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Financial fragility in open-ended mutual funds: the role of liquidity management tools

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Non-technical summary

Research Question

Open-ended investment funds frequently suffer liquidity crises. The open-ended structure implies that investors can always ask the asset manager for the redemption of their fund shares at the net value of the assets held by the fund. The trading costs that the fund incurs to rebalance the portfolio or to obtain liquidity in fire sales to meet redemptions can be large, especially if the securities held by the fund are illiquid. Moreover, these costs are borne by investors remaining in the fund. Thus investors that expect many others to withdraw, have an incentive to withdraw as well. Price-based liquidity management tools, such as redemption fees and anti-dilution levies, as well as quantity-based liquidity management tools, such as redemption gates and suspension of conversion, are considered measures to mitigate this panic-induced fragility of open-ended investment funds.

Contribution

While there is a lively policy debate on whether funds should be obliged to introduce price-based liquidity management tools, evidence of the benefits of these tools is scarce. This paper uses unique data collected by the Central Bank of Ireland that reports for each investment fund domiciled in Ireland which liquidity management tool the fund manager has available. This allows us to study whether the availability of price-based tools on top of quantity-based tools made funds more resilient during the COVID-19 crisis.

Results

Our results show that funds with more sensitive flows to past returns experienced lower net outflows and higher returns in March 2020 if they also had price-based liquidity management tools available. These funds engaged in less portfolio rebalancing and sold off fewer illiquid bonds during the crisis. As a consequence we find that bonds held relatively more by Irish-domiciled funds with price-based (as opposed to Irish funds with only quantity-based) liquidity management tools experienced a lower price drop during the crisis.

Nichttechnische Zusammenfassung

Fragestellung

Offene Investmentfonds sind häufig von Liquiditätskrisen betroffen. Die offene Struktur impliziert, dass Anleger jederzeit vom Emittenten eine Rücknahme ihrer Fondsanteile zum Nettoinventarwert der vom Fonds gehaltenen Vermögenswerte verlangen können. Die Handelskosten, die dem Fonds durch die Portfolioreadjustierung nach Rücknahmen oder durch Notverkäufe zur Erlangung von Liquidität für die Rücknahme entstehen, können erheblich sein, insbesondere wenn die vom Fonds gehaltenen Wertpapiere illiquide sind. Diese Kosten tragen jedoch die verbleibenden Anleger. Daher haben Anleger, die erwarten, dass viele andere Investoren ihre Anteile zurückgeben, einen Anreiz, dies ebenfalls zu tun. Preisbasierte Liquiditätsmanagement-Tools, wie Rücknahmegebühren und Anti-Dilution-Abgaben, sowie mengenbasierte Liquiditätsmanagement-Tools, wie Rücknahmebeschränkungen und Aussetzung der Konvertierung, werden als geeignete Maßnahmen angesehen, um diese durch Panik ausgelöste Fragilität offener Investmentfonds zu mindern.

Beitrag

Obgleich eine intensive politische Debatte darüber besteht, ob Fonds auch verpflichtet werden sollten, preisbasierte Liquiditätsmanagement-Tools einzuführen, gibt es nur wenig belastbare Untersuchungen der Vor- und Nachteile dieser Instrumente. Dieses Papier verwendet einzigartige Daten der Irischen Zentralbank, die für jeden in Irland ansässigen Investmentfonds berichten, welches Liquiditätsmanagement-Tool dem Fondsmanager zur Verfügung steht. Dies ermöglicht es uns, zu untersuchen, ob die Verfügbarkeit von preisbasierten Tools zusätzlich zu mengenbasierten Tools die Fonds während der COVID-19-Krise widerstandsfähiger gemacht hat.

Ergebnisse

Unsere Ergebnisse zeigen, dass insbesondere Fonds, deren Nettozuflüsse empfindlicher auf die vergangenen Erträge des Fonds reagierten, im März 2020 geringere Nettoabflüsse und eine höhere Rendite verzeichneten, wenn sie auch preisbasierte Liquiditätsmanagement-Tools zur Verfügung hatten. Diese Fonds führten weniger Portfolio-Umschichtungen durch und verkauften während der Krise weniger illiquide Anleihen. Folglich finden wir zudem, dass Anleihen, die relativ stärker von in Irland ansässigen Fonds mit preisbasierten (im Gegensatz zu irischen Fonds mit nur mengenbasierten) Liquiditätsmanagement-Tools gehalten wurden, während der Krise einen geringeren Kursrückgang erlitten.

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Abstract

We study the role of liquidity management tools (LMTs) in mitigating financial fragility in investment funds during the COVID-19 market distress. We employ a unique dataset that reports the availability of different types of LMTs in a sample of Irish-domiciled corporate bond funds. We find that funds with access to price-based tools such as redemption fees or anti-dilution levies experienced lower net outflows in March 2020, as compared to funds with only quantity-based tools such as redemption gates, temporary suspensions, or redemptions in kind. This difference is stronger among funds with a high sensitivity of flows to past performance and reflects both higher gross inflows and lower gross outflows during this episode. Funds with price-based LMTs also rebalance their portfolios towards less liquid bonds. This portfolio rebalancing results in a lower price decline of bonds held disproportionally more by funds with price-based LMTs in our sample of Irish-domiciled funds.

Keywords: liquidity management tools, investment funds, COVID-19, financial fragility.

JEL classification: G2, G23.

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1 Introduction

In March 2020 concerns about the looming COVID-19 pandemic caused significant financial market distress and an unprecedented run on open-ended investment funds by investors worldwide. Figure 1 illustrates the severity of this event among open-ended funds domiciled in Ireland, which hosts the second largest investment funds sector in Europe (Cima, Killeen, Madouros, et al., 2019). Irish-domiciled investment funds saw a total of more than 72 billion euros of net redemptions in March 2020 (see Figure 1a), with funds investing in corporate bonds experiencing particularly severe distress (see Figure 1b).

Funds investing in corporate bonds are known to be particularly fragile and susceptible to runs as their pricing mechanism brings about strategic complementarities in investors' redemption decisions (Chen, Goldstein, and Jiang, 2010; Goldstein, Jiang, and Ng, 2017). This is because withdrawing investors can typically redeem their shares at a daily fixed net asset value (NAV), while the trading costs incurred by the fund to obtain sufficient liquidity to meet withdrawals and costs of subsequent portfolio readjustments are born by investors who keep their money in the fund. As such, large withdrawals can impose a negative externality on remaining investors, which is particularly high during episodes of market-wide distress and in funds investing in relatively illiquid assets such as corporate bonds. To contain these externalities and mitigate the resulting fragility of open-ended funds, various liquidity management tools have been proposed by regulators and, in some cases, have already been introduced.[1] However, evidence on the effectiveness of these different LMTs is still very scarce.

In this paper, we provide the first systematic analysis of the effectiveness of a wide range of liquidity management tools, using the context of corporate bond funds in Ireland during the COVID-19 shock in March 2020. We document that the presence of price-based liquidity management tools (such as anti-dilution levies and redemption fees) as opposed to just quantity-based liquidity management tools (redemption gates, temporary suspension of dealing, redemption in kind) was more effective in mitigating outflows during the COVID-19 crisis. This effect is found especially among funds with a high past flow-to-performance sensitivity which experienced lower gross outflows as well as higher gross inflows. These funds also performed better and sold off fewer (illiquid) bonds during the crisis. As a consequence, bonds held over-proportionately by those funds experienced less price pressure in March 2020.

For our analysis, we employ a unique dataset collected by the Central Bank of Ireland, which combines information on monthly fund flows with data on the availability of liquidity management tools (LMTs). Irish-domiciled investment funds were among the first to introduce a wide range of LMTs (ESRB, 2017) and, since 2018, report to the regulator on the availability of six types of tools: anti-dilution levies, redemption fees, redemption gates, temporary suspension of dealing, redemption in kind and side-pockets. In the entire population of open-ended funds domiciled in Ireland, we observe that a large majority (94% at the end of 2020) report the availability of at least one type of tool. Moreover, there is an increase in the availability of most LMTs over the period 2018-2020 covered in our dataset. Tools such as suspension of dealing, redemption gates, or redemption in

[1] See, for example, the recommendation of the European Systemic Risk Board of 7 December 2017 on liquidity and leverage risks in investment funds (ESRB/2017/6).

Figure 1: Net flows into open-ended funds domiciled in Ireland

(a) Aggregate net flows around March 2020 (b) Impact by type of funds

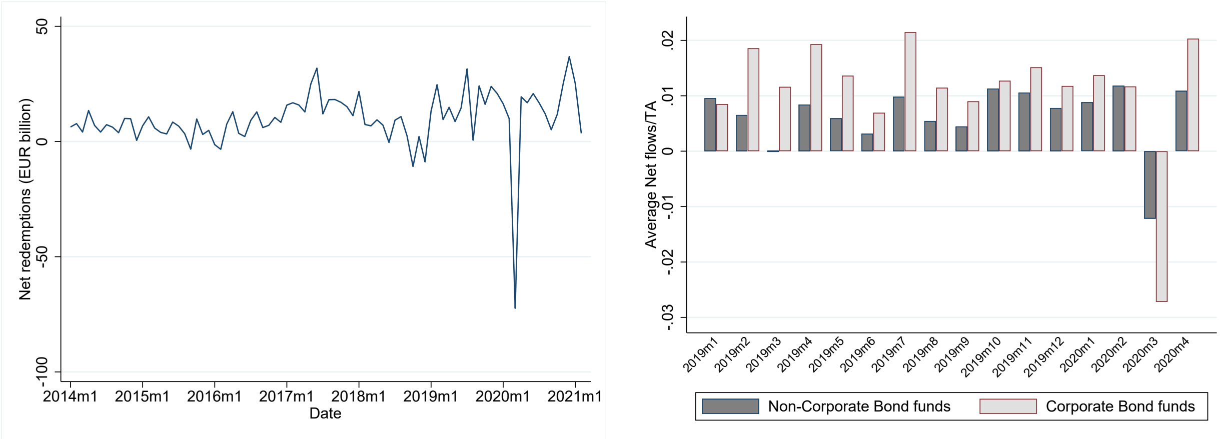


Figure (a) shows the sum of monthly net flows in the population of Irish-domiciled open-ended funds (in billions of EUR). Figure (b) shows the average net flows to Total Assets by fund type. Corporate bond funds are bond and mixed funds investing in corporate bonds. Non-corporate bond funds are the rest of the funds in our sample.

kind are widely present, although survey evidence suggests they are rarely employed in practice (ESMA, 2020). On the other hand, redemption fees are available in around 30% of funds, while the presence of anti-dilution levies increased from 54% to 60% of funds over the period considered. Funds report, on average, four different tools, with bond and mixed funds having more LMTs available.

Moreover, the presence of certain tools tends to be highly correlated: for example, funds that have redemption gates are more likely to also report suspensions, while the availability of redemption fees is negatively correlated with that of anti-dilution levies. Given this distribution of LMTs among Irish domiciled funds, we focus our analysis on the effectiveness of so-called *price-based* tools such as fees or levies, in addition to the more widespread *quantity-based* tools such as gates, suspensions, and redemption in kind. Our main empirical strategy compares funds reporting a combination of price- and quantity-based tools (treatment group) to a control group with only quantity-based tools.

We classify according to this definition a sample of 521 funds that invest in corporate bonds, including bond funds as well as mixed funds. We then use a difference-in-difference approach to investigate the effectiveness of price-based LMTs in mitigating investor outflows in March 2020. Causal identification in such a diff-in-diff approach relies on several assumptions. The first is that the shock was not anticipated, i.e. that investors with different sensitivities to stress events did not select out of treated funds prior to the shock. We show that this assumption holds, as there are no clear trends in net flows in the two groups of funds prior to March 2020. Second, identification relies on the assumption that selection in control and treatment groups is random or at least not related to other characteristics affecting funds' susceptibility to performance shocks and large-scale withdrawals. We address this concern in several ways. First, a key aspect of the data is that the introduction of a liquidity management tool occurs at the fund-family level, and is not necessarily driven by individual fund characteristics.[2] As such, we focus our analysis only on individual funds that are part of fund families. Second, we control for heterogeneity across funds in the treatment and control groups by including several fund characteristics such as size, age, asset liquidity, past performance, flow volatility, investment style, and fund investor types, as well as interactions between these time-varying characteristics and the March 2020 time indicator. This wide range of covariates together with fund and time fixed-effects allows us to control for characteristics that could drive both LMT decisions and outflows.[3] Finally, to further mitigate concerns about unobservable heterogeneity between treated and non-treated funds, we split the sample of funds according to their sensitivity of flows to performance prior to the COVID-19 shock. By focusing on the sample of funds that have a high sensitivity of flows-to-performance, we reduce the concern that investors in the treated group are less sensitive to shocks and that treated funds have (endogenously) more or less liquid asset holdings. This mitigates also the concern that the effect we capture is solely due to investor selection into funds with different LMTs as a result of their sensitivity to large liquidity shocks.

We find that funds with access to fees or levies experienced lower net outflows in March 2020, as compared to funds with only quantity-based tools. This difference is strongest among funds with an above-median past flow-to-performance sensitivity, but not significant in the sample with a below-median sensitivity, suggesting that access to price-based LMTs is effective in mitigating financial fragility, particularly among funds most prone to panic-induced distress. Thus our findings support the view that price-based LMTs indeed help to contain panic-based withdrawals at bond funds. The effect is economically significant: funds in the treated group have 5% lower net outflows to total assets as compared to funds in the control group (average net outflows to total assets in March 2020 is around 3%). This effect cannot be explained by heterogeneity in funds' investor base. The average percentage of a fund's shares held by households, banks and other investment funds, as well as pension funds and insurance companies, is not significantly different for funds with price-based LMTs compared to funds with only quantity-based LMTs. Furthermore, focusing on funds that introduced price-based LMTs in our sample period, we do not find that the ownership structure across these investor classes changed significantly with the introduction of price-based LMTs.

Looking separately at gross outflows and gross inflows provides further evidence supporting the view that price-based LMTs indeed contain investors' worries about payoff externalities. We find that this differential effect on net outflows is due to both lower gross outflows and higher gross inflows, suggesting that the availability of price-based LMTs

[2]We confirm this institutional characteristic in a small subsample of fund families that introduced LMTs in 2019 by showing that their introduction is not correlated with individual funds' past volatility of flows or returns, but rather with the level of cash buffers or investor base of the fund family. For instance, fund families with higher cash buffers are less likely to introduce such tools, which is intuitive given that these funds can use their higher levels of liquidity to meet redemptions. At the same time, fund families with a higher share of ownership by banks or investment funds are more likely to introduce such tools, while those with higher ownership by pension funds are less likely. This is also intuitive given the documented pro-cyclical investment behaviour of banks and investment funds and the counter-cyclical investment behaviour of pension funds (Timmer, 2018).

[3]In robustness tests, we also show that our results hold when employing the entropy balance reweighting algorithm in Hainmueller (2012) that addresses selection biases through constructing similar treatment and control samples across several fund characteristics.

mitigates the observed negative correlation between outflows and inflows during periods of distress. This suggests that fees and levies not only contain incentives to withdraw in a crisis but also make it more attractive to purchase fund shares as new investors' returns will be less impaired by portfolio adjustment costs induced by current outflows.

In line with this reasoning, we also find that funds with price-based LMTs outperformed other funds during the crisis, but not other periods, while controlling for fund and time fixed-effects, as well as time-varying fund characteristics. At the same time, funds with price-based LMTs also experience lower outflows-induced selling pressure, particularly among their more illiquid bond holdings. Specifically, we investigate the change in the portfolio shares of different asset classes between December 2019 and March 2020 using ISIN-level data of asset holdings in our sample of Irish-domiciled funds. We show that funds with price-based LMTs saw a larger increase in the share of illiquid corporate bonds, but a smaller one in that of cash holdings, relative to quantity-based LMTs funds. This suggests that treated funds sold relatively fewer illiquid assets during this episode of severe financial distress.

We then investigate whether the lower outflows-induced selling pressure had an effect on the fragility of bonds' prices around March 2020. In a sample of bonds held by both treatment and control groups, we build a measure of a bond's exposure to selling pressure as the fraction of its total outstanding amount held across the two types of funds in our sample. We show that bonds that were held disproportionally more by the sample of price-based LMT funds experienced smaller changes in yield during March-April 2020. This suggests that, by mitigating outflow-induced selling pressures, the availability of price-based LMTs can also contain the negative price impact on securities markets and thereby alleviate spillovers to the securities markets and to other financial institutions.

