($\gamma_1 + \gamma_2$). These findings are in line with the model predictions of Chen et al. (2010) and corroborate the empirical findings of Goldstein et al. (2017): Whereas retail investors do not hesitate to withdraw from a fund following to bad fundamentals, institutional investors who hold the majority of fund shares

Table 3: Estimating the flow-performance relationship

		Dependent variable: $Flow_{k,t}$			
Performance measure $R_{k,t-1}$:		Market-adjusted fund return		Raw fund return	
Observations at the fund-month level (k,t).		(1)	(2)	(3)	(4)
$\Delta BAS^{pf}_{k,t}$	κ_1		-0.0790**		-0.0777**
			(0.0393)		(0.0388)
$\Delta BAS^{pf}_{k,t} \cdot INST_{DUMMY\ k,t-1}$	κ_2		0.0851**		0.0847**
			(0.0409)		(0.0405)
	$\kappa_1 + \kappa_2$		0.0061		0.0070
			(0.0122)		(0.0123)
$R_{k,t-1}$	γ_1	0.7506**	0.7537**	0.7959***	0.7519***
		(0.3174)	(0.3179)	(0.2628)	(0.2778)
$R_{k,t-1} \cdot INST_{DUMMY\ k,t-1}$	γ_2	-0.5841	-0.6745	-0.6238*	-0.6699*
		(0.4539)	(0.4529)	(0.3493)	(0.3609)
	$\gamma_1 + \gamma_2$	0.1665	0.0791	0.1721	0.082
		(0.3728)	(0.3726)	(0.2956)	(0.2964)
$R_{k,t-1} \cdot LIQ_{k,t-1}$	γ_3	-0.1708	-0.2654	-0.0518	-0.0143
		(0.5102)	(0.4951)	(0.3856)	(0.4042)
$R_{k,t-1} \cdot LIQ_{k,t-1} \cdot INST_{DUMMY\ k,t-1}$	γ_4	0.5155	0.699	0.5022	0.5293
		(0.636)	(0.6266)	(0.5145)	(0.5276)
	$\gamma_1 + \gamma_3$	0.5799*	0.4883	0.7441**	0.7376**
		(0.3451)	(0.3453)	(0.3224)	(0.3313)
	$\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4$	0.5112*	0.5127*	0.6225**	0.597**
		(0.277)	(0.2858)	(0.265)	(0.2671)
$Flow_{k,t-1}$		0.1242***	0.1244***	0.1232***	0.1235***
		(0.0308)	(0.0307)	(0.0306)	(0.0306)
Log($Age_{k,t-1}$)		-0.014*	-0.0135	-0.0147*	-0.0142*
		(0.0082)	(0.0083)	(0.0083)	(0.0083)
Log($TNA_{k,t-1}$)		0.0041	0.0042	0.0042	0.0043
		(0.0046)	(0.0047)	(0.0046)	(0.0047)
Load $fee_{k,t-1}$		0.1269	0.1097	0.1352	0.119
		(0.2295)	(0.2298)	(0.2288)	(0.2289)
Constant		-0.019	-0.02	-0.0226	-0.0239
		(0.0764)	(0.0772)	(0.076)	(0.0768)
Monthly observations		2790	2715	2790	2715
Fund share classes (clusters)		151	150	151	151
R^2 (within)		0.0750	0.0792	0.0768	0.0810
Marginal effects predicted at $R_{k,t-1}$ = -5%					
Retail-based funds:					
Flow response at $LIQ_{k,t}$ = 0		-0.0299**	-0.0278*	-0.0345***	-0.0307**
		(0.0151)	(0.0150)	(0.0470)	(0.0136)
Flow response at $LIQ_{k,t}$ = 1		-0.0214	-0.0071	-0.0311*	-0.0300
		(0.0190)	(0.0168)	(0.0184)	(0.0189)
Institutional-oriented funds:					
Flow response at $LIQ_{k,t}$ = 0		-0.0121	-0.0162	-0.0139	-0.0089
		(0.0167)	(0.0190)	(0.0141)	(0.0142)
Flow response at $LIQ_{k,t}$ = 1		-0.0293**	-0.0304**	-0.0356**	-0.0347**
		(0.0147)	(0.0152)	(0.0141)	(0.0144)

Notes: Sample is limited observations of underperformance. Sample period: November 2009 to June 2016. Corporate bond funds are classified in liquidity segments $LIQ_{k,t} \in [0,1]$, where $LIQ_{k,t}$ takes the value of one if it is below the cross-section median of the holdings-weighted top decile bid-ask spread of the fund portfolio in month *t*, and zero otherwise. The dependent variable $Flow_{k,t}$ denotes the net flow of all investor groups, expressed as a percentage of lagged total net assets. The indicator variables $INST_{DUMMY\ k,t-1}$, $LIQ_{k,t-1}$ and $LIQ_{k,t-1} \cdot INST_{DUMMY\ k,t-1}$ are included but not reported here. Moreover, month fixed effects and fixed effects at the fund share class level are included. To account for serial correlation of residuals at the fund share class level, we cluster standard errors by fund share class. Robust standard errors are reported in parentheses.

are reluctant to do so. To a certain degree, the latter consider the redemption costs their withdrawal would inflict on the fund, which comes close to an internalisation of the external illiquidity- and outflow-induced damage. Conversely, things are different when the cost of an asset sale is low: institutional funds with a liquid front-end are found to be more exposed to outflows than illiquid ones. As transaction costs are lower for liquid funds, a withdrawal would not do much harm to a large investor, and no substantial externalities need to be internalised. Therefore sophisticated institutional investors have no incentive to stay invested, but may rather withdraw for reasons of bad fundamentals.[38] This pattern may have repercussions on the asset liquidation strategies of fund managers, which we explore in Section 4.2. Managers of institutional-oriented funds will be shown to prefer a pecking order strategy to keep transaction costs low; the resulting deterioration in portfolio liquidity does not matter to them – given the previously found non-vulnerability of illiquid funds in the hands of institutional investors. A completely different pattern turns out for flows to illiquid retail-based funds: here, the flow-performance relationship is significant, which can be interpreted as a reflection of a first-mover advantage arising from strategic complementarities.

We further corroborate the differences in response patterns across ownership groups by adding the change of the average portfolio bid-ask spread as an explanatory factor in Regression (1b), that is: $\kappa_1 \, \Delta BAS_{k,t}^{pf} + \kappa_2 \, \Delta BAS_{k,t}^{pf} \cdot INST_{DUMMY\;k,t-1}$. According to Table 3 in columns 2 and 4, a decline in portfolio liquidity prompts investors to withdraw from underperforming retail-based funds, but not at all from underperforming institutional-oriented funds. This limited responsiveness of institutional shareholders contrasts with the findings of Wang (2015) for US corporate bond funds.

Based on these estimations, we report the flow impact of an assumed fund performance of -5% at the bottom of Table 3: the assumed decline in performance is predicted to entail withdrawals from illiquid funds amounting to about 3 per cent if the fund is retail-based, but outflows are insignificant if the fund is under institutional control. On the contrary, applying the same shock to liquid funds shows significant withdrawals from institutional-oriented funds, but mostly insignificant responses for retail-based funds. To sum up, within funds with an illiquid front-end, a distinct difference is revealed between the two ownership groups: while funds dominated by retail shareholders are exposed to redemptions after bad performance, this is not the case when institutional investors control the majority of fund shares.

4.2 Asset liquidation strategies

The previous results on the role of ownership motivate us to address the question of *how* fund managers sell their assets and whether the liquidity structure is affected by net redemptions. As the key contribution of this paper, the following two approaches are applied to measure which part of bonds and other securities under management is liquidated in the first place. First, we

[38] This sensitivity of flows to past performance is close to the constellation highlighted in the demandable debt financing model of Calomiris and Kahn (1991), where fast liquidation is an option for better-informed investors, which incentivises them to provide capital.

look at the change in overall portfolio liquidity at the fund-month level. Second, we carry out regressions of a binary sale indicator at the fund-security-month level.

With respect to the first approach (described in Section 4.2.1), a liquidity status that worsens due to outflows should reflect an asset sale in a liquidity pecking order style. The intuition is that portfolio liquidity tells us something, after several controls, about the sale behaviour and intended asset reallocations of fund managers. Here, the coefficient of the flow regressor is key to answering the question of whether fund managers carry out sales in a pecking order style or in a pro-rata style. For example, managers who are worried about the threat of an illiquidity-driven run should preserve their average portfolio liquidity – e.g. by carrying out sales on a pro-rata basis –, which would imply an insignificant flow coefficient. In times of high macroeconomic uncertainty[39], we hypothesise retail-based funds to do so rather than institutional-oriented funds, as the former are found to be more vulnerable to an illiquidity-induced run:[40]

Hypothesis 2: *In times of elevated aggregate uncertainty, managers of institutional-oriented funds sell bonds in a liquidity pecking order style, thereby preserving short-term performance. At the same time, retail-based funds do not let portfolio liquidity deteriorate – presumably to attenuate incentives for illiquidity-induced runs.*

To test Hypothesis 2, we start with an empirical investigation of the determinants of portfolio liquidity when redemptions have to be met (Section 4.2.1). We then proceed by presenting an in-depth approach where sale probabilities are estimated as a function of fund flows and bond liquidity (Section 4.2.2). The latter will show that the pecking order behaviour identified in the first approach for institutional-oriented funds proves robust in phases of high aggregate uncertainty, but not in tranquil times.

4.2.1 *Drivers of portfolio liquidity*

In the first approach, we estimate the impact of redemptions on portfolio liquidity at the fund-month level. We claim that asset sales in a pecking order style should be reflected, to a certain degree, in a deterioration of average portfolio bid-ask spreads of funds that face redemptions. If no deterioration is observed, we interpret this as an attempt of managers to preserve the liquidity status of their portfolio. The latter strategy would come close to sales on a pro-rata basis. In this first approach we use the same breakdown of our sample in two liquidity classes as before:[41] $LIQ_{k,t}[0,1]$, where $LIQ_{k,t} = 1$ for funds whose weighted bid-ask spread of the top portfolio decile remains below its cross-section median. For both liquidity segments we examine whether ownership-dependent vulnerabilities – evident in different degrees to which redemption costs are mutualised according to Hypothesis 1 – determine the presence of a liquidity pecking order.

[39] We define these phases to be characterised by a VDAX exceeding its 75% percentile in the sample period (24.157).

[40] According to Hypothesis 1, bad performance does not pose a threat on illiquid funds in the hands of institutional investors.

[41] See Section 4.1.

To this end, we restrict the sample to single funds, excluding multiple share classes belonging to one fund.[42] To quantify the impact of redemptions on average portfolio liquidity, we regress changes in the fund's average portfolio liquidity on contemporaneous net outflows, on the aforementioned liquidity indicator variable as well as the interaction of the two:

$$(2)\ \Delta BAS_{k,t}^{pf} = \theta_1\, Flow_{k,t} + \theta_2\, Flow_{k,t} \cdot LIQ_{k,t} + \theta_3\, LIQ_{k,t} + \theta_4\, \Delta Cash_{k,t} + \theta_5\, \Delta Leverage_{k,t} + \theta_6\, \Delta Stressed\_holdings_{k,t} + \lambda\, X_{k,t} + \tau_t + \mu_k + \varepsilon_{k,t} \quad |\ Flow_{k,t} < 0$$

Equation (2) estimates how changes in the holdings-weighted average portfolio bid-ask spread respond to contemporaneous net redemptions as we restrict the sample to negative flows (gross outflows exceed gross inflows). The idea behind this approach is that under a pecking order strategy of security liquidations, redemptions should drive $\Delta BAS_{k,t}^{pf}$ and thus impair the liquidity status of the fund portfolio. Unless there is a full buffering of outflows using cash reserves or borrowing, the manager is assumed to sell assets.[43] For illiquid funds, we expect a pecking order style to be reflected in a significantly negative flow coefficient θ_1. The interaction term $Flow_{k,t} \cdot LIQ_{k,t}$ captures the increment (coefficient θ_2) of the $Flow_{k,t}$ variable attached to liquid funds. To make θ_1 and θ_2 reliable measures, several controls have to be added. First, we capture a possible influence of changes in cash holdings and the fund's borrowing, both expressed in relation to past total net assets. The reason is that discretionary changes in cash balances and leverage positions may require trading in securities.[44] Moreover, we control for changes in market liquidity by introducing the portfolio share held *stressed securities*. We assume a security to be under illiquidity-driven stress when its bid-ask spread is elevated compared to its usual level (exceeding its 75th quantile of its distribution over time). The share of stressed securities is then defined as the ratio of such stressed security holdings in relation to total security holdings of a fund. This control is necessary because our variable of interest (the change in average portfolio liquidity, $\Delta BAS_{k,t}^{pf}$) can be affected by movements in the market liquidity of securities under management. To approximate the latter, we relate the stressed holdings (where $D_{i,t}^{stressed} = 1$ applies) to all security holdings of fund *k*:[45]

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[42] We do so because multiple fund share classes belonging to one fund are often characterized by disparities in the ownership structure (which is our explanatory variable) on the funding side, while their asset side is tied together, implying one portfolio liquidity structure (which is our dependent variable).