Our results are robust to a variety of specifications including alternative definitions for the treatment and control groups, different sample definitions, and econometric specifications.

We contribute to several strands of the literature. First, a large literature documents the extent of financial market distress in March 2020 in bond markets, particularly among corporate bonds (Haddad, Moreira, and Muir, 2020; Kargar, Lester, Lindsay, Liu, Weill, and Zúñiga, 2020). Several papers look specifically at open-ended funds during the COVID-19 crisis.[4] Closely related to our paper is Ma, Xiao, and Zeng (2020) who find that the liquidity transformation of fixed-income funds and their exposure to large-scale withdrawals during the COVID-19 crisis induced those funds to primarily sell liquid sovereign and corporate bonds contributing to the huge selling pressure in those securities markets. Falato, Goldstein, and Hortaçsu (2021) analyze daily flows of US bonds funds around March 2020 and show that some fund characteristics such as illiquidity or vulnerability to fire sales were important in explaining the fragility of outflows. Similarly, Grill, Vivar, and Wedow (2022) investigate the determinants of suspensions of redemptions during the COVID-19 market turmoil and find that illiquid funds investing in real estate were substantially more likely to suspend than other funds. We complement this evidence by looking at the effectiveness of liquidity management tools in mitigating outflows. Dunne and Giuliana (2021) also provide evidence on the effects of liquidity management tools in a sample of Irish-domiciled Money Market Funds. They exploit legal liquidity requirements

[4]For example, Pástor and Vorsatz (2020) show that during the crisis passive funds outperformed actively managed funds, and funds with high sustainability ratings experienced lower outflows.

imposed on this type of fund and show that redemption gates can exacerbate outflows during periods of distress if the fund is close to the legal threshold. Several works also study the implications of funds' portfolio liquidity structure on the fragility of the assets they hold. Chiefly, Jiang, Li, Sun, and Wang (2022) shows that bonds held by funds with more illiquid portfolios experienced more negative returns and larger reversals around March 2020.

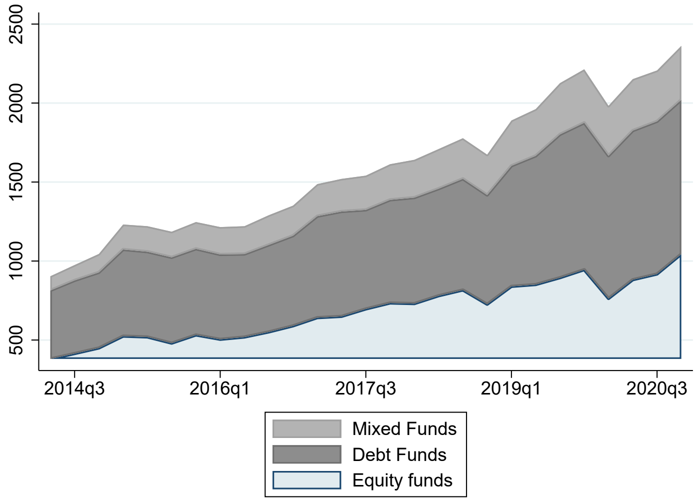
Our work is also related to a large literature on financial stability and runs on financial institutions. While most of the focus has been on the banking sector, recent work has highlighted how the liquidity transformation performed by open-ended funds makes them prone to similar run-type behaviour. Chen et al. (2010) develop a model of runs in a global games framework and show how complementarities in investors' actions will generate an amplification of outflows following a bad performance, especially if the fund is illiquid. Consistent with this prediction, they show that the sensitivity of outflows to bad performance is higher in equity funds that hold less liquid assets. Goldstein et al. (2017) complement this evidence in a sample of bond mutual funds by showing that they exhibit a concave flow-to-performance relationship where outflows are sensitive to bad performance more than their inflows are sensitive to good performance. We provide the first systematic evidence consistent with the effectiveness of different liquidity management tools in reducing this first-mover advantage. In this regard, closest to our work is Jin, Kacperczyk, Kahraman, and Suntheim (2022), who investigate the effectiveness of one particular LMT, swing pricing, in a sample of 299 UK corporate bond funds.[5] They show that swing pricing eliminates the first-mover advantage arising from the traditional pricing rule and significantly reduces outflows during market stress. However, they do not focus on episodes of severe market distress such as the COVID-19 shock or other types of LMTs.[6] Importantly, they observe investor-level data and can introduce investor-level fixed effects, which allows them to control for any investor selection into funds with different pricing structures. While we do not observe investor-level data, our split sample analysis based on investors' past sensitivity of flows to performance allows us to mitigate the concern that the effects of price-based LMTs we observe are solely due to investor selection. We also perform several tests that show that there is no significant change in different investor classes both before the COVID-19 shock as well as around the introduction of price-based LMTs (in a subsample of funds where we observe the year in which the tool is introduced).

The remainder of this paper is organized as follows. Section 2 describes the institutional background and data. Section 3 presents the empirical strategy, section 4 the results and the last section concludes.

[5]While the data collected by the Central Bank of Ireland does not explicitly distinguish between swing pricing and anti-dilution levies, both tools work in the same way by adjusting the share price to incorporate the costs associated with a transaction. As such, funds in our sample employing swing pricing would report and be included in the anti-dilution levy category of liquidity management tools.

[6]Kashyap, Kohn, and Wessel (2020) discuss qualitatively the role of swing-pricing in crisis episodes such as the COVID-19 shock.

Figure 2: Assets under management (bil euro) of Irish-domiciled investment funds



2 Institutional background and data

Ireland is home to a large number of open-ended funds with a total of assets under management (AUM) amounting to over 3.2 trillion euros in 2020. The majority of these funds are equity, bond, and mixed open-ended funds, which have seen a dramatic growth in their AUM from 2014 to 2020 (see Figure 2).

Irish-domiciled investment funds report annually to the Central Bank of Ireland on a wide range of fund characteristics including liquidity management tools available to the fund.[7] Investors must be informed about the availability of all LMTs at a fund's disposal and, in Ireland, this is made explicit in the prospectus of the fund's family. The report inquires about the availability of six types of tools detailed in Table 1 and the data is available over the period 2018-2020. Funds domiciled in Ireland were among the first to introduce a wide variety of LMTs (ESRB, 2017; Daly, Moloney, et al., 2017) and we observe an increase in the availability of these tools from the end of 2018 to the end of 2020. Specifically, Figure 3 shows the availability of different tools across the entire population of Irish-domiciled funds in 2018 (5,506 funds) and 2020 (5,869 funds), while Figure 4 focuses on the sample of equity, bond and mixed mutual funds (a total of 4,070 funds in December 2019).

Only 6% of funds in the entire population do not report any tool at the end of 2020 and funds can employ, on average, four types of liquidity management tools. LMTs can be intuitively split into two categories: (i) quantity-based LMTs, which include suspensions, gates, and redemptions in kind, and impact the ability to redeem fund shares during periods of distress, and (ii) price-based LMTs such as anti-dilution levies and redemption fees, which impact the prices of the shares redeemed.[8] As evident from Figures 3 and

[7]Readers should note that this reporting (Fund Profile) is not a regulatory return and the data is not subjected to the same level of validation as data from a regulatory return.

[8]Side-pockets would also be included in this category, however, we will not consider this tool in the rest of the analysis, as funds that cater to retail customers, which represent the large majority of our sample, are not legally allowed to employ this tool in Ireland. Moreover, the percentage of funds reporting this tool is very low (around 9% in the entire population of Irish-domiciled funds).

Table 1: Liquidity Management Tools

Tool	Definition
Anti-dilution levy	Costs (transaction costs, taxes, or stamp duties) corresponding to the sale of underlying assets in case of redemption (or acquisition in case of new subscriptions) are charged to the investors executing the redemption/subscription.
Redemption fee	Fee typically charged as a percentage of the NAV of the shares being redeemed.
Redemption gates	Usually applied once redemption requests in a dealing day exceed a certain percentage of the NAV or the total number of shares.
Suspension	Temporary suspension of dealing/calculation of NAV.
Redemption in kind	Transfer of an underlying asset to a redeeming investor.
Side pocket	Creation of side pocket share classes into which assets that become illiquid or difficult to value are placed. Investors receive shares in that side pocket class, thus avoiding the need to redeem less liquid assets at heavily discounted prices in order to meet redemption requests (tool not permitted for retail funds).

4, the quantity-based LMTs (QLMTs) are widely available across all types of investment funds. However such tools are usually considered "extraordinary" and are rarely employed in practice due to reputational concerns.[9] On the other hand, price-based LMTs (PLMTs) are less frequent. For example, redemption fees are present in around 30% of funds, while anti-dilution levies become more prevalent over time (with an increase from 54% to 60% of all funds from 2018 to 2020). Bond and mixed funds also tend to report, in general, more LMTs, and, in particular, tools such as anti-dilution levies and redemption fees are more widespread among these funds (see Figure 4).

Our dataset allows us to observe the introduction of different liquidity management tools over time at the individual fund level. However, the decision to introduce a liquidity management tool generally occurs at the fund family or asset management company level.[10] While this is very helpful for our identification strategy as it ensures that the

[9] For example, a survey among European funds conducted by the European Securities and Markets Authority (ESMA) found that, in a sample of 541 funds that experienced significant distress in March 2020, only six suspended redemptions due to large outflows (ESMA, 2020).

[10] Investment funds are registered in Ireland as ICAVs (Irish collective asset management vehicles) which constitute an umbrella fund (or a family of funds). The availability of liquidity management tools

Figure 3: Availability of liquidity management tools (entire sample)

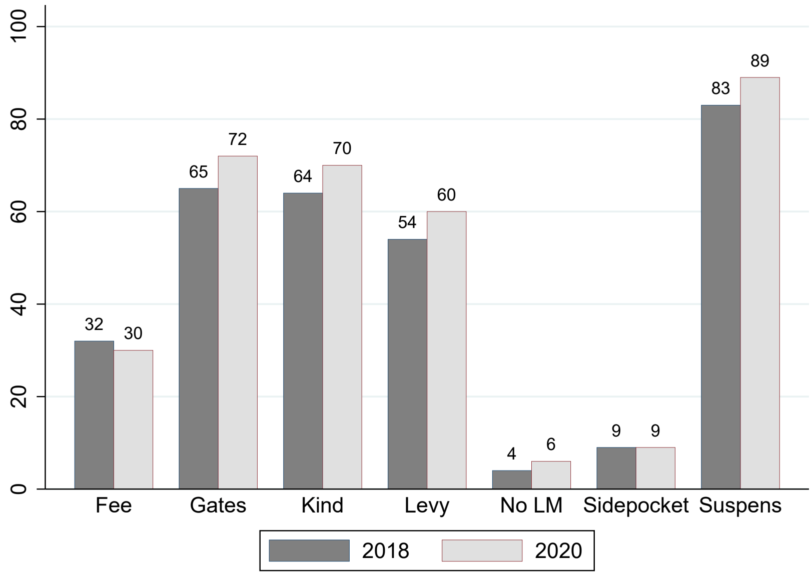


Figure shows the proportion of funds reporting the availability of different liquidity management tools in December 2018 as compared to December 2020 in the entire population of Irish-domiciled mutual funds (a sample of 5,506 funds in December 2018 and 5,869 in December 2020). Changes in percentages reflect both the entry of new funds, as well as the switch to new tools by existing funds.

introduction of an LMT is not an endogenous decision of the individual fund, characteristics at the fund-family level are still likely to determine whether and when a particular LMT is introduced.

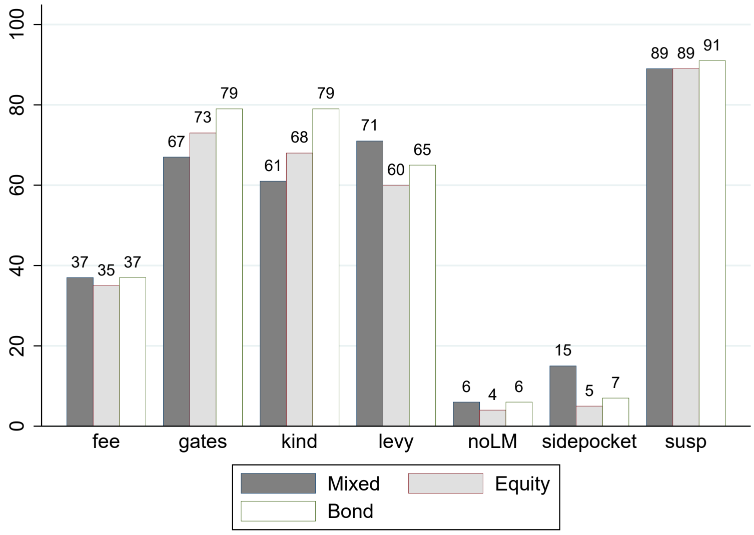
We investigate several fund-family characteristics that are potentially correlated with the probability of introducing a new LMT (on average a fund-family in our sample comprises 20 different funds). For that purpose, we construct several fund family characteristics that capture institutional ownership, size, liquidity, as well as flow-related measures such as past volatility of flows, the sensitivity of flows to performance, or the average number of "distressed" funds in the family defined as those in the lowest decile of net flows in a given month in a given class of funds. Appendix Table A details the construction of fund-family variables.

Appendix Table 11 shows the results of a series of cross-sectional probit models where the dependent variable is an indicator equal to one if the fund family has introduced a new LMT from December 2018 to December 2019.[11] We find that several fund-family characteristics are correlated with the probability of introducing LMTs. Chiefly, large fund families, measured by the log of total assets under management, are more likely to

is detailed in the umbrella fund prospectus and should normally apply to all funds in the family (unless, for legal requirements, this is not allowed, such as in the case of side pockets). Moreover, we cross-check that, in our sample of funds, the introduction of a new tool occurs across all funds within a family (Umbrella Fund). This is indeed the case for almost all introductions of new tools (small exceptions refer to the introduction of side pockets and potential misreporting due to the timing of reporting to the regulator).

[11] We exclude 2020 from this analysis as the COVID-19 shock might explain the introduction of tools in 2020.

Figure 4: Percentage of funds with different LM tools (sample of equity, bond and mixed funds)



The figure shows the proportion of funds reporting the availability of different liquidity management tools in 2019m12. The sample is 1,132 Bond funds, 2,018 Equity Funds, and 920 Mixed.

add LMTs. On the other hand, families with higher average levels of liquidity, measured as the average level of cash and liquid government bonds to total assets, are less likely to introduce new liquidity management tools. This is intuitive as funds with larger cash buffers can more easily meet redemptions.

We also construct several measures of ownership by different institutional groups: (1) banks and investment funds, (2) pension and insurance companies and (3) households.[12] We find that the investor base matters in the decision to introduce new LMTs, with families with higher shares of banks and investment funds being more likely to adopt LMTs, while those with a higher share of pension funds and insurance companies are less likely. This negative correlation between high ownership by pension funds and the introduction of LMTs is consistent with the counter-cyclical investment behaviour of pension funds, documented by Timmer (2018), which makes them less likely to redeem in periods of market distress. We also find that families with a larger share of equity funds are less likely to adopt LMTs, which is expected given that equity funds are less likely to face the liquidity mismatch problems that LMTs aim to address. Finally, note that the past volatility of flows, the past sensitivity of flows to performance, or the average number of distressed funds are not correlated with the decision to introduce a new LMT. This suggests that the decision to introduce LMTs is not necessarily related to an individual funds' redemption experiences, which is our main outcome variable of interest.

[12]Note however that the share of ownership by households is not perfectly observed in our data, which only identifies households residing in Ireland. Foreign households' ownership is measured through the custodian bank.

2.1 Sample construction

The descriptive statistics presented in the previous section show that quantity-based LMTs are not only available for the vast majority of funds, but, as Table 2 shows, funds typically report most of these tools together: the availability of suspensions, redemption gates and redemption in kind tends to be highly correlated in the sample of Irish-domiciled equity, bond and mixed funds. Various surveys conducted by the ESRB show that, although these tools have historically been available to funds, their actual usage is limited due to the significant reputational concerns (ESRB, 2017; 2020). In contrast, the introduction of anti-dilution levies and redemption fees is not only more recent but Table 2 shows that their availability across funds is negatively correlated, suggesting they are viewed as substitute tools.[13]

Table 2: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Anti-dilution levies	1					
(2) Gates	0.16	1				
	(0.000)					
(3) Redemption in kind	0.097	0.587	1			
	(0.000)	(0.000)				
(4) Suspension	0.205	0.512	0.45	1		
	(0.000)	(0.000)	(0.000)			
(5) Redemption fees	-0.021	0.095	0.086	0.14	1	
	(0.119)	(0.000)	(0.000)	(0.000)		
(6) Side pocket	0.01	0.112	0.092	0.022	-0.13	1
	(0.477)	(0.000)	(0.000)	(0.111)	(0.000)	

Correlations are based on a sample of 1,132 Bond funds, 2,018 Equity Funds, and 920 Mixed funds in 2019m12. P-values in parenthesis.

Consequently, our main empirical investigation will focus on the "add-on effect" that price-based LMTs have over and above quantity-based LMTs on funds' resilience. To this end, we classify funds into treatment and control groups as depicted in Figure 5. Specifically, we include in the treatment group (PLMT) funds that report the availability of either redemption fees or levies and *at least one* of the QLMTs: suspensions, gates, and redemption in kind. The control group is represented by funds that do not report either fees or levies, but have at least one of QLMT. This classification of funds allows us to take into account the fact that the QLMTs are reported as available in a large proportion of funds. We perform, however, robustness tests where we consider alternative definitions.

Furthermore, we focus our analysis on a sample of funds that invest in corporate bonds. Since corporate bonds are comparably illiquid, corporate bond holdings of open-end mutual funds drive their liquidity transformation and their exposure to panic-driven runs (Ma et al., 2020). In our sample, these funds were most susceptible to investor runs (Figure 1b). We classify a fund as a corporate bond fund based on self-reported data

[13]Irish-domiciled funds were among the first to use redemption fees and anti-dilution levies to mitigate liquidity risk (ESRB, 2017; Daly et al., 2017). For example, in a survey of 283 Irish-domiciled funds, Daly et al. (2017) document that around 19% of funds report employing an anti-dilution levy during 2007-2015.

Figure 5: Treatment definition

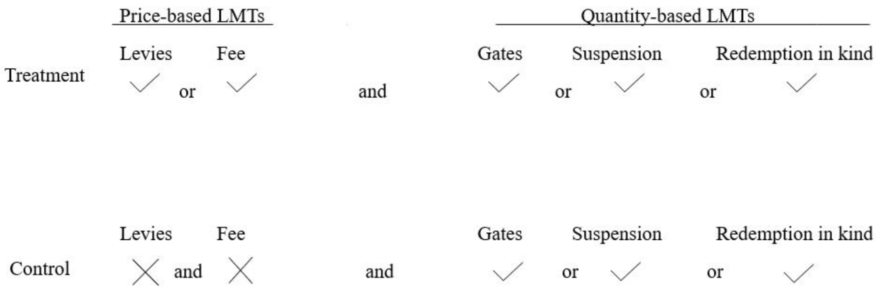
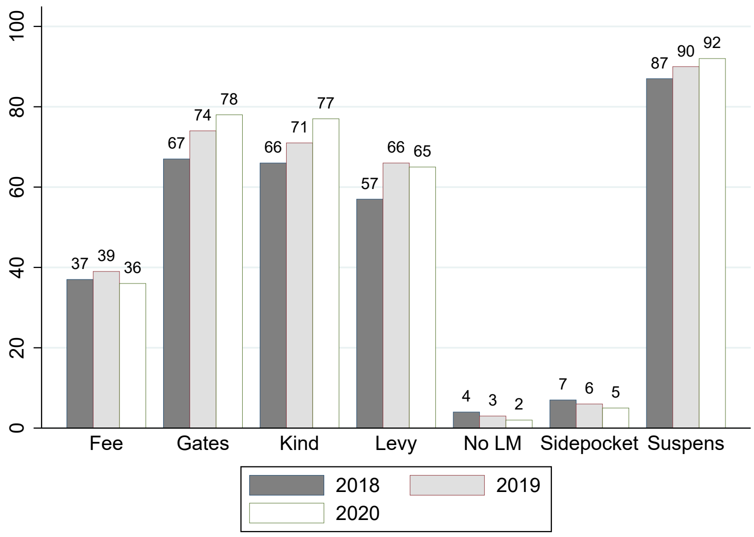


Figure 6: Percentage of funds with different LM tools in the sample of funds investing in corporate bonds



The figure shows the proportion of funds reporting the availability of different liquidity management tools in the sample of corporate bond funds in December 2018 (507 funds), 2019 (521 funds) and 2020 (530 funds).

collected by the Central Bank of Ireland.[14] As of December 2019, 521 funds in the dataset are classified as corporate bond funds and will constitute the main sample in our analysis. Figure 6 shows the availability of different LMTs in the sample of corporate bond funds. Overall, it shows similar patterns as in the overall sample, with gates, redemption in kind and suspensions being widely present. It also shows an increase in the availability of most tools in the three years of reporting available.

In the sample of corporate bond funds considered, 68% are included in the treatment group, while 32% have only quantity-based LMTs available. Table 3 shows some descrip-

[14]Precisely, we include pure bond funds that self-report to the CBI as corporate bond funds. We also include mixed funds that hold corporate bonds in their portfolio. The average share of corporate bond holdings in the sample of pure bond funds is 45%, while in the sample of mixed funds is 17%. We present robustness tests where we vary these definitions and the sample of funds classified as corporate bond funds.

tive statistics for the fund characteristics we observe for the treatment and control group separately. Overall, funds in the two groups have comparable characteristics, although PLMT funds tend to be larger, in terms of total assets. They do not, however, belong to larger fund families or are older. Importantly, returns and volatility of flows are not statistically different both prior to the shock (December 2019), as well as on average over the period of January 2019-December 2019.[15] Liquidity, measured as cash plus liquid government bonds to total assets, is, however, notably higher in the control group. This points to an additional benefit of introducing PLMTs, as funds can hold lower levels of low-yield securities to meet redemption demands. Still, industry reports often cite competitive pressures and concerns about stigma as the main costs preventing funds from adopting LMTs (IMF, 2022).[16]

Finally, the ownership shares of different investor classes are also comparable across the two groups of funds, as is the share of funds that are leveraged and the proportion of funds with an investment grade rating. On the other hand, PLMT funds are more likely to belong to bank-holding corporations.

3 Empirical strategy

Our main empirical investigation aims to understand if and what types of liquidity management tools were effective in mitigating the fragility of flows during the COVID-19 episode of market distress. The baseline analysis looks at the net flows to total assets of individual funds at a monthly frequency:

$$\begin{aligned}\frac{\text{Net Flow}_{i,t}}{\text{Total Assets}_{i,t-1}} &= \alpha_i + \mu_t + \beta \text{PLMT}_i \times \text{March2020}_t + \theta' X_{i,t-1} + \\ &\quad \gamma' X_{i,t-1} \times \text{March2020}_t + \epsilon_{i,t} \qquad (1)\end{aligned}$$

where Net $\text{Flow}_{i,t}$/Total $\text{Assets}_{i,t-1}$ is defined as monthly inflows minus outflows of shares at the market price at the time of the transaction divided by the fund's total assets in the previous month.[17] $PLMT_i$ is an indicator variable equal to one if fund i is in the treatment group and zero if the fund is in the control group, as defined in Figure 5. March 2020 is a

[15] The t-statistics for the difference in means over the period of January 2019-December 2019 is 0.69 for the past volatility of flows and 0.003 for returns.

[16] Anecdotal evidence from discussions with internal Central Bank of Ireland supervisors suggests several costs associated with introducing LMTs (including price-based LMTs) which might discourage funds from introducing such tools. These include, firstly, fixed administrative/regulatory compliance costs mainly associated with changing prospectuses and getting them approved. Secondly, informing investors and seeking their feedback would involve additional costs that depend on the number of investors and their sophistication. Furthermore, if the LMTs are triggered by certain conditions (involving a judgement by the fund manager or a board) this introduces additional running costs. Finally, there are potential indirect costs (risks) associated with the introduction of LMTs, as certain tools might not be aligned with investor preferences leading to large initial outflows or might result in a competitive disadvantage in terms of attracting new investors.

[17] As the data available at the Central Bank of Ireland records inflows and outflows at the market price of the transaction, our measure of net flows is directly computed, rather than the indirect measure imputed from changes in portfolio size and asset prices as it is common in the literature.

Table 3: Descriptive Statistics

Variable	PLMT Mean	PLMT Std. Dev.	QLMT Mean	QLMT Std. Dev.	t-test
Funds in family	21.93	18.12	20.24	16.52	-0.76
ln Assets	19.01	1.66	18.32	1.51	-3.40***
Return	0.00	0.01	0.00	0.02	0.19
Fund age	4.83	4.57	6.13	5.73	2.18**
Belongs to BHC	0.28	0.45	0.05	0.22	-4.37***
Volatility	0.05	0.05	0.04	0.05	-0.81
Leverage	0.53	0.50	0.65	0.48	1.84
Liquidity/TA	0.04	0.08	0.06	0.15	2.30**
Investment grade	0.34	0.47	0.33	0.47	-0.10
Share of Banks & IF	0.39	0.45	0.33	0.43	-1.13
Share of Pension & Insurance	0.11	0.27	0.12	0.27	0.22
Share of Households	0.013	0.004	0.01	0.005	-0.29

The table presents descriptive statistics across funds in December 2019. Return is the change in the monthly change in NAV. Belongs to BHC is an indicator variable for funds that belong to families whose ultimate global owner is a Bank Holding Company. Volatility is the rolling standard deviation of net flows to TA over the past 12 months. Liquidity/TA is the ratio of cash and equivalents plus holdings of US and German government bonds to TA. Leverage is an indicator variable equal to one if the fund uses leverage and zero otherwise (self-reported by the fund). Investment grade is an indicator variable equal to one if the fund has an investment grade rating. Share of Banks & IF is the percentage of fund shares owned by banks and other investment funds. Share of Pension & Insurance is the percentage of fund shares owned by pension funds and insurance corporations. Share of Households is the percentage of fund shares owned by households. The last column shows the t-statistic of a t-test on the difference in means between PLMT and QLMT funds.***, ** show significance at 1% and 5% levels.

dummy equal to one in March 2020 and zero from January 2018 to February 2020.[18] $X_{i,t-1}$ is a vector of lagged fund characteristics, which include measures of size, liquidity, past performance and flow volatility, as well as ownership shares. Appendix A provides details on variable definitions. We also present results where we include interactions between these other fund characteristics and the March 2020 dummy to alleviate concerns that underlying fund differences in, for example, liquidity or the investor base might explain flows in March 2020. Finally, throughout all specifications, we control for month and fund fixed effects to absorb aggregate shocks in a given period, as well as time-invariant fund characteristics. Time fixed effects will also absorb the coefficient of the March 2020 dummy variable and allow us to obtain identification from differences in net flows across funds in the same month.

The coefficient of interest is β. A positive coefficient implies that the difference in net flows in March 2020 compared to the pre-shock period was higher among funds with levies or fees as compared to the control group. In other words, PLMT funds experienced lower net redemptions during March 2020, as compared to funds with only QLMTs. Causal identification relies on several assumptions.

The first is that the market distress in March 2020 was not anticipated, causing investors with different sensitivities to stress events to select into funds that did not have access to redemption fees or levies before the shock. There is significant evidence documenting the distress in the bond markets, which shows that the periods of turmoil started in early March and ended towards the end of March when major central banks announced asset purchase programs (Kargar et al., 2020; Falato et al., 2021; Haddad et al., 2020).

[18] Our sample period in the baseline specifications ends in March 2020, but our results hold when we include several months after March 2020.

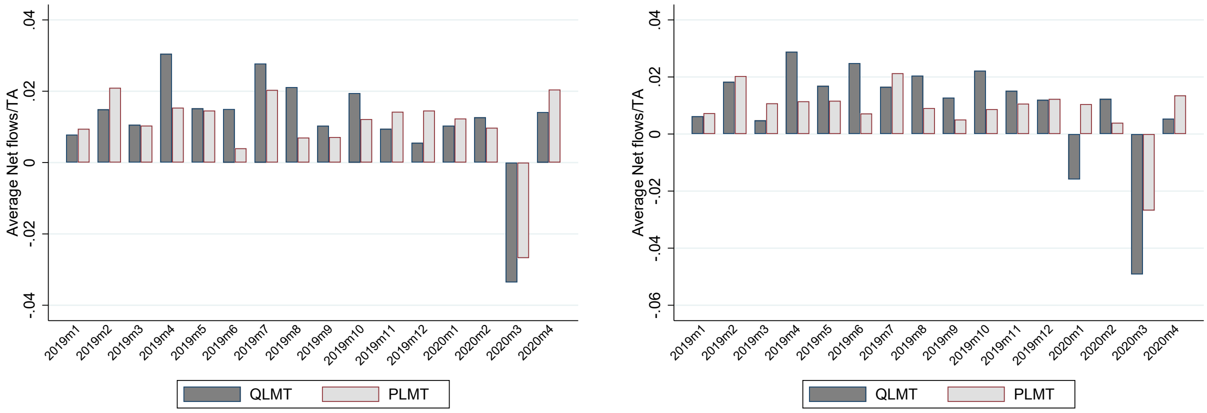
Figure [7a](#) confirms this in our sample of funds by showing the average net flows to total in the treated and control groups from January 2019 to April 2020. In the first months of 2020, both groups experience net inflows with no clear shift of investors towards funds without fees or levies prior to March 2020. There are also no clear pre-trends on a longer time horizon in the average monthly net flows between the two groups.

Second, we also need to assume that selection into the treatment and control groups is random and not related to the outcome variable of interest, i.e., differences in net flows. As we have argued in the previous section the introduction of LMTs occurs at the family level and is not related to funds' flow volatility or the sensitivity of flows to performance. To further mitigate concerns that other fund characteristics that might be correlated with the availability of PLMTs can also explain differences in net flows in March 2020, we saturate the model with a wide array of fund observable characteristics and fund fixed effects.

Figure 7: Average Net flows/TA

(a) Entire sample

(b) Funds with high sensitivity of flows to performance



Yet, one remaining concern is that of unobservable matching between investors and funds, such that investors who are more prone to withdraw during market distress select out of funds that apply fees or levies. To alleviate this concern, we split the sample of funds according to their past sensitivity of flows to performance. By focusing on a sample of funds that have a high sensitivity of flows to performance, we mitigate the role of investor selection in explaining the results. We classify funds following the flow-to-performance literature by relating net flows in a fund to its past return (Chevalier and Ellison, 1997; Sirri and Tufano, 1998; Huang, Wei, and Yan, 2007). Specifically, for each fund i in our sample, we estimate a time-series regression over the period January 2014 - December 2018, as follows:

$$\frac{\text{Net flows}_{i,t}}{TA_{i,t-1}} = \alpha_i + \beta_i Return_{i,t-1} + \epsilon_{i,t}, \tag{2}$$

where $Return_{i,t-1}$ is fund i's return in the previous month, computed as the percentage change in its NAV. We rank funds based on their estimated β_is into those with an above-median sensitivity of flows to performance and those with a below-median sensitivity. We then perform split sample analyses, where we estimate Eq.(1) separately for funds with an above-the-median sensitivity and those with a below-the-median one.[19]

Descriptive evidence in Figure 7b suggests monthly net outflows in the high-sensitivity group are sizably lower for the PLMT as compared to the QLMT group of funds. This difference in net flows in March 2020 between treatment and control groups is notably larger in the high-sensitivity sub-sample as compared to the entire sample of corporate bond funds depicted in Figure 7a. The empirical analysis in the next section confirms this result more rigorously.

4 Results

The results from the baseline model in Eq.(1) are presented in Table 4. We first present the results for the full sample of funds, followed by a split sample analysis based on the funds' sensitivity of flows to performance. For each subsample, we include specifications that only include fund characteristics, as well as interactions of additional fund controls and the March 2020 indicator. The results for the entire sample of funds in columns (1) and (2) show a positive, albeit only marginally significant, coefficient of the interaction term PLMT $\times$ March 2020. In column (2), funds with access to price-based LMT experienced a 2.6% higher net flows to total assets (lower net outflows) during March 2020 as compared to funds with only quantity-based LMTs. This effect is strongest among funds with an above-the-median past sensitivity of flows to performance (columns (3)-(4)) and less so among those with a below-the-median sensitivity (columns (5)-(6)). In the sample of high-sensitivity funds, the estimates in column (3) suggest that the presence of PLMTs corresponds to a 5% higher net flows to total assets as compared to the control funds in March 2020 versus the pre-period. This effect is economically significant, given the average net flows to total assets in March 2020 of around -3%.