[43] While a perfect liquidity *pecking order* would require managers to use available cash first, we find that the vast majority of observed outflows coincide with cash movements that are insufficient to meet redemptions or even go in the wrong direction. Since cash and leverage are only used to a minor extent by German bond funds as a buffer to outflows, we narrow the focus of our analysis down to the question of whether there is a liquidity pecking order within the *securities portfolio* under management.

[44] For example, a build-up of cash reserves may require asset sales and reinforce the liquidity effect when outflows are to be met. Vice versa, increases in leverage or reduced cash holdings may absorb outflows and attenuate the flow effect on portfolio liquidity. See Morris, Shim and Shin (2017) for a schematic description of constellations of flows, changes in cash holdings, and asset transactions.

[45] $P_i^{75\%}(bas_{i,t})$ denotes the 75th percentile of the time series of security i's bid-ask spread, i.e. the monthly average derived from daily Bloomberg bid-ask spreads of this security, $bas_{i,d}^{Bloomberg}$.

$$D_{i,t}^{stressed} = \begin{cases} 0 \ if \ \ bas_{i,t} \leq P_i^{75\%}(bas_{i,t}) \\ 1 \ if \ \ bas_{i,t} > P_i^{75\%}(bas_{i,t}) \end{cases}$$

The portfolio share of stressed security holdings can then be expressed as:[46]

$$Stressed\_holdings_{k,t} = \sum_{i(t)} \frac{q_{k,i,t} \cdot price_{i,t} \cdot D_{i,t}^{stressed}}{\sum_{i(t)} q_{k,i,t} \cdot price_{i,t}}$$

Hence the regressors $\Delta Cash_{k,t}, \Delta Leverage_{k,t}$ and $\Delta Stressed\_holdings_{k,t}$ are introduced to capture changes in portfolio liquidity that are not driven by outflow-induced asset reallocations. The regression results reported in Table 4 show that especially $\Delta Stressed\_holdings_{k,t}$ has explanatory power (in three out of four specifications). A pecking order then requires the $Flow_{k,t}$ variable to affect $\Delta BAS_{k,t}^{pf}$ negatively after these influences have been controlled for. Moreover, we include set of fund-specific control variables X (log age, log fund size, load fee charged by the fund) in equation (2). As before, we include fixed fund effects μ_k and month fixed effects τ_t.

Our regression results are reported in Table 4. As a first result, the average portfolio bid-ask spread of funds with a liquid front-end is not sensitive at all to net outflows, as displayed by the linear combination $\theta_1 + \theta_2$. A second result is that higher withdrawals from institutional-oriented funds with an illiquid front-end go hand in hand with a declining liquidity of the remaining portfolio: the negative flow coefficient θ_1 is highly significant for the entire sample period and weakly significant for tranquil sub-periods as well as in phases of high aggregate uncertainty. This outflow-induced deterioration of portfolio liquidity can be interpreted as a first hint of asset sales in a liquidity pecking order style. Remarkably, the coefficients in columns (4) and (2) suggest that the extent to which portfolio liquidity deteriorates is substantially higher in periods of heightened aggregate uncertainty[47] than in tranquil periods. Thus pecking order sales are relatively accentuated during uncertainty. Based on these estimations, the marginal effect of assumed redemptions at 5% (bottom of Table 4) are predicted to reach ΔBAS^{pf}=1.7 basis points in tranquil periods and 5.4 basis points in times of uncertainty.

By contrast, the coefficient θ_1 is always insignificant for retail-based funds with an illiquid front-end: contemporaneous withdrawals do not entail a change in average portfolio liquidity.

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[46] $price_{i,t}$ and $q_{k,i,t}$ denote the price and quantity of the security *i*. The numerator reflects the holdings of 'stressed securities' of fund *k* at a given point in time, where each security under management is classified as 'stressed' when its bid-ask spread lies in the upper quartile of all observed values (Dummy $D_{i,t} = 1$). The denominator reflects the total securities managed by fund *k*, limited to securities for which bid-ask spread information is available.

[47] High aggregate uncertainty refers to months where the VDAX exceeds its 75th percentile in the period November 2009 to June 2016.

Table 4: Asset liquidation strategies – impact on portfolio liquidity

Net redemptions only		*Dependent variable:* ΔBAS^{pf}					
Observations at the fund-month level (k,t).		Tranquil periods		Phases of high aggregate uncertainty		Entire sample period	
$LIQ_{k,t} = \begin{cases} 1 \ if \ BAS^{top}_{k,t} < median_t(BAS^{top}_{k,t}) \\ 0 \ if \ BAS^{top}_{k,t} \geq median_t(BAS^{top}_{k,t}) \end{cases}$		(1) Retail-based funds	(2) Inst.oriented funds	(3) Retail-based funds	(4) Inst.oriented funds	(5) Retail-based funds	(6) Inst.oriented funds
$Flow_{k,t,}$ | $Flow_{k,t} <0$	θ_1	-0.2942 (0.2674)	-0.1299* (0.0701)	-0.0417 (0.3747)	-0.6438* (0.3819)	-0.4233 (0.2707)	-0.2188*** (0.0789)
$Flow_{k,t} \cdot LIQ_{k,t}$	θ_2	0.1712 (0.3126)	0.1639* (0.0875)	0.0283 (0.4403)	0.7785 (0.5364)	0.4227 (0.3013)	0.2812*** (0.0962)
	$\theta_1 + \theta_2$	-0.123 (0.1214)	0.034 (0.0839)	-0.0133 (0.3089)	0.1348 (0.3742)	-0.0006 (0.1473)	0.0525 (0.0686)
$\Delta Cash_{k,t}$		-0.0918 (0.1447)	0.1769* (0.1007)	-0.583 (0.3957)	0.2072 (0.2765)	-0.3032 (0.26)	0.2198 (0.1389)
$\Delta Leverage_{k,t}$		-5.4689 (4.3479)	0.2571 (0.9897)	-6.7886 (4.5268)	3.3264 (5.4563)	0.19 (8.6971)	0.1735 (0.9026)
$\Delta Stressed\_holdings_{k,t}$		0.3025*** (0.0666)	0.1925*** (0.0626)	0.5016** (0.219)	0.3413 (0.2453)	0.3313*** (0.1009)	0.2689*** (0.0929)
Monthly observations		395	589	175	224	570	813
Fund share classes (clusters)		39	47	30	43	39	50
R^2 (within)		0.4320	0.2745	0.5920	0.4749	0.4327	0.3504
Marginal effects at $\boldsymbol{Flow = -0.05}$ ***of*** $\boldsymbol{TNA_{t-1}}$***:***							
Predicted change in BAS^{pf} *at LIQ* = 0:		+0.0242** (0.0116)	+0.0172*** (0.0057)	+0.0202 (0.0156)	+0.0536*** (0.0151)		
Predicted change in BAS^{pf} *at LIQ* = 1:		-0.0010 (0.0072)	-0.0060 (0.0053)	+0.0019 (0.0136)	-0.0095 (0.0186)		