These results suggest that tools such as redemption fees or anti-dilution levies were effective in mitigating net outflows during the COVID-19 shock to financial markets, particularly in the sample of funds that are more susceptible to liquidity shocks.

In all models, we control for a rich set of observable fund characteristics such as size, past volatility of flows, past returns, liquidity, leverage, and ownership measures. Moreover, in columns (2), (4), (6) and (8) we also include interactions between these fund characteristics and the March 2020 dummy to take into account that funds with different characteristics experienced heterogeneous net flows in March 2020. Overall, the results are stronger and more robust in this more stringent specification and we present the coefficient estimates of the additional controls in Appendix Table 12. Among these fund characteristics, we find that larger funds (measured by total assets) and those with higher past volatility of flows experienced lower net flows in March 2020. At the same time, leveraged funds and those with higher ownership by banks, investment funds or pensions and insurance corporations experienced lower net outflows in March 2020.

Finally, all estimations include fund and month fixed effects, which absorb all unobservable fund heterogeneity as well as aggregate market developments, such as the overall

[19] Appendix Table 10 shows average fund characteristics for treatment and control groups separately for funds with an above and below the median sensitivity. These statistics are comparable to the full sample ones presented in Table 3 suggesting that funds with below/above average sensitivity are comparable across most other fund characteristics we observe.

Table 4: Fund Flows during March 2020

Dependent variable: Net flow/TA	Full sample		High sensitivity		Low sensitivity		Full sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PLMT × March2020	0.009	0.025*	0.049**	0.064***	-0.024	-0.002	-0.023	-0.003
	(0.015)	(0.015)	(0.021)	(0.017)	(0.016)	(0.018)	(0.016)	(0.017)
High sensitivity × March2020							-0.062***	-0.058***
							(0.018)	(0.015)
PLMT × March2020 × High sensitivity							0.067***	0.065***
							(0.022)	(0.020)
Observations	10,223	10,223	5,310	5,310	4,487	4,487	9,797	9,797
R-squared	0.259	0.269	0.292	0.305	0.202	0.213	0.252	0.262
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund-level controls X March 2020	No	Yes	No	Yes	No	Yes	No	Yes

The dependent variable is *Net Flow/TA*, defined as the net monthly capital flow into a fund divided by the fund's total net assets in the previous month. PLMT is an indicator variable equal to one for funds with fees or levies and at least one quantity-based tool (suspensions, gates, or redemption in kind) and zero for funds with neither fees nor levies, but at least one of the QLMTs. March 2020 a dummy variable equal to one in March 2020 and zero from January 2018 to February 2020. High Sensitivity is an indicator variable equal to one if a fund has an above-the-median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include the lagged values of net flows to total assets, monthly return, number of funds in a fund family, ln of total assets, 12-month rolling volatility of fund flows, leverage, a dummy variable for investment grade funds, the share of assets owned by banks and investment funds, pension funds and insurance corporations, as well as households. Fund-level controls X March 2020 represents an interaction between the fund controls and the March 2020 dummy variable. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

impact of the March 2020 distress across the Irish fund industry. We cluster standard errors at the family level across all specifications as this is the treatment assignment level (see Bertrand, Duflo, and Mullainathan, 2004).

Finally, in columns (7)-(8) of Table 4, we present the alternative specification to the split sample analysis through a triple interaction term between (i) the treatment condition, (ii) the March 2020 dummy variable and (iii) an indicator variable equal to one for funds above the medium sensitivity of flows to past performance and zero for those below (High Sensitivity). Specifically, the model estimated is:

$$\begin{aligned}\frac{\text{Net Flow}_{i,t}}{\text{Total Assets}_{i,t-1}} &= \alpha_i + \mu_t + \beta_1 \text{PLMT}_i \times \text{March2020}_t \times \text{High Sensitivity}_i + \\ &\quad \beta_2 \text{PLMT}_i \times \text{March2020}_t + \beta_3 \text{March2020}_t \times \text{High Sensitivity}_i + \\ &\quad \beta_4 \text{PLMT}_i \times \text{High Sensitivity}_i + \gamma' X_{i,t-1} \times \text{March2020}_t + \epsilon_{i,t} \qquad (3)\end{aligned}$$

The coefficient β_1 in Eq. (3) of the triple interaction term captures the differential net flows in March 2020 as compared to previous months, in treatment versus control funds, in the sample of high sensitivity funds as compared to the low sensitivity ones. The baseline results are consistent in this alternative specification. Moreover, the negative coefficient of the interaction between High Sensitivity× March 2020 confirms that funds with a more stringent complementarity of actions among investors (i.e. with a high performance sensitivity) were also the ones experiencing lower net flows in March 2020.

One concern with the results in Table 4 is that investors anticipated the stress event and shifted their funds into investment funds that do not apply redemption fees or levies before March 2020. While the descriptive statistics in Figure 7 suggest that this is unlikely, we further validate this identifying assumption by showing the difference in net flows in the

Figure 8: Timing of effects

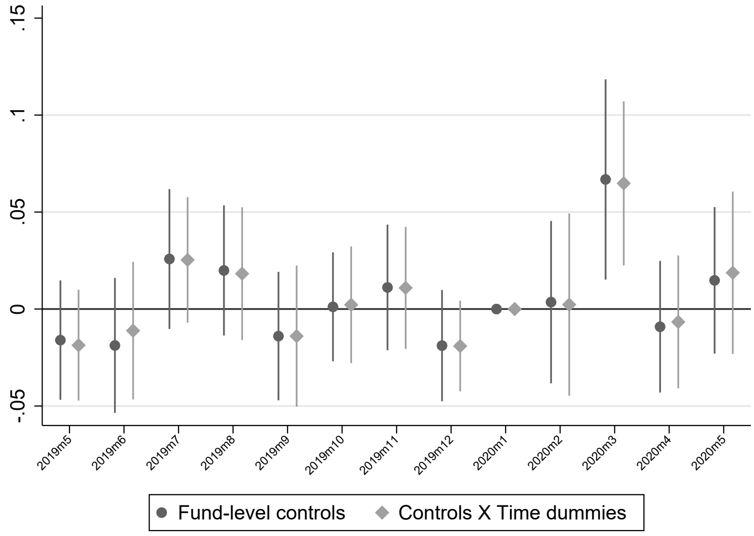


Figure shows the estimated coefficient β_q in Eq. (4) for two regressions that include (1) only lagged fund-level controls as well as (2) interactions between fund-level controls and month dummy variables. January 2020 is taken as the baseline month and is dropped. 95% confidence intervals are shown.

treatment and control groups in each month from March 2019 to May 2020. Specifically, we estimate the following model:

$$\frac{\text{Net Flow}_{i,t}}{\text{Total Assets}_{i,t-1}} = \alpha_i + \mu_t + \sum_{q=2019m3}^{2020m5} \beta_q \times \text{PLMT}_i \times \text{High sensitivity}_i + \theta' X_{i,t-1} + \epsilon_{it} \quad (4)$$

where $\text{PLMT}_i \times \text{High sensitivity}_i$ is interacted with a series of indicator variables equal to one in each month q and zero otherwise. Figure 8 shows the coefficient estimates of this triple interaction term (relative to January 2020, which is taken as the baseline month). In a first regression, we control for lagged fund characteristics ($X_{i,t-1}$), while in a second model, we also include interaction terms between fund time-varying characteristics and the month dummy variables. Figure 8 shows that the triple interaction term is statistically significant in March 2020 but not in any other month, which also confirms the conditional parallel trends assumption of no significant difference before and after March 2020 between the treatment and control groups.[20]

4.1 Robustness tests

We perform a series of robustness tests for our baseline results presented in Table 4. First, we consider alternative definitions of the treated and control groups. Specifically, in Appendix Table 13, we show that the results hold for both the sample of bond funds

[20] In unreported robustness tests, we also replace the March 2020 dummy with one that takes the value one in February 2020 and zero from January 2018 to January 2020. This is not statistically significant.

and mixed funds separately. Second, we consider alternative definitions for the treatment and control groups. In Appendix Table 14, the variable PLMT2 includes as treated funds those that have either fee or levies and *all* QLMTs, i.e., gates, suspensions and redemptions in kind. The control group includes funds that have all QLMTs. Although this reduces our sample size considerably, we still find a strong differential effect. In an alternative definition, which we call PLMT3, we exclude the redemptions in kind tool from both the treatment and control groups. This increases our sample size as compared to the PLMT2 definition, however, the results are still robust.

We also consider the robustness of our results to the definition of funds investing in corporate bonds. Our main sample includes bond funds that self-identify as corporate bond funds in their yearly reporting to the Central Bank of Ireland. We consider two alternative definitions. First, we follow Chakraborty, Ferracuti, Heater, and Phillips (2022) and include funds that hold at least 15% of their portfolio in corporate bonds. This results in a sample of 606 bond and mixed funds. Second, we consider a larger sample of funds that hold at least one corporate bond in their portfolio. This results in a sample of 1,011 bond and mixed funds. Appendix Figure 13 presents the coefficient β_1 in Eq.(3) of the triple interaction term PLMT $\times$ March 2020 $\times$ High Sensitivity for these alternative specifications and samples. Results are robust across all models, albeit less precisely estimated for the largest sample that includes all funds that hold at least one corporate bond.

Next, we consider the robustness of our results to model specification. For instance, Roth, Sant'Anna, Bilinski, and Poe (2022) recommend clustering standard errors in diff-in-diff models at the unit of observation level whenever the number of clusters at the level at which treatment is independently assigned (fund family, in our case) is not very large. At the same time, clustering at the fund level also allows us to account for the correlation in fund flows across time. The results presented in Appendix Figure 13 show that the coefficient of interest is not sensitive to the choice of clustering.

Finally, we check the sensitivity of our results to the sample split between high and low-sensitivity funds. In our baseline results, we estimate the flow-to-performance relationship over the period 2014-2018 to classify funds. However, one concern is that, for funds already employing fees or levies during that period, this relationship is affected by the presence of these liquidity management tools. This would, however, create a downward bias in the estimate of β in Eq. (2), making funds that have employed the tools for a longer period be classified with a below-the-median sensitivity. Nonetheless, to overcome this concern, we check the robustness of our main results to restricting the sample of funds to only those that introduce either fees or levies during 2019. For this sample, the estimated flow-to-performance sensitivity during the period 2014-2018 is not biased by the presence of the LMTs. As such the new treatment group includes only the funds for which we observe the introduction of levies or fees in December 2019 (35 corporate bond funds). The control group remains the same as in the baseline definition: funds that do not have access to fees or levies but have at least one of the QLMTs. The results of the baseline model in Eq. (1) using this alternative sample are presented in Appendix Table 16 and show that our main results are robust even in this restricted sample of switchers.

4.2 Selection biases

In this section, we address two selection concerns that might affect our results. The first is that the selection of funds into the treatment group is not random. While controlling for a large number of fund characteristics and their interaction with the March 2020 dummy helps mitigate this concern, we also use a re-weighting method that guarantees that the treatment and control groups are similar in terms of average characteristics. Specifically, we use the entropy balance re-weighting algorithm of Hainmueller (2012), which allows us to obtain a treatment and control sample that are indistinguishable in terms of average fund size, age, and the likelihood of belonging to a bank holding company. These are the main fund characteristics that were found to be significantly different across PLMT and QLMT funds in Tables 3 and 10. Appendix Table 15 shows the results from estimating Eq. (1) and (2) after reweighting the observations. The results based on the re-weighting algorithm show an even stronger effect of the presence of price-based LMTs on flows in March 2020, particularly in the sample of high-sensitivity funds.

The second concern is that we cannot fully control for investor selection into the treatment and control groups before the shock. In other words, if the presence of LMTs or the COVID-19 shock leads to a differential selection of investors into the two types of funds, then the observed differences will be the result of this selection and not the presence of the various liquidity management tools.

This concern is mitigated to some extent by the fact that (1) we control for interactions of different investor classes and the March 2020 dummy, and (2) we only compare funds with similar past sensitivities of flows to performance. However, we cannot fully address this issue without introducing investor-level fixed effects, which is not possible as, in our dataset, we do not observe the individual investors in the fund.

Nonetheless, in this section, we provide several tests that aim to address this concern indirectly. First, we show that the shares of different investor classes are rather stable over our sample period. Appendix Figure 14 plots the evolution of the average share ownership by banks and investment funds (Figure 14a), households (Figure 14b) as well as pension funds and insurance corporations (Figure 14c) as a percentage of total net assets over the period 2019-2020. It shows relatively stable shares before March 2020, with some divergence after the shock, particularly among the QLMT funds. These figures reduce concerns about investor selection before the COVID-19 shock.

We then investigate the possibility of investor selection around the time of the introduction of a price-based tool. To this end, we rely on the sub-sample of funds for which we observe the introduction of these tools before 2020. Specifically, we identify 40 individual funds that introduce either redemption fees or anti-dilution levies (or both) and we restrict the treated group to these funds. We keep the control sample the same: funds that have neither redemption fees nor anti-dilution levies, but at least one of the quantity-based tools. We then perform a simple cross-sectional analysis where we look at the changes in the share of ownership by the different investor classes around the introduction of PLMTs for the switcher funds as compared to the control group. Since we do not observe the exact date of the introduction, the dependent variable is simply the percentage change in the ownership share at the end of the calendar year as compared to the end of the previous year: $\ln(\text{Share}_t/\text{Share}_{t-12})$. Our main control variable is a dummy equal to one for funds that introduce PLMTs in a given year and zero for the control group. We present the

Table 5: Changes in investor base around the introduction of PLMTs

	(1)	(2) Controls	(3) High sensitivity	(4) Low sensitivity
Panel A: %Δ Share Household ownership				
PLMT (switchers)	-0.058	-0.108	-0.185	-0.235
	(0.077)	(0.117)	(0.148)	(0.270)
Observations	224	210	110	86
R-squared	0.001	0.068	0.103	0.098
Panel B: %Δ Share Banks and investment funds ownership				
PLMT (switchers)	-0.090	-0.123	-0.236	-0.056
	(0.084)	(0.135)	(0.304)	(0.055)
Observations	224	210	110	86
R-squared	0.001	0.041	0.079	0.053
Panel C: %Δ Share Pension funds and IC ownership				
PLMT (switchers)	-0.047	-0.089	0.098**	-0.291
	(0.081)	(0.141)	(0.049)	(0.323)
Observations	224	210	110	86
R-squared	0.000	0.015	0.048	0.035

The dependent variable is the percentage change in the ownership share at the end of the calendar year as compared to the end of the previous year: $\ln(\text{Share}_t/\text{Share}_{t-12})$. PLMT (switchers) is an indicator variable equal to one for funds that introduce fees or levies in 2018-2019 and have at least one quantity-based tool (suspensions, gates, or redemption in kind) and zero for funds with neither fees nor levies, but at least one of the QLMTs. High Sensitivity is the sample of funds with an above-the-median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include the number of funds in a fund family, ln of total assets, 12-month rolling volatility of fund flows, leverage, and a dummy variable for investment grade funds. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

results from this cross-sectional analysis in Table 5. Each of the three panels looks at the change in the ownership of different investor bases around the introduction of PLMTs in the sample of switchers as compared to the overall control sample. We include only the treatment dummy in the first column and control for the same fund-level characteristics in the second column as in our analysis so far (excluding, naturally, the investor base which is now our dependent variable). Finally, we perform a split sample analysis based on the flow-to-performance sensitivity classification in columns (3) and (4), respectively. Table 5 shows no significant changes in the investor base around the introduction of price-based tools as compared to the control group. This, coupled with the fact that the two groups have, on average, comparable shares of investor ownership in the period before March 2020 (see Table 3), further mitigates concerns that our results are only driven by investor selection and not the presence of different LMTs.

Table 6: Outflows versus inflows

	High sensitivity			Low sensitivity		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	$\frac{Outflows}{TA}$	$\frac{Inflows}{TA}$	Prob neg net flows	$\frac{Outflows}{TA}$	$\frac{Inflows}{TA}$	Prob neg net flows
PLMT × March 2020	-0.033*	0.041***	-0.303***	-0.008	-0.020	0.045
	(0.019)	(0.014)	(0.084)	(0.027)	(0.028)	(0.081)
Fund Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls X March 2020	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,310	5,310	5,310	4,487	4,487	4,487
R-squared	0.205	0.317	0.323	0.191	0.217	0.432

The dependent variable in columns (1) and (4) is *Outflows/TA*, defined as the monthly redemptions from a fund divided by the fund's total net assets in the previous month. The dependent variable in columns (2) and (5) is *Inflows/TA*, defined as the monthly new subscriptions into a fund divided by the fund's total net assets in the previous month, while in columns (3) and (6) it is a dummy equal 1 if the fund experienced a negative net flow in a given month, and 0 otherwise. PLMT is an indicator variable equal to one for funds with fees or levies and at least one of the QLMTs (suspensions, gates, or redemption in kind) and 0 for funds with neither fees nor levies, but at least one of the QLMTs. March 2020 a dummy variable equal to 1 in March 2020 and zero from January 2018 to February 2020. High Sensitivity is the sample of funds with an above-the-median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include the lags of net flows to total assets, fund return, number of funds in the family, log of assets, volatility of flows, leverage, a dummy for investment grade funds, the share of assets owned by banks and investment funds, as well as the share owned by pension funds and insurance corporations. Fund-level controls X March 2020 represents an interaction between the controls and the March 2020 dummy variable. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

4.3 Outflow and inflows

The results in the previous section show that funds with anti-dilution levies or redemption fees experienced higher net flows during March 2020. One natural question is to investigate whether the higher net flows are due to lower outflows or higher inflows or both. The analysis in Table 6 estimates Eq. (1) by considering as dependent variables outflows to total assets, as well as inflows to total assets. Similar to previous results we present the estimates for the low versus the high-sensitivity funds separately. Outflows and inflows are both positive numbers, with zeros recorded for funds that experienced no outflows or inflows in a given month.

We find that PLMT funds had both relatively lower outflows (column (1)) and higher inflows (column (2)) in March 2020 as compared to the control group. Moreover, column (3) shows that these funds also have a disproportionally lower probability of having negative net flows, where the dependent variable in this column is an indicator variable equal to 1 if net flows are negative and 0 if they are positive. Furthermore, as before, this effect is only observed in the high-sensitivity sample of funds.

Table 7: Correlation between outflow and inflows

Dependent variable: Inflows/TA	(1)	High sensitivity (2)	Low sensitivity (3)
Outflows/TA	0.447***	0.268***	0.327**
	(0.037)	(0.087)	(0.116)
Outflows/TA × March 2020	-0.140*	-0.135	-0.095
	(0.078)	(0.101)	(0.134)
PLMT × Outflows/TA × March 2020		0.267***	0.081
		(0.098)	(0.133)
PLMT × March 2020		-0.020*	-0.021
		(0.011)	(0.018)
Fund-level controls	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes
Observations	12,062	5,797	4,872
R-squared	0.375	0.393	0.275

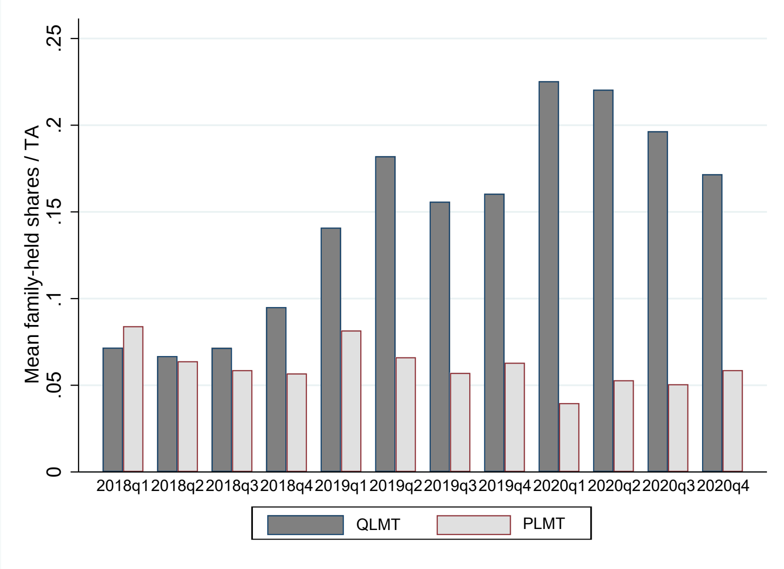
The dependent variable is *Inflows/TA*, defined as the net monthly inflows of capital into a fund divided by the fund's total net assets in the previous month. PLMT is an indicator variable equal to one for funds with fees or levies and at least one of the QLMTs (suspensions, gates or redemption in kind) and zero for funds with neither fees nor levies, but at least one of the QLMTs. March 2020 a dummy variable equal to one in March 2020 and zero from January 2018 to February 2020. High Sensitivity is the sample of funds with an above-the-median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include the lags of net flows to total assets, fund return, number of funds in the family, log of assets, volatility of flows, leverage, a dummy for investment grade funds, the share of assets owned by banks and investment funds, as well as the share owned by pension funds and insurance corporations. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

The findings in Table 6 suggest that the presence of PLMTs affects both inflows and outflows in periods of distress. One channel through which this happens is via changes in the correlation between inflows and outflows. Specifically, in periods of distress, we might expect a negative correlation between inflows and outflows, as potential investors are concerned about the impact that outflows will have on the fund's NAV. However, in funds where the cost of withdrawals is more likely to be borne by the investors who execute the transaction, this concern is reduced.

Table 7 presents evidence of this mechanism. In column (1), we find that the correlation between inflows and outflows is generally positive, but significantly lower in March 2020, consistent with a first mover advantage reasoning. However, when we include an interaction term with the treatment condition (PLMT × Outflows/TA × March 2020), we find that among funds with fees or levies, the correlation becomes positive again (column (2)). This suggests that the presence of PLMTs affects the strategic complementarities in investors' actions. Again, the results hold for funds that are more likely to be characterized by such strong complementarities, i.e. funds with a high sensitivity of flows to performance.

One concern with the results above is that the observed increase in inflows is the result

Figure 9: Proportion of fund share held by other funds in the same family



The figure shows the proportion of fund shares held by other funds in the same family in each quarter from the first quarter of 2018 to the last quarter of 2020.

of intra-family liquidity support. For example, Bhattacharya, Lee, and Pool (2013) show that affiliated funds of mutual funds provide an insurance pool against temporary liquidity shocks to other funds in the family. While we do not observe investor-level information in our dataset, we can compute, for each individual fund, the share of assets owned by other funds in the same family. Specifically, for each fund belonging to a fund family, we can compute the proportion of its fund shares that are held by other funds in the same family. We then plot the evolution of the average proportion of fund shares held by other funds in the family for the treated and control funds. Figure 9 shows that, over the period 2018-2020, funds in the control group have, on average, a higher share of their equity held by other funds in the family. We observe asset ownership only at the quarterly level, so to compare the increase in cross-family ownership we compare the last quarter of 2019 to the first quarter of 2020 (ending in March). We observe that funds in the treated group did not experience an average increase in intra-family ownership, if anything the ratio appears to be decreasing in 2020Q1 as compared to 2019Q4 in this group. On the other hand, the proportion of shares held within the family increases visibly in the control group suggesting increased liquidity support in this group. These descriptive statistics suggest that the increase in inflows observed among PLMT funds is not likely the result of cross-family liquidity support.[21]

[21] It should be noted that we only considered ownership by funds in the same family that are domiciled in Ireland. If there are funds in the same family legally domiciled in another country, we do not observe this ownership data. However, this is not likely to be a significant number of funds, as management companies incorporate umbrella funds (fund families) as ICAVs under Irish law.

4.4 Fund performance

A large literature documents that portfolio adjustments due to redemptions are costly and can dilute fund performance (Goldstein et al., 2017). Given the mitigating effect on outflows of price-based LMTs documented in the previous section, one would expect that treated funds also see superior returns following the shock. To test this hypothesis, we estimate Eq. (4) using the monthly return as the dependent variable, as follows:

$$\Delta NAV_{i,t} = \alpha_i + \mu_t + \sum_{q=2019m3}^{2020m5} \beta_q \times 1_{t=q} \times \text{PLMT}_i + \theta' X_{i,t-1} + \epsilon_{i,t}, \tag{5}$$

where $\Delta\text{NAV}_{i,t}$ is the percentage change in NAV in month t with respect to $t-1$. The coefficient β_q captures the difference in returns between PLMT and QLMT funds in each month and is presented in Figure 10.[22] Eq. (5) controls for several fund characteristics, including the lag of total assets and a series of dummy variables that reflect investment strategy: (i) the fund's investment rating, (ii) an indicator variable for bond funds (as opposed to mixed) as well as (iii) indicator variables for regional strategy (regions included being Europe, Americas, Emerging Markets, Asia Pacific). In separate regressions, we also control for interaction terms between these fund characteristics and the month dummy variables. This allows us to compare the performance of funds with the same investment strategy in a given month. Finally, we also include a separate regression when we include a triple interaction term between the month indicators, the treatment dummy and the high sensitivity indicator. This interaction term captures the difference between treatment and control in each month relative to the baseline one in the high versus the low sensitivity sample of funds.

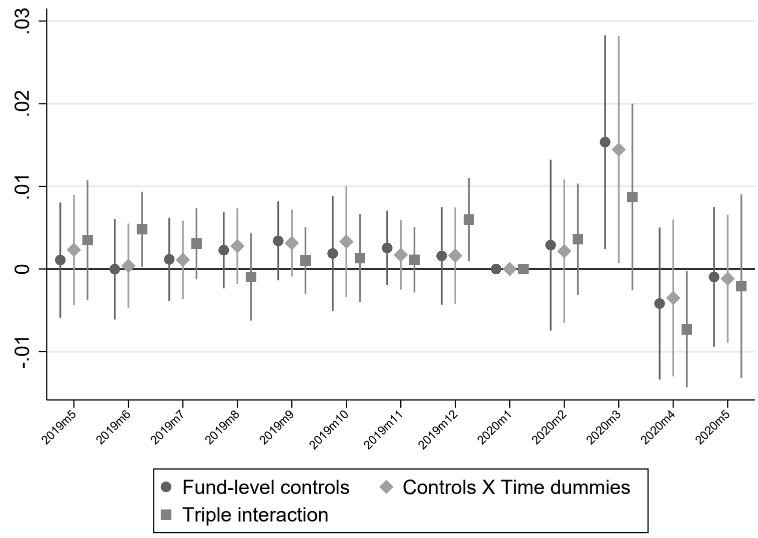
We observe in Figure 10 that both prior to and post-March 2020, there are no statistically significant differences in performance between the PLMT and QLMT funds. However, in March 2020, treated funds see a significantly higher performance. This performance is less robustly estimated when we include the triple interaction term suggesting that both high and low-sensitivity funds saw higher changes in their NAV.

4.5 Selling pressure and portfolio rebalancing

We turn next to the impact of the COVID-19 shock on the asset holdings of mutual funds with different types of LMTs. Previous evidence shows that, when faced with redemption risk, asset managers actively manage the liquidity of funds' portfolios. For example, Morris, Shim, and Shin (2017) show that bond funds do not necessarily reduce cash holding to meet investor outflows, but would very often sell other less liquid assets. This cash hoarding behaviour is more pronounced among less liquid funds and can amplify fire sales during periods of market distress (see also Chakraborty et al., 2022; Jiang et al., 2022). Similarly, Jiang, Li, and Wang (2021) show that, during tranquil market conditions, corporate bond funds reduce liquid asset holdings to meet redemptions, whereas during market turmoil they tend to scale down their liquid and illiquid assets proportionally to preserve portfolio liquidity. This also suggests that funds' liquidity management can introduce fragility into

[22] Appendix Table 17 shows the estimates of the baseline diff-in-diff model in Eq. (1) for fund performance using the March 2020 dummy, as opposed to indicators for each month as in Eq. (5).

Figure 10: Fund performance



The figure shows the coefficient estimates of β_q in Eq. (5) for each month for three separate regressions that include (1) only lagged fund-level controls; (2) interactions between fund-level controls and month dummy variables as well as (3) a triple interaction term between the treatment indicator, the month dummy variables and the high sensitivity indicator. January 2020 is considered the baseline month and is dropped. 95% confidence intervals are shown.

asset prices. For instance, Jiang et al. (2022) show that bonds held disproportionally by more illiquid funds experienced more negative returns and larger reversals around March 2020.

As our evidence thus far suggests that price-based LMTs mitigate redemption risk, we expect this to also have consequences in terms of the liquidity structure of funds' portfolios following the COVID-19 shock. Specifically, facing a lower redemption risk, PLMT funds should experience a lower pressure to build up cash reserves or hold more liquid assets to meet future outflows. At the same time, given the severe distress in the corporate bond market during March 2020 (Haddad et al., 2020; Kargar et al., 2020), we expect PLMT funds to sell fewer bonds that traded at a discount, such as more illiquid corporate bonds. This, in turn, can have implications for the price fragility of the assets held by these funds at the peak of market distress.

To address these questions, we extend our dataset to include the asset holdings of funds. We focus in this subsection on the sample of corporate bond funds only i.e., excluding the mixed funds, since our goal is to understand how the liquidity structure of funds' portfolios changes and the subsequent consequences of this portfolio rebalancing on the yields of the bonds held in the portfolio. We obtain data on quarterly asset holdings reported by Irish-domiciled funds to the Central Bank of Ireland (Money Market and Investment Funds statistics). This database contains ISIN-level information on all the asset holdings of reporting funds. For each bond i we collect information on the holding amount by each fund j at the end of March 2020 (Q1) and end of December 2019 (Q4) and compute the change in portfolio shares within this period.

We start by investigating portfolio rebalancing across assets with different levels of

Table 8: Portfolio rebalancing

Dependent variable	ΔCash/TA		Δ Corporate bonds/TA		Δ Illiquid bonds/TA		Δ Bonds/TA		Δ Corporate Bonds/TA	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PLMT	-0.300**	-0.348**	0.249***	0.280**	0.208**	0.256**				
	(0.151)	(0.165)	(0.089)	(0.116)	(0.086)	(0.108)				
High sensitivity		-0.487		-0.195		-0.323**				
		(0.363)		(0.131)		(0.155)				
PLMT × High Sensitivity		0.430		-0.057		0.071				
		(0.404)		(0.185)		(0.186)				
PLMT × Illiquidity							0.023***	0.024***	0.024***	0.024***
							(0.007)	(0.007)	(0.007)	(0.008)
Illiquidity × High Sensitivity								0.036*		0.027
								(0.021)		(0.021)
PLMT × Illiquidity × High Sensitivity								-0.018		-0.010
								(0.024)		(0.024)
Observations	383	383	396	396	396	396	108,451	108,451	101,983	101,983
R-squared	0.041	0.046	0.068	0.073	0.080	0.077	0.462	0.465	0.460	0.460
Fund-level controls	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Bond FE	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Fund FE	No	No	No	No	No	No	Yes	Yes	Yes	Yes

The dependent variable in columns (1)-(6) is the percentage change in the share of asset class c in fund j's portfolio, while in columns (7)-(10) it is the change in portfolio share of asset i from December 2019 to March 2020. Columns (7)-(8) include all bonds held by the sample of corporate bond funds considered, while columns (9)-(10) include only the subsample of corporate bonds. PLMT is an indicator variable equal to one for funds with fees or levies and at least one of the QLMTs (suspensions, gates, or redemption in kind) and zero for funds with neither fees nor levies, but at least one of the QLMTs. Illiquidity refers to bonds with a Markit score of 2 or higher. High Sensitivity is an indicator equal to one for funds with an above-the-median sensitivity of flows to performance over the period 2014-2018. Fund-level controls are measured in December 2019 and include fund return, number of funds in the family, log of assets, volatility of flows, leverage, a dummy for investment grade funds, the share of assets owned by banks and investment funds, as well as the share owned by pension funds and insurance corporations. Robust standard errors in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

liquidity from December 2019 to March 2020. Specifically, we look at the change in the portfolio share of five types of assets: cash, government and corporate bonds, as well as illiquid corporate and government bonds, respectively. To this end, we estimate a cross-sectional model where we regress the percentage change in the share of asset class c in fund j's portfolio on our treatment dummy, as follows:

$$\%\Delta Share_{c,j} = \alpha + \beta_1 PLMT_j + \theta' X_j + \epsilon_j, \tag{6}$$

where $\%\Delta Share_{c,j}$ is measured as $\ln(Share_{c,j,March}/Share_{c,j,Dec19})$ and the portfolio share is computed as the ratio of portfolio holdings of asset class c to total assets: $Share_{c,j,t} = \frac{\sum_{i \in c} \text{Holding amount}_{i,j,t}}{\text{Total Assets}_{j,t}}$. We estimate the model in (6) separately for each asset class c. We capture a bond's liquidity through its IHS Markit liquidity score (which is a score from 1 to 5, with 1 being the most liquid and 5 being the least liquid).[23] We define a bond to be illiquid if it has a Markit score of 2 or higher and liquid if the score is 1.[24] We also control for the same fund-level characteristics as in previous sections, which include fund return, number of funds in family, total assets, volatility of flows, leverage, a dummy for investment grade funds, the share of assets owned by banks and investment funds, the share owned by pension funds and insurance corporations as well as households, all measured in December 2019.