Notes: The dependent variable is the change in the holdings-weighted portfolio bid-ask spread of a fund. Sample period: November 2009 to June 2016. The sample is restricted to single funds (excluding multiple share classes belonging to one fund) where net outflows are observed. The variables *Flow*, $\Delta Cash$ and $\Delta Leverage$ are expressed as a percentage of lagged total net assets. Funds are classified in liquidity segments $LIQ_{k,t} \in [0,1]$, where $LIQ_{k,t}$ takes the value of one if it is below the cross-section median of the holdings-weighted bid-ask spread of the top liquid decile of the fund portfolio in month *t*, and zero otherwise. Further fund-specific controls (not reported) are the log fund age, log total net assets, and the load fee. Funds are classified as institutional-oriented if institutional investors hold more than 50% of fund shares. The variable Δ*Stressed holdings* denotes the change in the share of securities where the bid-ask spread at time *t* exceeds the 75th percentile of all bid-ask spreads observed for that security over time. Month fixed effects and fixed funds effects are included. We cluster standard errors by fund to account for serial correlation of residuals at the fund level. Robust standard errors are reported in parentheses. Regressions reported in columns (3) and (4) refer to phases of high aggregate volatility, defined by a monthly VDAX exceeding 24.157 (equal to the 75th percentile referring to the period from Nov.2009 to June 2016). Col. (1) and (2) refer to VDAX levels below 24.157.

Whereas the associated marginal effect of a 5% outflow indicates a pecking order-style liquidation in tranquil times (ΔBAS^{pf}=2.4), there is no such effect in phases of uncertainty. Consistent with asset sales on a pro-rata basis, retail-based funds seem to avoid a worsening portfolio liquidity in these phases. Given the vulnerability of this group of funds according to Hypothesis 1, this form of liquidity management can be regarded as an attempt to reduce the incentives for an illiquidity-induced run on their fund. Given the trade-off between preserving short-term performance and preserving liquidity, their managers choose the latter, while managers of institutional-oriented funds choose the former, as bad liquidity is not harmful to them. Since institutional-oriented funds are not vulnerable to illiquidity-induced outflows, a meltdown of the liquid part of their portfolio is not harmful to them.

4.2.2 *Drivers of sale probabilities*

To examine whether ownership-related differences in liquidation strategies are special in times of elevated aggregate uncertainty, we carry out an in-depth analysis of Hypothesis 2 in a second approach. To this end, we abandon the liquidity classification at the fund level and look deeper into the liquidity structure of bond portfolios. Since we are interested in the portfolio adjustment in the presence of net redemptions, we exclude observations where outflows are offset by inflows. Then our database comprises 124,536 holdings positions at the fund-security-month level managed by single corporate bond funds.[48] We take into account bid-ask spreads and return series for 7,398 debt securities, of which 5,232 are corporate debt securities.[49] With a breakdown by tranquil times and phases of high aggregate uncertainty, we apply a logistic model of the fund's propensity to sell a bond. Here, we combine the state-contingent approach of Jiang et al. (2017)[50] with a breakdown along the lines of ownership structures. To our knowledge, the role of ownership as a determinant of sale strategies in a liquidity pecking order mode is novel to the mutual fund literature. To test this, we investigate whether the sale probability is a function of its liquidity[51], the outflow variable and the interaction between the two. We estimate the following relationship for retail-based funds and institutional-oriented funds in separate regressions:

$$(3)\quad Logit(Sold_{k,i,t}) = \gamma_1\, Flow_{k,t} + \gamma_2\, bas_{i,t} + \gamma_3\, Flow_{k,t}\cdot bas_{i,t} + \xi\,\Delta Cash_{k,t} + \omega Y_{i,t} + \lambda X_{k,t} + \varepsilon_{k,i,t} \qquad |\; Flow_{k,t} < 0$$

[48] That is, we exclude multiple fund share classes belonging to one fund. See footnote 41.

[49] The remaining debt securities refer to bank issuers (1,420 securities), governments (552 securities), and other issuers.

[50] In their analysis for US funds, Jiang et al. (2017) find a *pro-rata* sale strategy in periods of high aggregate uncertainty, while in tranquil phases, managers are found to rely on cash and government bonds to meet redemptions. Moreover, these authors find that corporate bonds are sold in a liquidity pecking order mode.

[51] As described in Section 3, $bas_{i,t}$ is the monthly average bid-ask spread of a security i derived from daily price bid-ask spreads $bas_{i,d}$.

The sale indicator $Sold_{k,i,t}$ is the dependent binary variable, which takes the value of one if fund *k* reduces its nominal holdings of bond *i* between month *t-1* and month *t*, and zero otherwise:

$$Sold_{k,i,t} = \begin{cases} 1 & if\ Holdings^{nominal}_{k,i,t} < Holdings^{nominal}_{k,i,t-1} \\ 0 & otherwise \end{cases}.$$

Table 5: Asset liquidation strategies, by shareholder majority

Net redemptions only	*Dependent variable: Sale of a bond [0,1]*			
Observations at the fund-security-month level (k,i,t)	Tranquil periods		Phases of high aggregate uncertainty	
Logit regressions (Logistic model)	Retail-based funds	Inst.-oriented funds	Retail-based funds	Inst.-oriented funds
$Flow_{k,t}$ $\mid Flow_{k,t} < 0$ γ_1	-11.2817**	-12.0274**	-13.8189	-21.4639***
	(4.4302)	(4.7007)	(14.2856)	(5.0794)
Bond bid-ask spread$_{i,t}$ γ_2	8.2341	6.3149	-2.2921	13.3632
	(14.3714)	(19.5994)	(10.758)	(10.871)
$Flow_{k,t}$ · *Bond bid-ask spread*$_{i,t}$ γ_3	1021.684**	-113.784	-283.368	506.635***
	(504.5228)	(218.22)	(309.135)	(175.002)
Bond return$_{i,t}$	6.1385	-4.084**	2.4019	1.1464
	(3.796)	(1.5854)	(1.6465)	(1.6163)
Bond residual maturity$_{i,t}$	0.0046**	0.0066	-0.0025*	-0.0028
	(0.0021)	(0.0045)	(0.0015)	(0.0045)
Bond amount outstanding$_{i,t}$	-0.0922	0.0443***	-0.0909	0.0526***
	(0.0733)	(0.0138)	(0.0732)	(0.0079)
Bond coupon rate$_{i,t}$	0.1319	-0.0314	0.1176	0.0356
	(0.1054)	(0.0467)	(0.0823)	(0.0347)
$Log(Age_{k,t-1})$	-0.1844	0.6321	5.2494***	1.5421**
	(0.7299)	(1.4307)	(1.0331)	(0.6073)
$Log(TNA_{k,t-1})$	-1.6296***	2.682	-0.8296	0.3611
	(0.2156)	(1.768)	(2.0248)	(0.3848)
Load fee$_{k,t-1}$	23.0575	16.1576	199.0972***	-49.4429
	(98.4189)	(66.7223)	(47.8517)	(38.6672)
$\Delta Cash_{k,t}$	2.4651	14.0983**	-4.103	14.0499*
	(5.6869)	(5.516)	(7.0183)	(8.1885)
Fund return$_{k,t-1}$	-9.384	1.7005	13.0068**	2.4853
	(11.9848)	(14.3373)	(6.1661)	(11.693)
Constant	22.9835***	-58.0856	0.0348	-14.2151*
	(4.3838)	(37.4647)	(33.7862)	(7.9624)
Number of fund-month-security obs.	27,007	65,277	10,647	24,753
Pseudo R^2	0.4527	0.3627	0.4454	0.2460
Marginal effects at $Flow = -0.05$ ***of*** TNA_{t-1}***:***				
Sale probability at bond bid-ask spread = 10 BP	0.2979***	0.1210***	0.3289***	0.1114***
	(0.0147)	(0.0062)	(0.0459)	(0.0086)
Sale probability at bond bid-ask spread = 100 BP	0.2586***	0.1708*	0.3408***	0.0159
	(0.0151)	(0.0883)	(0.0476)	(0.0115)

Notes: The binary dependent variable takes the value of one if fund *k*'s nominal holdings of security *i* decrease over month *t*, and zero otherwise. Sample is restricted to observations of net outflows of single funds (excluding multiple fund share classes belonging to one fund). It comprises 130,185 observed security positions coinciding with outflow events. Sample period: November 2009 to June 2016. The variables $Flow_{k,t}$ and $\Delta Cash_{k,t}$ are expressed as a percentage of lagged total net assets. Regressions reported in columns (3) and (4) refer to phases of high aggregate volatility, defined by a monthly VDAX exceeding 24.157 (equal to the 75th percentile referring to the period from Nov.2009 to June 2016). Columns (1) and (2) refer to tranquil periods (VDAX < 24.157). Fixed fund effects are included. To account for serial correlation of residuals, we cluster standard errors at the fund level. Robust standard errors are reported in parentheses.

In this approach, each bond position is treated equally irrespective of its weight in the fund portfolio. A negative flow coefficient γ_1 indicates that the propensity to sell a bond is increasing in net redemptions of the fund (as flows become more negative). Ceteris paribus, the larger the size of redemptions, the more likely is a sale. A positive coefficient γ_3 of the interaction term *Flow · bond bid-ask spread* suggests that the relationship captured by the flow coefficient is less intense for less liquid bonds, i.e. redemptions are met by adjusting the portfolio in a liquidity pecking order. If instead, γ_3 is insignificant, a pecking order would not be detected, i.e. sale probabilities do not differ across levels of bond liquidity. As the decision to sell may depend on bond characteristics too, we control for a set of its specific attributes: the vector Y captures the bond's residual time to maturity, its coupon, the amount outstanding, and its return. Additionally, we include fund-level controls in vector X (log age, log fund size, load fee).[52] Finally, we control for changes in cash holdings, $\Delta Cash_{k,t}$, simply because the use of cash is the most frequently used way to meet redemptions at least in part. Indeed, part of our regressions show that the probability of selling a bond tends to increase in cash holdings, which confirms a substitutional relation between cash and bond sales.[53]

Table 5 reports the results of logit regressions for retail-based funds and institutional-oriented funds. For each group of funds, estimations are carried out a) for tranquil periods and b) for periods of high macroeconomic uncertainty. In three out of four specifications, the flow coefficient γ_1 turns out to be negative and statistically significant: with the exception of retail-based funds during uncertainty, the sale probability of a bond increases in redemptions. As mentioned beforehand, the coefficient γ_3 provides information about the presence of pecking order sales: in phases of high aggregate uncertainty, we find that γ_3 is positive and significant for institutional-oriented funds (column 4), but insignificant for retail-based funds (column 3).
This uneven portfolio adjustment to meet redemptions corroborates the dependence on ownership highlighted in Hypothesis 2. In times of stress, institutional-oriented funds sell their bonds in a pecking order mode, while retail-based funds preserve their liquidity status.
The opposite pattern is found in tranquil periods (columns 1 and 2), where the signs and significance of γ_3 reverse between retail-based and institutional-oriented funds. We interpret this as a hint that in these times retail-based funds are less concerned about losing their liquidity status, and their managers rather prefer low transaction costs when redemptions have to be met. This picture leads us to argue that phases of low uncertainty make them perceive a reduced risk of illiquidity-driven outflows.

Based on the estimated coefficients, we calculate the marginal effects of an assumed 5 per cent redemption (bottom of Table 5). In phases of high uncertainty, the sale probability of a liquid bond ($bas_{i,t} = 10\ BP$) is predicted to reach 33% for retail-based funds and 11% for institutional

[52] The size of the fund family (approximated by the number of funds within one investment company) is omitted as a control variable, because its effects turn out to be insignificant.
[53] Other things being equal, stepping up cash buffers requires bond sales, and reducing cash buffers to meet redemptions implies less bond sales.

funds, and the sale probability of an illiquid bond ($bas_{i,t} = 100\,BP$) is unchanged at 34% for retail-based funds, but insignificant for institutionally controlled funds. This numerical example corroborates the presence of a pecking order style in institutional-oriented funds. Things are different in tranquil times: here, retail-based funds show signs of a pecking order, with a 30% sale probability of a liquid bond and a 26% sale probability of an illiquid bond. By contrast, these times point to sale strategies of institutional-oriented funds in a pro-rata style.
Finally, to check the robustness of our ownership-related findings, we introduce the institutional share ($Inst_{k,t}$) as a continuous variable and modify equation (3) as follows:

$$(4)\ Logit(Sold_{k,i,t}) = \gamma_1\, Flow_{k,t} + \gamma_2\, bas_{i,t} + \gamma_3\, Flow_{k,t} \cdot bas_{i,t} + \gamma_4\, Inst_{k,t} + \gamma_5\, Flow_{k,t} \cdot Inst_{k,t} + \gamma_6\, bas_{i,t} \cdot Inst_{k,t} + \gamma_7\, Flow_{k,t} \cdot bas_{i,t} \cdot Inst_{k,t} + \xi\, \Delta Cash_{k,t} + \omega Y_{i,t} + \lambda X_{k,t} + \varepsilon_{k,i,t} \quad |\ Flow_{k,t} < 0$$