The results are presented in columns (1)-(6) of Table 8 and point to significant differences in portfolio rebalancing between PLMT and QLMT funds. Specifically, PLMT funds experience a significantly lower increase in Cash/TA, which suggests that the pres-

[23]Markit bond liquidity score is computed based on several criteria, which include market depth (such as the number of dealers quoting and the number of pricing sources); bid-ask spread; bond maturity; as well as a measure of shadow liquidity for bonds that are not as widely quoted, but are priced and traded off the same curve as liquid assets.

[24]The liquidity threshold is driven by the distribution of bonds in our sample, as 71% of these bonds have a score of 1.

ence of anti-dilution levies or redemption fees is associated with less pressure to increase the share of cash to Total assets to meet redemptions after the COVID-19 shock. Aggregate evidence shows that the share of cash to total assets in bond funds went up in March 2020, which implies that funds sold more assets than needed to meet redemptions thereby putting additional pressure on bond prices (Schrimpf, Shim, and Shin, 2021). This was also the case in our sample, with both treatment and control groups holding a higher average share of cash to TA at the end of March compared to the previous quarter. However, the evidence in Table 8 suggests PLMT funds increased their share of cash holding to a lesser extent. As a consequence, they rebalanced their portfolios towards holding more corporate bonds (columns (3)-(4)), and, in particular, illiquid ones (columns (5)-(6)). For each asset class, we also include a specification where we interact the treatment dummy with the high-sensitivity one (see columns (2), (4) and (6)), however, this interaction term is not robustly estimated, suggesting both high and low-sensitivity funds adjusted their portfolios towards holding less liquid assets.

We then confirm these fund-level results at the bond-fund level, which allows us to also control for bond and fund fixed effects. Specifically, the dependent variable in columns (7)-(10) of Table 8 is the percentage change in the share of bond i in the portfolio of fund j, computed as $\%\Delta Share_{i,j} = \ln(Share_{i,j,March}/Share_{i,j,Dec19})$ with $Share_{i,j,t} = \frac{\text{Holding amount}_{i,j,t}}{\text{Total Assets}_{j,t}}$. We regress this on an interaction term between our treatment indicator and an indicator for whether the bond is illiquid (*Illiquidity*). The results in columns (7)-(10) are consistent with the fund-level analysis. Specifically, in the entire sample of bonds (column (7)-(8)), the interaction term is positive, suggesting PLMT increased the share of illiquid bonds disproportionally more than QLMT funds. Furthermore, this result is driven by the sub-sample of corporate bonds (columns (9)-(10)). Similar to the fund-level results, we do not find any statistically significant difference between high versus low-sensitivity funds (see columns (8) and (10)). This is intuitive as low-sensitivity PLMT funds would also have fewer incentives to re-balance their portfolios towards more liquid assets.

Overall, the results in Table 8 suggest PLMT funds sold disproportionally fewer illiquid bonds as a share of total assets and, consequently, held more illiquid portfolios afterwards. We investigate next whether these portfolio rebalancing decisions had any implications for the price fragility of the assets held by our treatment and control funds.

To this end, we focus on a sample of corporate bonds that were held by both treatment and control funds in December 2019. For this sample of corporate bonds, we first investigate whether our treatment and control funds sold off a significantly different share of a bond's outstanding around March 2020. At difference with our analysis in Table 8 where we looked at the share of different types of bonds in the portfolio of the particular fund, we focus here on whether the differential sell-off of a bond held by treated and control funds represented a significant share of the bond's outstanding amount. Specifically, we look at changes in the holding amount of bond i by fund j from December 2019 to March 2020 as a share of the total amount outstanding across our sample of funds, as follows:

$$\frac{\Delta\text{Holdings}_{i,j}}{\text{Outstanding amount}_i} = \alpha_i + \beta_1 PLMT_j + \theta' X_j + \epsilon_{i,j}, \tag{7}$$

where the dependent variable is the change in holdings of bond i by fund j from December

Table 9: Changes in bond holdings

	(1)	(2)	(3)	(4)	(5)	(6)
PLMT	0.0001***	0.0001***				
	(0.000)	(0.000)				
High Sensitivity		-0.0004***				
		(0.000)				
PLMT × High Sensitivity		0.0002***				
		(0.000)				
PLMT × Illiquidity			0.0002***	0.0002***	0.0002***	0.0002***
			(0.000)	(0.000)	(0.000)	(0.000)
PLMT × High Sensitivity × Illiquidity				-0.0001		-0.0001
				(0.000)		(0.000)
Observations	91,378	91,378	91,371	91,371	86,334	86,334
Fund-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	No	No	Yes	Yes	Yes	Yes

The dependent variable is the log change in holdings of bond i by fund j from December 2019 to March 2020, scaled by the amount outstanding of the bond. PLMT is an indicator variable equal to one for funds with fees or levies and at least one of the QLMTs (suspensions, gates or redemption in kind) and 0 for funds with neither fees nor levies, but at least one of the QLMTs. High Sensitivity is an indicator variable equal to one is the fund has an above-the-median sensitivity of flows to performance over the period 2014-2018. Illiquid Bond is an indicator variable equal to one if a bond is illiquid based on its Markit liquidity score. Fund-level controls include the change in total assets from December 2019 to March 2020, as well as fund return, number of funds in the family, log of assets, volatility of flows, leverage, a dummy for investment grade funds, the share of assets owned by banks and investment funds, the share owned by pension funds and insurance corporations measured in December 2019. Robust standard errors in parenthesis.*** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

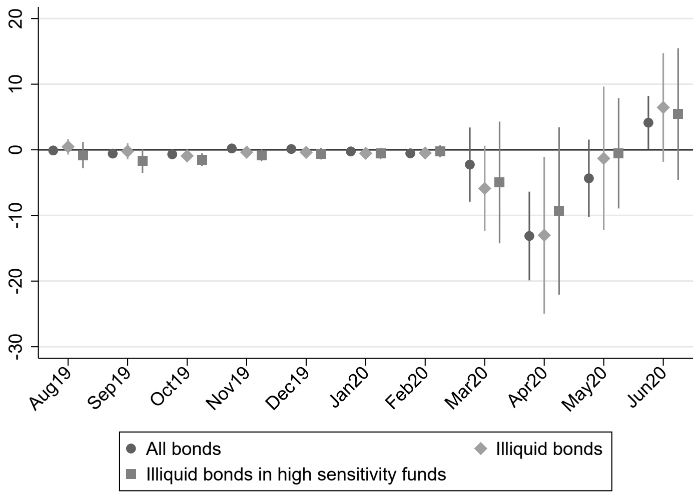
2019 to March 2020 as a share of the outstanding amount of bond i in December 2019. Our main independent variable is the treatment variable, $PLMT_j$, and we control for the same set of fund-level characteristics as in the flow level analysis measured in December 2019. We also include the change in total assets from December to March to account for the differences in net flows during the period. All specifications include bond-fixed effects (α_i), which control for the riskiness and performance of the bond during the period, allowing us to obtain identification from within bond variation across funds with different LMTs.

The results are presented in Table 9 and confirm our flow-level analysis in the previous section: PLMT funds, which experienced fewer net redemptions, reduce their bond holdings by less (the change in holding from March 2020 to December 2019 is higher) as compared to QLMT funds holding the same bonds in their portfolio. Moreover, the change in bond holdings is even larger among the sample of high-sensitivity funds, which is in line with the results in previous sections.

We then turn to the liquidity of the bonds sold. In columns (3)-(6), we interact the PMLT indicator with our measure of bond illiquidity. We find that PLMT funds sold, on average a lower share of illiquid bonds relative to their outstanding amount, as compared to QLMT funds. Importantly, the inclusion of the interaction term PLMT × Illiquidity in columns (3)- (6) also allows us to also control for fund fixed effects in this specification.

The results in Table 9 suggest that the availability of price-based liquidity management tools mitigates the selling pressure on the bonds held by the funds with access to such tools. Furthermore, this result is strongest among the more illiquid bonds. We investigate next, whether this lower outflows-induced selling pressure can, in turn, reduce the fragility of bonds' prices around March 2020, in particular for those held disproportionally by our sample of Irish funds. To investigate this effect, we follow Jiang et al. (2022) and compute a measure of the exposure of a bond to outflows-induced selling based on a

Figure 11: Impact on bond yields



The figure shows the coefficient estimates of γ in Eq. (9) in each month. It presents coefficient estimates for (1) the entire sample of bonds held by PLMT and QLMT funds, (2) the subsample of illiquid bonds only, and (3) the subsample of illiquid bonds in high-sensitivity funds. 90% confidence intervals are presented.

holdings-weighted average across funds with PLMTs versus QLMTs as follows:

$$Exposure_{i,t} = \frac{\sum_{j=1}^{J} \text{Holding amount}_{i,j,t} \times PLMT_j}{\text{Outstanding Amount}_i}, \tag{8}$$

whereby J are all Irish funds.

As such, the measure in (8) implies that bonds with high *Exposure* are held disproportionately by the sample of Irish funds that report having PLMTs. Given the lower outflows-induced selling pressure documented in Table 9, we then expect bonds with a high *Exposure* measure to also exhibit a lower change in yield around March 2020. To show this, we look at the average monthly changes in yields in the sample of bonds held by both treatment and control funds and estimate the following cross-sectional regressions in each month:

$$\Delta Yield_{i,t} = \alpha_{Issuer} + \gamma Exposure_{i,t} + \theta' X_{i,j,t} + \epsilon_{i,t}, \tag{9}$$

where $\Delta Yield_{i,t}$ is the average monthly change in yield of bond i in the period August 2019- June 2020. In $X_{i,j,t}$, we control for the fraction of a bond's outstanding amount held by all the Irish-domiciled funds in our sample (i.e., $\frac{\sum_{j=1}^{J} \text{Holding amount}_{i,j,t}}{\text{Outstanding Amount}_i}$), as well as the share of a bond i held by the sample of PLMT funds in the total holdings of Irish domiciled funds (i.e., $\frac{\sum_{j=1}^{J} \text{Holding amount}_{i,j,t} \times PLMT_j}{\sum_{j=1}^{J} \text{Holding amount}_{i,j,t}}$). The latter variable controls for the selection of Irish PLMT funds into more pro-cyclical or illiquid bonds (given that the presence of the price-based tools mitigates investor runs). Additionally, we include indicator variables for a bond's investment grade rating and liquidity (captured by the Markit score).

The coefficient γ in (9) captures the change in yield of bonds disproportionally held by Irish funds with PLMTs and is presented in Figure 11. We present this coefficient for the overall sample of bonds held by our treatment and control groups as well as for a subsample of illiquid bonds measured by their Markit liquidity score. We further interact our measure of exposure with the high-sensitivity dummy variable to capture the differential effect among the funds for which PLMTs had the strongest effect on net flows in March 2020. Across all specifications, the results in Figure 11 suggest that bonds held by PMLTs experienced a lower change in yield during March-May 2020, with the strongest impact in April 2020. Importantly, there is no difference in yields before March 2020, with the coefficient estimate being very close to zero in all prior months. The vertical axis is expressed in percentage points, so considering the average measure of exposure of 1.01% of the amount outstanding, the coefficient estimate in April 2020 implies, on average, a 13%×1.01%=0.13% lower yield across all bonds in the sample. Alternatively, if we consider the standard deviation of the exposure measure of 0.02, then one standard deviation increase in exposure is equivalent to a 0.26 basis points lower yield for bonds held by PLMT funds.

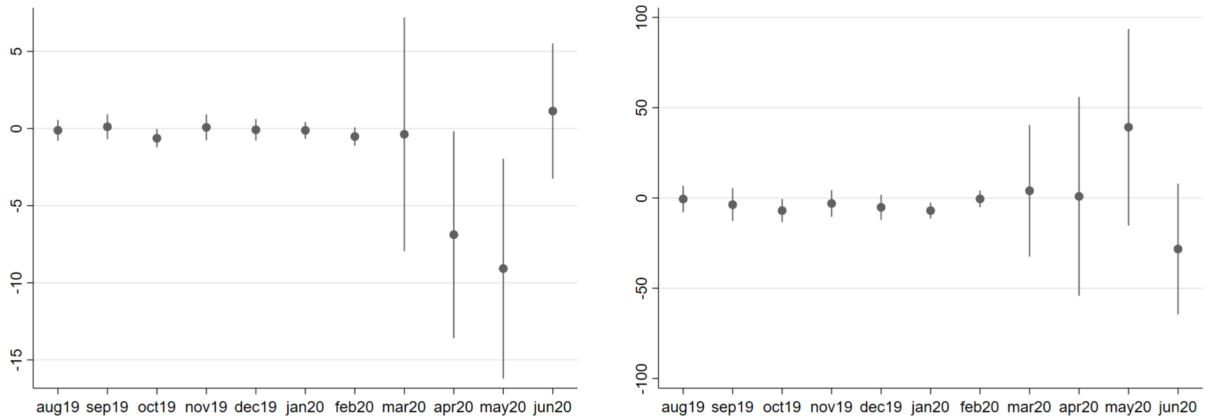
The evidence in Figure 11 suggests that the significantly lower selling pressure documented in Table 9 resulted in lower price volatility (smaller change in yields) for bonds held by Irish PLMT funds, particularly if these funds held a larger fraction of the bond's outstanding amount. The magnitude of the effect is small since our sample of Irish-domiciled mutual funds holds a rather small fraction of the total amount outstanding of each bond in their portfolio. In Figure 12, we repeat the analysis by splitting the sample of bonds around the average fraction of the amount outstanding that is held by our sample of funds. Specifically, Figure 12a) shows the estimate of γ in Eq. (9) for the sample of funds with an above-the-average fraction of holdings in the total amount outstanding ($\frac{\sum_{j=1}^{J} \text{Holding amount}_{i,j,t}}{\text{Outstanding Amount}_i}$), while Figure 12b) for those below the average, respectively. As expected, the effect is observed only in the former subsample and the magnitude is larger: in this subsample the average holdings is 3% of the amount outstanding, implying a 6.88%×0.03=0.2% lower yield for bonds held by PLMT as compared to those held by QLMT.

Overall, the results in Table 9 and Figures 11-12 point to an important effect of funds' liquidity management strategy on the fragility of the assets held in their portfolio during episodes of market distress such as the COVID-19 shock. We show that funds with price-based LMTs not only sold fewer illiquid bonds, but this also translated into less price fragility of the bonds that were disproportionally held by these funds.

Overall, the results in this subsection suggest that the presence of price-based LMTs has important consequences for portfolio rebalancing following episodes of market distress. Our treated group rebalance their portfolio towards less liquid assets suggesting that the mitigating effect of PLMTs on net flows is also associated with a lower selling pressure on illiquid assets and price volatility of these assets. This suggests that the availability of price-based liquidity management tools in open-ended funds can have important implications for financial stability. Similar evidence is provided in King and Semark (2022) who perform a simulation exercise on the universe of UK corporate bond funds and find that a widespread use of swing pricing among these funds would reduce the amplification of outflow-induced shocks to investment grade bond spreads by around 8%, and by around 22% for high yield bonds.