Here, we have added three interaction terms: first, an interaction term between flows and the share of fund assets held by institutional investors (coefficient γ_5), second, the interaction between the institutional share and the security bid-ask spread (γ_6), and third, a three-way interaction between outflows, the institutional share and the bond bid-ask spread (γ_7). These amendments are informative about the role of ownership with respect to the presence of sales in a pecking order style. Controlling for changes in cash holdings and other fund- and bond-specific characteristics, the institutional share and macroeconomic uncertainty are found to govern the impact of outflows on the liquidity management of funds (Table 6): the coefficient γ_7 displays the manager's strategy. Based on robust standard errors, it is significantly positive at high VDAX levels.[54] This suggests that to meet redemptions, bonds are increasingly sold in a pecking order style as the institutional share goes up. In turn, this implies that managers of retail-based refrain from carrying out pecking order sales and rather prefer to preserve the liquidity of their portfolio, which is consistent with our previous findings. Pro-rata sales appear to be their way to sell bonds during macroeconomic uncertainty. In these times, a presumed outflow shock of 5% entails almost equal sale probabilities for liquid and illiquid bonds in the hands of retail-based funds, while managers of institutional-oriented funds have a clear preference to sell liquid bonds (see bottom of Table 6). Interestingly, when the latter exhibit an illiquid front-end (column 4), the pecking order appears to be particularly accentuated. This fits to our flow-performance estimations for illiquid funds.

As expected, the significance of γ_7 gets lost in tranquil times (columns 1 and 2): We infer that a larger institutional shareholdings is not associated with a more intense pecking order strategy in these periods. Hence the introduction of the institutional share as a continuous variable that interacts with fund outflows and bond liquidity (equation 4) leads us to infer that phases of low uncertainty do not reveal asset liquidations that differ between institutional-oriented funds and retail-based funds.

[54] See column 3 for all funds and column 4 for funds with an illiquid portfolio front-end.

Table 6: Asset liquidation strategies with ownership interaction

Net redemptions only		*Dependent variable: Sale of a bond [0,1]*			
		Tranquil periods		Phases of high aggregate uncertainty	
Observations at the fund-security-month level (k,i,t) *Logit regressions (Logistic model)*		All funds	Funds with an illiquid front-end	All funds	Funds with an illiquid front-end
$Flow_{k,t,}$ | $Flow_{k,t} < 0$	γ_1	-12.6827* (7.3904)	-5.3713 (10.0486)	-8.7875 (11.5477)	-16.0288 (20.9975)
Bond bid-ask spread$_{i,t}$	γ_2	21.627 (25.598)	-17.5871 (17.610)	-0.1639 (18.018)	-21.2236 (16.843)
$Flow_{k,t}$ · *Bond bid-ask spread*$_{i,t}$	γ_3	906.52 (564.528)	597.64 (484.652)	-427.43 (343.157)	-636.03 (479.770)
$Inst_{k,t}$	γ_4	-2.3692 (3.5364)	3.5377 (3.3503)	-2.7736 (1.8028)	3.6501 (3.3176)
$Flow_{k,t,}$ · $Inst_{k,t}$	γ_5	4.02 (9.7378)	0.85 (18.3501)	-15.60 (15.0872)	-9.29 (23.2199)
Bond bid-ask spread$_{i,t,}$ · $Inst_{k,t}$	γ_6	-20.38 (45.4003)	37.61 (30.6012)	5.15 (33.5638)	66.56* (35.284)
$Flow_{k,t}$ · *Bond bid-ask spread*$_{i,t}$ · $Inst_{k,t}$	γ_7	-1070.51 (655.01)	-1161.71 (952.21)	924.1** (449.36)	1412.44** (607.66)
Log(Age$_{k,t-1}$*)*		0.0173 (1.1027)	-0.5959 (0.7338)	2.0147*** (0.7116)	5.9976*** (1.7382)
Log(TNA$_{k,t-1}$*)*		0.866 (1.1636)	-0.3339 (0.4612)	0.5578 (0.3996)	-0.036 (0.7667)
Load fee$_{k,t-1}$		17.612 (25.494)	-22.689 (74.480)	36.709 (30.906)	-692.449 (881.508)
$\Delta Cash_{k,t}$		9.3605** (4.1249)	3.3069 (4.0532)	9.1772* (4.8311)	5.9555 (5.2722)
Constant		-19.3199 (23.5224)	-0.2589 (9.4025)	-18.3513** (7.9824)	-8.7223 (30.8241)
Number of fund-month-security obs.		94,290	30,246	37,035	13,145
Pseudo R^2		0.3949	0.3782	0.3757	0.4125
Marginal effects at $Flow = -0.05,\ Inst = 1$:					
Sale probability at bond bid-ask spread = 10 BP		0.1083* (0.0617)	0.3947*** (0.1516)	0.1190*** (0.0391)	0.4474*** (0.1272)
Sale probability at bond bid-ask spread = 100 BP		0.1729 (0.1450)	0.7795** (0.3213)	0.0221 (0.0158)	0.1567 (0.1475)
Marginal effects at $Flow = -0.05,\ Inst = 0$:					
Sale probability at bond bid-ask spread = 10 BP		0.3974 (0.4747)	0.1154* (0.0624)	0.3665 (0.2386)	0.1173** (0.0472)
Sale probability at bond bid-ask spread = 100 BP		0.3635 (0.4433)	0.0927* (0.0515)	0.3980 (0.2465)	0.1225*** (0.0441)

Notes: The dependent variable takes the value of one if fund *k*'s nominal holdings of security *i* decrease in month *t*, and zero otherwise. Sample is restricted to observations of net outflows of single funds (excluding multiple fund share classes belonging to one fund). It comprises 124,536 observed debt security positions coinciding with outflow events. Sample period: November 2009 to June 2016. $Inst_{k,t}$ denotes the share of institutional owners in the shareholder base of a fund. The variables *Flow* and $\Delta Cash$ are expressed as a percentage of lagged total net assets. Bond-specific controls (not reported) are the bond's residual time to maturity, its coupon, and its return. Regressions reported in columns (3) and (4) refer to phases of high aggregate volatility, defined by a monthly VDAX exceeding 24.157 (equal to the 75th percentile referring to the period from November 2009 to June 2016). Fixed fund effects are included. To account for serial correlation of residuals, we cluster standard errors at the fund level. Robust standard errors in parentheses.

To sum up, our in-depth analysis of the funds' liquidity structure corroborates the role of the shareholder base as an explanatory factor for liquidation strategies in times of uncertainty, as stated in Hypothesis 2. While evidence of ownership-related differences is mixed in tranquil times, periods of high macroeconomic uncertainty point to robust differences across estimation approaches. As regards funds under institutional control, managers tend to preserve portfolio liquidity when the cost of selling illiquid assets is not too high. As the sale of illiquid assets is getting more costly during elevated uncertainty, they switch their strategy towards liquidations in a pecking order style. In this regard, our results for institutional-oriented funds deviate from the state-contingent pattern found for US corporate bond funds by Jiang et al. (2017). Instead, their evidence on asset sales carried out more on a pro-rata basis in times of high macroeconomic uncertainty is in line with our results for retail-based funds.[55]

5 Conclusion

Despite the virtues of liquid positions in periods of stress, bond funds have increasingly invested in illiquid corporate debt securities over the past years. To explore the flow-performance relationship of investors and the liquidity management of funds as a function of portfolio liquidity and fund ownership, the present study uses a unique panel of German corporate bond funds. To meet net redemptions, the manager can basically borrow, reduce cash reserves, or liquidate assets under management. Controlling for the first two options, we focus on strategies to liquidate securities. Our motivation to do so is the ownership-related disparity found in the flow-performance relationship: Hypothesis 1 states that underperforming funds with an illiquid front-end are highly vulnerable to outflows if retail-based, whereas illiquid funds under institutional control remain unaffected. In line with Goldstein et al. (2017), we interpret the exposure of the former as a reflection of strategic complementarities, while institutional investors appear to internalise the damage their withdrawal would otherwise inflict on the fund. This behaviour mirrors their ability to mitigate illiquidity-induced panics.

Turning to the impact of net redemptions on the liquidity structure of bond portfolios, we argue that the composition of the shareholder base should be taken into account to understand observed sale strategies. Given the trade-off between preserving short-term performance on the one side and preserving liquidity and longer-term viability on the other, we find that managers of institutional-oriented funds and managers of retail-based funds make contrarian choices amid elevated macroeconomic uncertainty (Hypothesis 2): A liquidity pecking order is the preferred option for funds under institutional control, which we trace back to the absence of an exposure to an illiquidity-induced run. Within funds with an illiquid portfolio front-end, ownership-related disparities turn out to be most pronounced. Retail-based funds are found to be vulnerable to illiquidity-induced outflows, which creates an incentive to preserve their liquidity status. That

[55] In their analysis for US funds, Jiang et al. (2017) find that in high VIX periods, the shrinking of asset holdings is more on a pro-rata basis, though at the expense of higher transaction costs.

is, preserving short-term performance and minimising transaction costs tend to be subordinate to retail-based funds.

The two different forms of liquidity management we detect in phases of high aggregate uncertainty clearly reflect the different vulnerabilities of funds arising from strategic complementarities: the high (low) exposure of retail-based (institutional-oriented) funds to outflows that might result from extensive illiquid asset holdings can explain their attempt to (reluctance to) reduce run incentives.

As regards the liquidity management of institutional-oriented funds, the level of macroeconomic uncertainty is key: as long as the cost of selling illiquid assets is not too high, which is likely to be the case in tranquil periods, their managers preserve portfolio liquidity consistent with a pro-rata style of asset liquidations and not different from retail-based funds. Conversely, as the sale of illiquid assets is getting more costly at high VDAX levels, they switch to a cost-saving strategy by selling bonds in a pecking order mode. As a result, ownership-related differences turn out to be robust in times of aggregate uncertainty, but no such differences are revealed in tranquil times. State-dependent transaction costs can explain these varying accentuations in asset allocations of institutional-oriented funds, as illiquidity does not matter to them according to our evidence. On the contrary, a heightened exposure to illiquidity-driven outflows arising from strategic complementarities is likely to be a driving factor in the liquidity-preserving strategy pursued by retail-based funds.

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Annex A

Measuring fund performance - Derivation of a market-adjusted fund return

A simple measure of fund performance is the *market-adjusted return*.[56] It is defined as the fund return minus a benchmark return. Hence this measure requires the availability of benchmark return data for each fund at each point in time. Since the benchmark is usually linked to the fund's investment style, we construct an indicator which approximates the investment style of a bond fund because data on fund-specific benchmark indices are not available in our study. In line with the ESA-2010 classification, we define the following asset classes and calculate a market return for each asset class held by a fund:

Table A1: Asset classes held by bond funds

		Country of issuer (ESA-2010)		
Asset type	Issuer sector (ESA-2010)	EMU	non EMU (ex EME)	Emerging markets (EME)
Debt securities*	Government debt securities	Class 1	Class 2	Class 7
	Non-financial corporate debt	Class 3	Class 4	
	MFIs and financial corporate issuers	Class 5	Class 6	
Equity		Class 8	Class 9	
Other assets**		Class 10		

*) Bonds, notes, and short term debt instruments, **) Futures, Options, Rights, etc.

For each asset class s[1,…,10], we define $R_{s,t}$ as the class-specific market return. It is calculated as the sum of the monthly total return of each asset i in class s weighted with its amount outstanding. We assume a class-specific market portfolio and a class specific return on that portfolio. We calculate a class-specific market return for each class s and each point in time t. Next, we calculate the portfolio weight $w_{k,s,t}$ attributed to class s by fund manager k at time t. This weight should approximate the fund's investment style and is allowed to vary over time. To derive an indicator for the market return that is relevant to a fund given its investment style, we combine the asset class-specific market return $R_{s,t}$ with the corresponding portfolio weight $w_{k,s,t}$ and sum the product $R_{s,t} \cdot w_{k,s,t}$ up over all asset classes s held by fund k:

$$R_{m,t}(k) = \sum_{s=1}^{10} w_{k,s,t} \cdot R_{s,t}$$

We use $R_{m,t}(k)$ as a proxy of the market 'benchmark' return $R_{m,t}$ which is relevant to the decision of investors. According to our definition, it is a) dependent on the investment style of fund k and b) is adjusted when the style varies over time. We therefore do not claim to reflect

[56] See Barber, Huang and Odean (2016), for example.

the 'true' style of a fund, but an approximation to it. In the paper we show that using the market-adjusted return based on this indicator – namely the difference between the fund return $R_{k,t}$ and the market return $R_{m,t}(k)$ – is successful in detecting strategic complementarities.