Figure 12: Impact on bond yields: split sample analysis

(a) Above average holdings (b) Below average holdings



The figure shows the coefficient estimates of β in Eq.(9) in each month. Figure a) is estimated on the subsample of funds with an above-the-average fraction of holdings in the total amount outstanding, while Figure b) for those with a below-the-average, respectively. 90% confidence intervals are presented.

5 Conclusions

The investment fund sector has seen a dramatic growth in its assets under management over the last two decades, which has raised concerns over its financial stability. As a result, regulators have encouraged the use of liquidity management tools to mitigate the pressure on funds' liquidity during episodes of massive investor withdrawals. However, there is limited empirical evidence of the effectiveness of such tools.

In this paper, we investigate the role of different liquidity management tools in mitigating financial fragility in the investment fund industry during the COVID-19 episode of market distress in March 2020. We document the availability of five types of LMTs in a sample of Irish-domiciled funds investing in corporate bonds. We show that the availability of tools has increased since 2018 and a large majority of funds report quantity-based tools such as redemption gates, suspension of dealings and redemption in kind. However, since these tools are less frequently employed, we focus our analysis on the effectiveness of price-based tools such as anti-dilution levies or redemption fees.

We show that funds with access to redemption fees or levies experienced higher net flows during March 2020 as compared with funds with only quantity-based tools. This effect is driven by a sample of funds with a high sensitivity of flows to performance, which are more susceptible to investor runs. Moreover, we document that the presence of liquidity management tools has also important consequences on portfolio rebalancing following episodes of market distress. Funds with price-based LMTs rebalance their portfolio towards less liquid assets suggesting that the mitigating effect of such tools on net flows is also associated with lower selling pressure on illiquid assets.

Overall, our results hold important policy implications and suggest that fostering the availability of price-based liquidity management tools helps to contain the financial fragility of open-ended funds.

References

Bertrand, M., E. Duflo, and S. Mullainathan (2004). How much should we trust differences-in-differences estimates? *The Quarterly journal of economics 119*(1), 249–275.

Bhattacharya, U., J. H. Lee, and V. K. Pool (2013). Conflicting family values in mutual fund families. *The Journal of Finance 68*(1), 173–200.

Chakraborty, I., E. Ferracuti, J. C. Heater, and M. Phillips (2022). The consequences of fund-level liquidity requirements. *Available at SSRN*.

Chen, Q., I. Goldstein, and W. Jiang (2010). Payoff complementarities and financial fragility: Evidence from mutual fund outflows. *Journal of Financial Economics 97*(2), 239–262.

Chevalier, J. and G. Ellison (1997). Risk taking by mutual funds as a response to incentives. *Journal of Political Economy 105*(6), 1167–1200.

Cima, S., N. Killeen, V. Madouros, et al. (2019). Mapping market-based finance in ireland. Technical report, No. 17/FS/19, Central Bank of Ireland.

Daly, P., K. Moloney, et al. (2017). Liquidity & risk management: Results of a survey of large irish-domiciled funds. *Central Bank of Ireland Quarterly Bulletin 3*, 48–62.

Dunne, P. G. and R. Giuliana (2021). Do liquidity limits amplify money market fund redemptions during the covid crisis?

ESMA (2020). Recommendation of the european systemic risk board (esrb) on liquidity risk in investment funds. Technical report, ESMA34-39-1119/ November 2020.

ESRB (2017). Eu shadow banking monitor. Technical report, No 2 / May 2017.

Falato, A., I. Goldstein, and A. Hortaçsu (2021). Financial fragility in the covid-19 crisis: The case of investment funds in corporate bond markets. *Journal of Monetary Economics 123*, 35–52.

Goldstein, I., H. Jiang, and D. T. Ng (2017). Investor flows and fragility in corporate bond funds. *Journal of Financial Economics 126*(3), 592–613.

Grill, M., L. M. Vivar, and M. Wedow (2022). Mutual fund suspensions during the covid-19 market turmoil-asset liquidity, liquidity management tools and spillover effects. *Finance Research Letters 50*, 103249.

Haddad, V., A. Moreira, and T. Muir (2020). When selling becomes viral: Disruptions in debt markets in the covid-19 crisis and the fed's reponse. Technical report, National Bureau of Economic Research.

Hainmueller, J. (2012). Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies. *Political analysis 20*(1), 25–46.

Huang, J., K. D. Wei, and H. Yan (2007). Participation costs and the sensitivity of fund flows to past performance. *The Journal of Finance 62*(3), 1273–1311.

IMF (2022). Global financial stability report. Technical report.

Jiang, H., D. Li, and A. Wang (2021). Dynamic liquidity management by corporate bond mutual funds. *Journal of Financial and Quantitative Analysis 56*(5), 1622–1652.

Jiang, H., Y. Li, Z. Sun, and A. Wang (2022). Does mutual fund illiquidity introduce fragility into asset prices? evidence from the corporate bond market. *Journal of Financial Economics 143*(1), 277–302.

Jin, D., M. Kacperczyk, B. Kahraman, and F. Suntheim (2022). Swing pricing and fragility in open-end mutual funds. *The Review of Financial Studies 35*(1), 1–50.

Kargar, M., B. Lester, D. Lindsay, S. Liu, P.-O. Weill, and D. Zúñiga (2020). Corporate bond liquidity during the covid-19 crisis. Technical report, National Bureau of Economic Research.

Kashyap, A., D. Kohn, and D. Wessel (2020). What is swing pricing? *Brookings, August 2020*.

King, B. and J. Semark (2022). Reducing liquidity mismatch in open-ended funds: a cost-benefit analysis.

Ma, Y., K. Xiao, and Y. Zeng (2020). Mutual fund liquidity transformation and reverse flight to liquidity. *Available at SSRN 3640861*.

Morris, S., I. Shim, and H. S. Shin (2017). Redemption risk and cash hoarding by asset managers. *Journal of Monetary Economics 89*, 71–87.

Pástor, L. and M. B. Vorsatz (2020). Mutual fund performance and flows during the covid-19 crisis. *The Review of Asset Pricing Studies 10*(4), 791–833.

Roth, J., P. H. Sant'Anna, A. Bilinski, and J. Poe (2022). What's trending in difference-in-differences? a synthesis of the recent econometrics literature. *arXiv preprint arXiv:2201.01194*.

Schrimpf, A., I. Shim, and H. S. Shin (2021). Liquidity management and asset sales by bond funds in the face of investor redemptions in march 2020. *Available at SSRN 3799868*.

Sirri, E. R. and P. Tufano (1998). Costly search and mutual fund flows. *The journal of finance 53*(5), 1589–1622.

Timmer, Y. (2018). Cyclical investment behavior across financial institutions. *Journal of Financial Economics 129*(2), 268–286.

Appendix

A Variable definitions

Variable name	Definition
Fund-level variables	
$Netflow_t/TA_{t-1}$	Net flow in month t computed gross inflows minus outflows scaled by lagged total assets: $\frac{Inflows_t - Outflows_t}{TA_{t-1}}$
$Return_t$	Monthly fund return computed as the changed in NAV: $ln\left(\frac{NAV_t}{NAV_{t-1}}\right)$
PLMT	Dummy equal to 1 if a fund has access to either redemption fees or levies and at least one of the QLMT tools (suspensions, gates, and redemption in kind) and zero if the fund does not report either fees or levies, but at least one of the QLMT tools .
High Sensitivity	Dummy equal to one if a fund has an above the median flow-to-performance sensitivity from 2014 (or date of creation) to 2018 and zero otherwise.
Nb funds in family	The number of funds in the fund family
Ln Assets	Log of Total Assets
Volatility	Past volatility of fund flows computed as the rolling standard deviation of net flows to TA over the past 12 months
Liquidity/TA	A quarterly measure of fund liquidity computed as the ratio of cash & equivalents plus holdings of US & German government bonds to TA
Leverage	An indicator variable equal to one if the fund uses leverage and zero otherwise (self-reported by fund)
Share of Banks & IF	Percentage of fund shares owned by banks and other investment funds
Share of Pension & Insurance	Percentage of fund shares owned by pension funds and insurance corporations
Investment grade	An indicator variable equal to 1 if the fund has investment grade rating
BHC	An indicator equal to 1 if the fund's asset management company belongs to a bank holding corporation (based on ultimate ownership data in Orbis Bureau Van Dijk)

Family family-level variables*	
Ln(Assets)	Log of Total Assets in fund family
Nb funds in family	The number of funds in the fund family
Liquidity/TA	Weighted average level of liquidity measured as a fund's ratio of cash & equivalents plus holdings of US & German government bonds to TA
High Sensitivity	Weighted average share of high flow-to-performance sensitivity funds in the family.
Share of Banks & IF	Weighted average percentage of fund shares owned by banks and other investment funds
Share of Pension & Insurance	Weighted average of percentage of fund shares owned by pension funds and insurance corporations
Share of distressed	Weighted average of the percentage of funds that are in the lowest decile of net flows in a given month in a class of funds, i.e., equity, bond and mixed funds.

Family-level variables are weighted averages, where the weights are represented by the share of an individual's funds assets in the total assets of the family.

B Additional results

Table 10: Descriptive statistics for high versus low sensitivity funds

	High Sensitivity					Low Sensitivity				
	PLMT		QLMT			PLMT		QLMT		
Variable	Mean	Std. dev.	Mean	Std. dev.	t-test	Mean	Std. dev.	Mean	Std.	t-test
Funds in family	22.68	17.78	21.29	17.64	-0.42	20.10	18.85	19.45	15.15	-0.20
ln Assets	19.18	1.70	18.48	1.66	-2.21**	19.10	1.53	18.17	1.42	-3.35***
Return	0.00	0.01	0.00	0.02	-0.53	0.00	0.02	0.00	0.01	0.60
Fund age	4.41	3.78	6.29	6.68	2.31**	6.98	5.10	7.05	4.71	0.07
BHC belong	0.28	0.45	0.03	0.17	-3.22**	0.21	0.41	0.05	0.23	-2.27**
Ratings dummy	0.37	0.48	0.47	0.51	1.14	0.29	0.46	0.24	0.43	-0.68
Volatility flows	0.05	0.04	0.04	0.03	-1.59	0.04	0.04	0.05	0.05	0.70
Leverage dummy	0.54	0.50	0.68	0.47	1.48	0.53	0.50	0.55	0.50	0.29
Liquidity	0.04	0.09	0.08	0.13	1.93*	0.03	0.05	0.06	0.17	1.77*
Share Banks & IF	0.41	0.45	0.30	0.41	-1.25	0.41	0.45	0.32	0.44	-1.13
Share of Pension & Insurance	0.12	0.28	0.09	0.21	-0.61	0.11	0.26	0.14	0.31	0.67
Share of Households	0.01	0.005	0.006	0.005	-0.22	0.02	0.008	0.014	0.01	-0.09

The table presents descriptive statistics in December 2019. Return is the change in the monthly change in NAV. Volatility is the rolling standard deviation of net flows to TA over the past 12 months. Liquidity/TA is the ratio of cash and equivalents plus holdings of US and German government bonds to TA. Leverage is an indicator variable equal to one if the fund uses leverage and zero otherwise (self-reported by the fund). Share of Banks & IF is the percentage of fund shares owned by banks and other investment funds. Share of Pension & Insurance is the percentage of fund shares owned by pension funds and insurance corporations. Share of Households is the percentage of fund shares owned by households. Investment grade is an indicator variable equal to one if the fund has an investment grade rating. The last column shows the t-statistic of a t-test on the difference in means between PLMT and QLMT funds.*** shows significance at 1% level.

Table 11: Introduction of Liquidity Management Tools

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ln (Assets)	0.143***	0.161***	0.157***	0.166***	0.181***	0.163***	0.174***	0.165***	0.162***	0.166***	0.172***	0.157***
	(0.033)	(0.035)	(0.036)	(0.035)	(0.037)	(0.036)	(0.038)	(0.035)	(0.035)	(0.035)	(0.037)	(0.036)
Nb funds	0.010*	0.009	0.009	0.008	0.010	0.009	0.008	0.008	0.009	0.009	0.009	0.009
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Median Age	0.000	0.000	-0.000	0.000	0.000	0.000	0.000	-0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Liquidity/TA		-1.090*	-1.133*	-1.105	-1.247*	-1.109*	-1.086*	-1.257*	-1.091*	-1.114*	-1.173*	-1.094*
		(0.635)	(0.642)	(0.704)	(0.678)	(0.644)	(0.635)	(0.690)	(0.635)	(0.659)	(0.665)	(0.643)
High sensitivity		0.092	0.093	0.139	-0.058	0.075	0.108	0.079	0.091	0.078	0.039	0.094
		(0.166)	(0.167)	(0.172)	(0.165)	(0.183)	(0.166)	(0.166)	(0.167)	(0.167)	(0.165)	(0.166)
Share households			-1.250									
			(0.817)									
Share Pension&Insurance				-0.987*								
				(0.504)								
Share Banks & IF					0.429**							
					(0.169)							
Volatility						0.562						
						(2.188)						
Share distressed							-2.066					
							(1.908)					
Share equity funds								-0.033**				
								(0.013)				
Share bond funds									-0.002			
									(0.018)			
Share mixed funds										0.019		
										(0.017)		
Share of retail funds											-0.018	
											(0.011)	
Belong to BHC												0.159
												(0.189)
Observations	1,149	934	934	934	934	934	934	934	934	934	934	934

The table shows a series of cross-sectional probit regressions where the dependent variable is an indicator equal to one if the fund family introduced an LMT in 2019. All explanatory variables are weighted averages at the fund-family level by using the share of assets of the fund in the total assets of the fund family as a weight. Liquidity/TA is the average cash and liquid bonds to total assets in the fund family. High sensitivity is the average sensitivity of flows to performance during 2017-2018. Share Pension & Insurance is the average share of ownership by pensions and insurance companies. Share Banks & IF is the average share ownership by banks and investment funds. Share of Households is the average share ownership by households. Volatility is the average family volatility of flows over the last 12 months. Share of distressed is the average number of funds that rank in the lowest decile of net flows to total assets in any given month during 2017-2018. Belong to BHC is an indicator equal to one if the asset management company is owned by a bank-holding corporation. Robust standard errors in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