Figure A1: Flow distribution in corporate bond funds

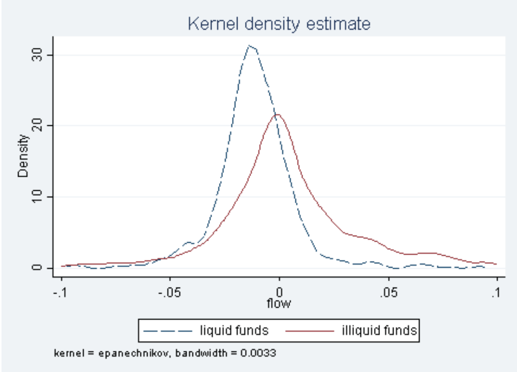
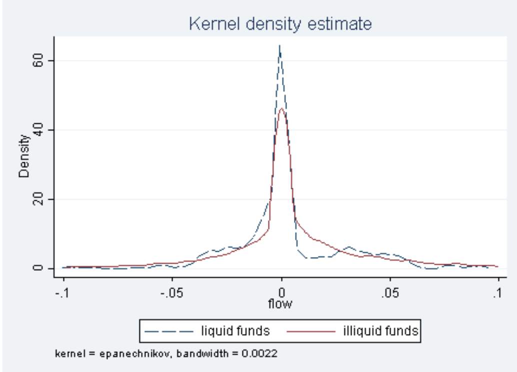
Net inflow into retail-based funds	Net inflow into institutional-oriented funds
	

Table A2: Raw fund returns and fund flows by liquidity and shareholder majority

Fund return, p.m.			
Retail-based funds		*Institutional-oriented funds*	
Liquid funds	*Illiquid funds*	*Liquid funds*	*Illiquid funds*
+0.2%	+0.3%	+0.2%	+0.4%
1,226 *obs*	1,327 *obs*	1,963 *obs*	1,807 *obs*
Testing for the equality of mean fund returns across fund types (t-test): $H_0\colon \mu(R_{liq}) - \mu(R_{illiq}) = 0$ $H_a\colon \mu(R_{liq}) - \mu(R_{illiq}) < 0$			
$\Pr(T < -2.01) = 0.02$ ⇨ H_0 *is rejected*		$\Pr(T < -2.06) = 0.02$ ⇨ H_0 *is rejected*	
Net flow, p.m.			
Retail-based funds		*Institutional-oriented funds*	
Liquid funds	*Illiquid funds*	*Liquid funds*	*Illiquid funds*
−0.1%	+1.4%	+0.9%	+0.8%
1,229 *obs*	1,326 *obs*	1,971 *obs*	1,810 *obs*
Testing for the equality of mean fund flows across fund types (t-test): $H_0\colon \mu(Flow_{liq}) - \mu(Flow_{illiq}) = 0$ $H_a\colon \mu(Flow_{liq}) - \mu(Flow_{illiq}) < 0$			
$\Pr(T < -5.95) = 0.00$ ⇨ H_0 *is rejected*		Pr(F < 0.08) = 0.53 ⇨ H_0 *is not rejected*	

Notes: Sample comprises inflows and outflows for funds where more than 50% of securities under management is held in corporate debt. It extends from November 2009 to June 2016. A fund is dubbed as *retail-based* (*institutional-oriented*) if its institutional share is below (above) 50% of total shareholdings. The *Flow* variable is expressed as a percentage of the fund's lagged total net assets. Funds are dubbed as *illiquid* if the holdings-weighted top decile bid-ask spread exceeds its cross-section median in month *t*, and dubbed as *liquid* otherwise.

Annex B

Impact of redemptions on fund performance

In Table B1, dummies for outflows and fund liquidity classes are regressed on performance measures of corporate bond funds according to the following equation, where $\mathrm{R}_{\mathrm{k,q}}$ denotes the performance measure, and $\mathrm{X}_{\mathrm{k,q}}$ represents a vector of fund-specific control variables:

(B1) $$R_{k,q} = \beta_1 R_{k,q} + \beta_2 R_{k,q-1} \cdot LIQ_{k,q-1} + \theta_1 OUT_{k,q} + \theta_2 OUT_{k,q} \cdot LIQ_{k,q-1} + \lambda X_{k,q} + \mu_k + \varepsilon_{k,q}$$

Irrespective of the performance measure used, redemptions are found to have an incremental negative impact in case of illiquid funds. Conditional on net redemptions, the illiquidity-induced external cost is quantified as follows: the raw fund return of liquid funds exceeds that of illiquid funds by 33 basis points. The differential of the market-adjusted return amounts to 22 basis points. This confirms that withdrawals from illiquid funds are more costly than withdrawals from liquid funds. Since the probability of a delayed sale is higher in illiquid funds, a first-mover advantage is larger in these funds, too.

Table B1: Response of fund performance to contemporaneous flows

GLS regression, quarterly data			
Dependent:		$\mathrm{R}_{\mathrm{k,q}}$= *Raw fund return*	$\mathrm{R}_{\mathrm{k,q}}$ = *Market-adj.return*
$\mathrm{R}_{\mathrm{k,q-1}}$		-0.0040 (0.0322)	-0.1047*** (0.0274)
$\mathrm{R}_{\mathrm{k,q-1}} \cdot \mathrm{LIQ}_{\mathrm{k,q-1}}$		0.0017 (0.0472)	0.1221 (0.0016)
$\mathrm{OUT}_{\mathrm{k,q}}$	θ_1	-0.0159*** (0.0019)	-0.0090*** (0.0016)
$\mathrm{OUT}_{\mathrm{k,q}} \cdot \mathrm{LIQ}_{\mathrm{k,q-1}}$	θ_2	0.0021 (0.0022)	0.0033* (0.0018)
	$\theta_1 + \theta_2$	-0.0138*** (0.0014)	-0.0057*** (0.0012)
Quarterly observations		1562	1571
Fund share classes (clusters)		130	129
R^2 (within)		0.1232	0.0715
Marginal effects: Predicted response of returns of funds subject to outflows			
0.0001 = 1 basis point			
$R_{illiquid}$ ($LIQ_{k,q}$=0, $OUT_{k,q}$=1)		+0.0002 (0.0015)	-0.0066*** (0.0012)
R_{liquid} ($LIQ_{k,q}$=1, $OUT_{k,q}$=1)		+0.0023** (0.0010)	-0.0033** (0.0009)
Implied loss due to redemptions:			
$\Delta = R_{illiquid} - R_{liquid}$		**-22 basis pts.**	**-33 basis pts.**

Notes: Panel regression at a quarterly frequency. Besides an intercept, fund-specific controls *Log(Age)*, *Log(TNA)* and *Load fee* are included. Regressions include fixed effects at the fund share class level. The indicator variable $OUT_{k,q}$ is equal to one in case of outflows, and assumes the value of zero otherwise. The indicator variable $LIQ_{q,t}$ is equal to one if the bid-ask spread of the top liquid portfolio decile is below its cross-section median in quarter q, and zero otherwise. To account for serial correlation of residuals at the fund share class level, we cluster standard errors by fund share class. Robust standard errors are reported in parentheses.