Table 12: Additional Control Variables for estimations in Table 4

Dependent variable: Net flow/TA	Full sample		High sensitivity		Low sensitivity		Full sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net flows/TA$_{t-1}$	0.128***	0.126***	0.143***	0.137***	0.121***	0.121***	0.138***	0.135***
	(0.025)	(0.025)	(0.028)	(0.029)	(0.038)	(0.039)	(0.025)	(0.026)
Return$_{t-1}$	-0.006	-0.006	-0.016	-0.026	-0.003	-0.002	-0.008	-0.006
	(0.006)	(0.008)	(0.014)	(0.042)	(0.005)	(0.005)	(0.006)	(0.007)
Nb funds in family	0.000	0.000	-0.000	-0.000	0.001	0.001	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Ln Assets$_{t-1}$	-0.045***	-0.042***	-0.048***	-0.045***	-0.033***	-0.031***	-0.043***	-0.041***
	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)	(0.008)	(0.005)	(0.005)
Volatility$_{t-1}$	0.000	0.009	0.021	0.038	-0.022	-0.028	0.012	0.023
	(0.043)	(0.043)	(0.047)	(0.047)	(0.075)	(0.078)	(0.042)	(0.043)
Leverage$_{t-1}$	0.003	-0.002	-0.002	-0.006	0.015	0.005	0.003	-0.003
	(0.007)	(0.008)	(0.007)	(0.006)	(0.012)	(0.014)	(0.007)	(0.008)
Investment Grade rating$_{t-1}$	-0.035***	-0.034***	-0.035***	-0.029*	-0.031***	-0.030***	-0.034***	-0.032***
	(0.011)	(0.012)	(0.008)	(0.016)	(0.011)	(0.011)	(0.010)	(0.011)
Share Banks & IF$_{t-1}$	0.079***	0.077***	0.093***	0.089***	0.045**	0.043**	0.078***	0.075***
	(0.012)	(0.011)	(0.014)	(0.014)	(0.018)	(0.017)	(0.012)	(0.011)
Share PF& Insurance$_{t-1}$	0.050*	0.049*	0.118***	0.118***	-0.004	-0.006	0.048*	0.046*
	(0.026)	(0.026)	(0.021)	(0.023)	(0.020)	(0.019)	(0.026)	(0.025)
Share households$_{t-1}$	0.169***	0.177***	0.188***	0.194***	0.079**	0.083**	0.161***	0.168***
	(0.043)	(0.042)	(0.071)	(0.071)	(0.039)	(0.040)	(0.048)	(0.047)
Return$_{t-1}\times$ March2020		0.002		0.015		-0.027		-0.005
		(0.010)		(0.042)		(0.112)		(0.009)
Fund age $\times$ March2020		-0.000		0.001		-0.001		-0.000
		(0.001)		(0.001)		(0.002)		(0.001)
Nb funds$\times$ March2020		-0.000		0.000		-0.000		-0.000
		(0.000)		(0.000)		(0.000)		(0.000)
BHC$_{t-1}\times$ March2020		-0.005		-0.013		-0.012		-0.012
		(0.014)		(0.013)		(0.027)		(0.013)
Ln Assets$_{t-1}\times$ March2020		-0.015***		-0.015***		-0.017**		-0.016***
		(0.003)		(0.003)		(0.007)		(0.003)
Volatility$_{t-1}\times$ March2020		-0.376**		-0.531***		-0.232		-0.384**
		(0.154)		(0.169)		(0.315)		(0.187)
Leverage$_{t-1}\times$ March2020		0.034***		0.041***		0.032*		0.037***
		(0.011)		(0.013)		(0.019)		(0.012)
Liquidity$_{t-1}\times$ March2020		-0.010		-0.022		0.051		-0.005
		(0.038)		(0.050)		(0.047)		(0.034)
Investment Grade$_{t-1}\times$ March2020		0.002		-0.004		-0.009		-0.004
		(0.013)		(0.013)		(0.021)		(0.014)
Share Banks &IF$_{t-1}\times$ March2020		0.029***		0.032***		0.010		0.030***
		(0.009)		(0.010)		(0.019)		(0.009)
Share households$_{t-1}\times$ March2020		0.080**		0.105		0.041		0.076*
		(0.036)		(0.100)		(0.035)		(0.041)
Share PF$_{t-1}\times$March2020		0.056**		0.056***		0.047		0.051**
		(0.024)		(0.020)		(0.043)		(0.025)
Observations	10,223	10,223	5,310	5,310	4,487	4,487	9,797	9,797
R-squared	0.259	0.269	0.292	0.305	0.202	0.213	0.252	0.262
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund-level controls X March 2020	No	Yes	No	Yes	No	Yes	No	Yes

Table 13: Net flows for Bond and Mixed funds separately

	Bond funds			Mixed funds		
	(1)	(2)	(3)	(4)	(5)	(6)
	High sensitivity	Low sensitivity	Full sample	High sensitivity	Low sensitivity	Full sample
PLMT × March 2020	0.074***	-0.033	-0.005	0.068***	-0.005	-0.012
	(0.027)	(0.026)	(0.024)	(0.018)	(0.020)	(0.019)
PLMT × High Sensitivity × March 2020			0.067**			0.078***
			(0.029)			(0.029)
High Sensitivity × March 2020			-0.058**			-0.060**
			(0.023)			(0.026)
PLMT × High Sensitivity			0.088***			-0.008
			(0.032)			(0.015)
Fund-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Fund-level controls X March 2020	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,856	2,643	5,499	2,347	1,804	4,151
R-squared	0.297	0.217	0.260	0.312	0.240	0.268

The dependent variable is *Net Flow/TA*, defined as the net monthly capital flow into a fund divided by the fund's total net assets in the previous month. PLMT is an indicator variable equal 1 for funds with fees or levies and at least one of the QLMTs (suspensions, gates or redemption in kind) and 0 for funds with neither fees nor levies, but at least one of the QLMTs. March 2020 a dummy variable equal to 1 in March 2020 and zero from January 2018 to February 2020. High Sensitivity is the sample of funds with an above-the-median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include: the lag of net flows to total assets, lag of return, number of funds in family, lag of ln of assets, lag of volatility of flows, lag of leverage, a dummy for investment grade funds, the share of assets owned by banks and investment funds, as well as the share owned by pension funds and insurance corporations. Fund-level controls X March 2020 represents an interaction between the controls and the March 2020 dummy variable. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

Table 14: Alternative treatment definitions

	High Sensitivity		Low Sensitivity	
	(1)	(2)	(3)	(4)
PLMT2 × March 2020	0.054**		0.016	
	(0.023)		(0.644)	
PLMT3 × March 2020		0.060***		-0.006
		(0.004)		(0.826)
Observations	3,449	3,895	2,586	2,927
R-squared	0.308	0.323	0.221	0.209
Fund-level controls	Yes	Yes	Yes	Yes
Fund-level controls X March 2020	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes

The dependent variable is Net Flow/TA. PLMT2 is an indicator variable equal to one if a fund reports fees or levies and *all* QLMTs (suspensions, gates, or redemption in kind) and 0 if a fund has access to *all* QLMTs. PLMT3 is an indicator variable equal 1 if a fund reports fees or levies and suspensions and gates and 0 if the fund does not report neither fees nor levies, but reports having access to suspensions and gates. March 2020 a dummy variable equal to 1 in March 2020 and zero from January 2018 to February 2020. High Sensitivity is the sample of funds with an above the median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include the lags of: net flows to total assets, return, number of funds in family, ln of assets, volatility of flows, a dummy for leveraged funds, a dummy for investment grade funds, the share of assets owned by banks and investment funds, as well as the share owned by pension funds and insurance corporations. Fund-level controls X March 2020 represents an interaction between the controls and the March 2020 dummy variable. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

Table 15: Fund Flows during March 2020: Entropy balancing

Dependent variable: Net flow/TA	(1) Full sample	(2) High sensitivity	(3) Low sensitivity	(4) Full sample
PLMT × March2020	0.028**	0.057***	-0.014	-0.014
	(0.014)	(0.014)	(0.017)	(0.016)
March2020 × High sensitivity				-0.061***
				(0.016)
PLMT × March2020 × High sensitivity				0.067***
				(0.020)
Observations	10,223	5,310	4,487	9,797
R-squared	0.315	0.379	0.226	0.306
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Fund-level controls	Yes	Yes	Yes	Yes
Fund-level controls X March 2020	Yes	Yes	Yes	Yes

The table shows the estimates of Eq. (1) and (2) weighted by the weights assigned by the entropy balancing procedure in Hainmueller (2012). The dependent variable is the net monthly capital flow into a fund divided by the total net assets in the previous month. PLMT is an indicator variable equal to one for funds with fees or levies and at least one of the QLMTs (suspensions, gates, or redemption in kind) and zero for funds with neither fees nor levies, but at least one of the QLMTs. March 2020 a dummy variable equal to 1 in March 2020 and zero from January 2018 to February 2020. High Sensitivity$_i$ is an indicator variable equal to one if a fund has an above-the-median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include the lag of net flows to total assets, lag of monthly return, number of funds in family, lag of log of total assets, lag of volatility of flows, lag of leverage, a dummy variable for investment grade funds, the share of assets owned by banks and investment funds, as well as the share owned by pension funds and insurance corporations. Fund-level controls X March 2020 represents an interaction between the controls and the March 2020 dummy variable. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

Table 16: Sample of switchers

	High sensitivity				Low sensitivity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Net flow/TA	Dummy outflows	Outflows/TA	Inflows/TA	Net flow/TA	Dummy outflows	Outflows/TA	Inflows/TA
PLMT Switch × March 2020	0.105***	-0.219	-0.110**	0.005	-0.056	-0.068	0.074	0.024
	(0.039)	(0.219)	(0.051)	(0.025)	(0.051)	(0.310)	(0.055)	(0.054)
Net flows/TA$_{t-1}$	0.233***	-0.601***			0.121**	-0.403**		
	(0.044)	(0.146)			(0.051)	(0.189)		
Outflows/TA$_{t-1}$			0.033				-0.033	
			(0.055)				(0.045)	
Inflows/TA$_{t-1}$				0.213***				0.190**
				(0.056)				(0.082)
Observations	1,270	1,270	1,270	1,270	1,103	1,103	1,103	1,103
R-squared	0.392	0.390	0.269	0.435	0.257	0.428	0.193	0.284
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

PLMT Switch is a sample of funds that introduced levies or fees in December 2019, and have at least one of the QLMT tools available. March 2020 a dummy variable equal to 1 in March 2020 and zero from January 2018 to February 2020. High Sensitivity is the sample of funds with an above the median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include the lags of: net flows to total assets, return, number of funds in family, ln of assets, volatility of flows, a dummy for leveraged funds, a dummy for investment grade funds, the share of assets owned by banks and investment funds, as well as the share owned by pension funds and insurance corporations. Fund-level controls X March 2020 represents an interaction between the controls and the March 2020 dummy variable. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.

Figure 13: Alternative clustering and sample definitions

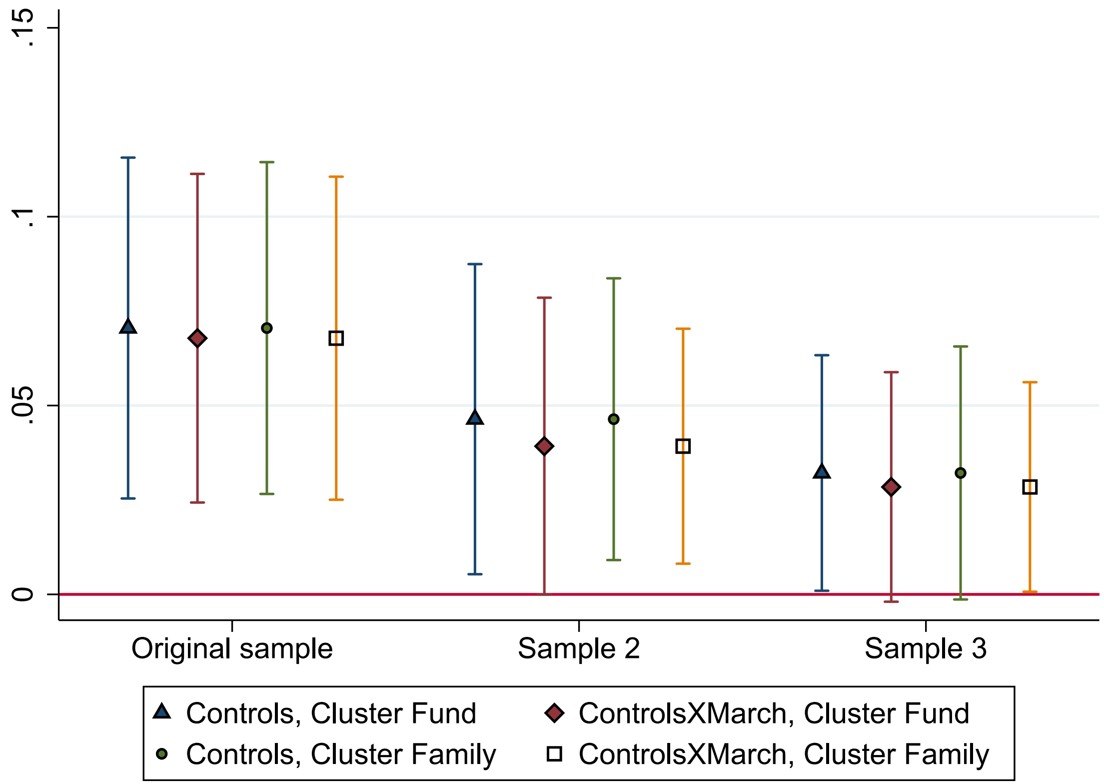
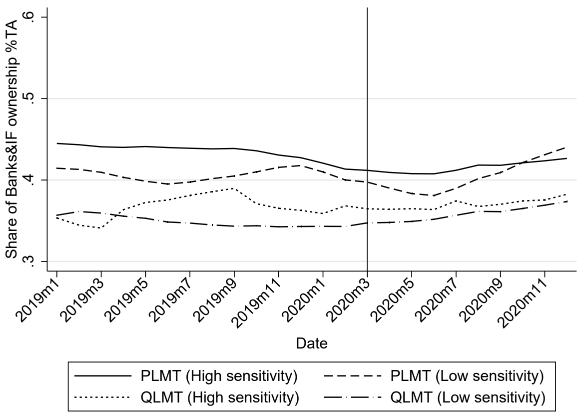


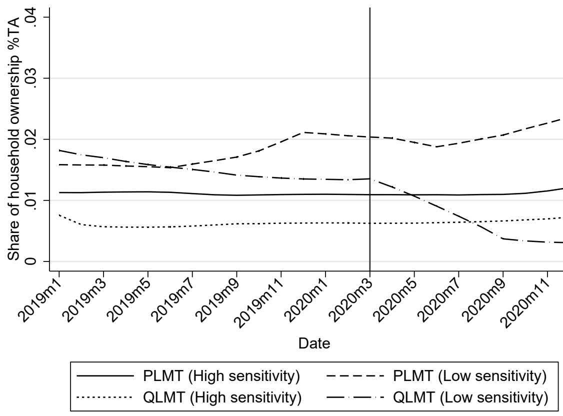
Figure shows the estimates of the coefficient β_1 in Eq. (3). The Original sample includes 521 funds, Sample 2 includes 606 funds, and Sample 3, 1,011, respectively. For the Original sample estimates, the first two estimates presented assume clustering at the Fund level, while the last two are robust standard errors. For Samples 2 and 3, the first two estimates presented assume clustering at the Fund level, while the last two at the Fund Family level.

Figure 14: Evolution of investor base

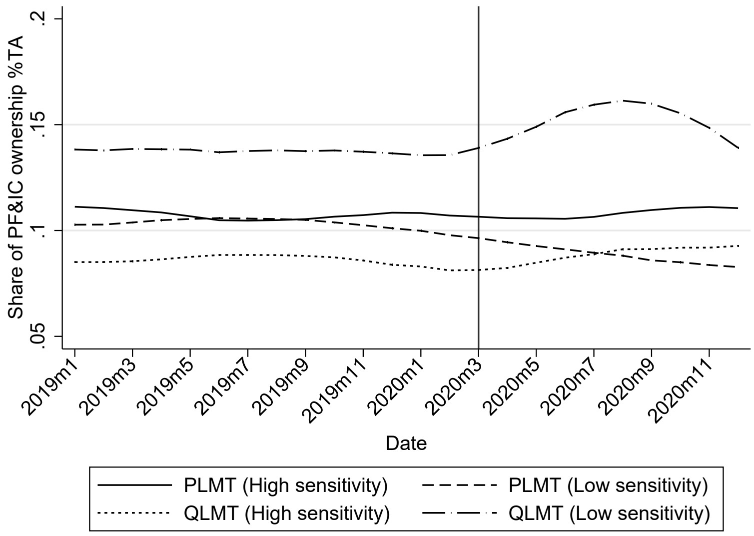
(a) Share of Banks and Investment funds



(b) Share of Households



(c) Share of Pension Funds and insurance corporations



The figure shows the evolution of the share of ownership of different investor classes as a percentage of total net assets over the period 2019m1-2020m12.

Table 17: Fund performance

	(1) Overall sample	(2) High sensitivity	(3) Low sensitivity
PLMT	0.004*	0.004**	0.002
	(0.002)	(0.002)	(0.005)
PLMT × March 2020	0.015***	0.012	0.020**
	(0.006)	(0.010)	(0.008)
Observations	9,841	5,062	4,353
R-squared	0.510	0.564	0.466
Fund-level controls	Yes	Yes	Yes
Fund-level controls × March 2020	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes

The dependent variable is ΔNAV, defined as percentage change in the NAV of the fund relative to the previous month. PLMT is an indicator variable equal to one for funds with fees or levies and at least one of the QLMTs (suspensions, gates or redemption in kind) and zero for funds with neither fees nor levies, but at least one of the QLMTs. March 2020 a dummy variable equal to 1 in March 2020 and zero from January 2018 to February 2020. High Sensitivity is the sample of funds with an above the median sensitivity of flows to performance over the period 2014-2018. Fund-level controls include lagged values of net flows to total assets, the number of funds in family, log of assets, volatility of flows, leverage, a dummy for investment grade funds, dummy variables for regional strategy, the share of assets owned by banks and investment funds as well as the share owned by pension funds and insurance corporations. Fund-level controls X March 2020 represents an interaction between the controls and the March 2020 dummy variable. Standard errors clustered at the fund family in parenthesis. *** represents significance at 1% level, ** at 5% level and, * at 10% respectively.