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Is the EU Money Market Fund Regulation fit for purpose? Lessons from the COVID-19 turmoil

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Abstract

The market turmoil in March 2020 highlighted key vulnerabilities in the EU money market fund (MMF) sector. This paper assesses the effectiveness of the EU's regulatory framework from a financial stability perspective, based on a panel analysis of EU MMFs at a daily frequency. First, we find that investment in private debt assets exposes MMFs to liquidity risk. Second, we find that low volatility net asset value (LVNAV) funds, which invest in non-public debt assets while offering a stable NAV, face higher redemptions than other fund types. The risk of breaching the regulatory NAV limit may have incentivised outflows among some LVNAV investors in March 2020. Third, MMFs with lower levels of liquidity buffers use their buffers less than other funds, suggesting low levels of buffer usability in stress periods. Our findings suggest fragility in the EU MMF sector and call for a strengthened regulatory framework of private debt MMFs.

Keywords: money market funds, financial fragility, COVID-19, regulation

JEL Codes: G11, G15, G23, G28

Non-technical summary

Research Question

Following the global financial crisis, EU legislators have introduced new rules on money market funds (MMFs), in particular through the adoption of the EU MMF Regulation in 2017. The COVID-19 market turmoil in March 2020 tested the resilience of the MMF sector as private debt MMFs faced large investor outflows. We focus on the events in March 2020 to assess the effectiveness of the EU MMF Regulation from a financial stability perspective.

Contribution

Our paper contributes to the literature on run risks in MMFs and how regulation can impact incentives among MMF investors and managers. We assess key aspects of the EU MMF Regulation, with a particular focus on low-volatility net asset value (LVNAV) funds and weekly liquidity requirements. By investigating the behaviour of investors and fund managers during the COVID-19 market turmoil in March 2020, we provide new evidence for fragility in the EU MMF sector and call for a strengthened regulatory framework, in particular for private debt MMFs.

Results

Our results identify three key vulnerabilities in the EU MMF sector. First, investment in private debt assets exposes MMFs to liquidity risk. We find that investors in MMFs investing in less liquid assets redeem more strongly than other investors during crisis periods. Second, LVNAV funds are particularly vulnerable to liquidity shocks as they invest in non-public debt assets while offering a stable NAV. The prospect of breaching the regulatory NAV limit may have incentivised outflows among some LVNAV investors during the March 2020 turmoil. Third, although some LVNAV funds experienced large outflows, fund managers did not draw down on their weekly liquid assets to the same extent, suggesting low levels of buffer usability. According to the MMF Regulation (MMFR), falling below liquidity requirements can lead LVNAV and CNAV MMFs to consider applying extraordinary liquidity measures, which may encourage investors to redeem early. We find that investors redeem more strongly from MMFs with lower liquidity buffers than from funds with larger buffers. At the same time, we find that funds with lower levels of weekly liquidity buffers use their buffers less than funds with higher buffers, suggesting a preference for those funds to sell other (often less liquid) assets, possibly to avoid getting too close or falling below the regulatory threshold.

1 Introduction

MMFs play a critical role in the financial system. They provide short-term funding to issuers, in particular banks, and are used as cash management vehicles by investors. MMF shares display cash-like properties since they are redeemable on demand and are typically perceived as providing low-risk and stable investments. Similarly, MMFs are commonly expected to raise liquidity by allowing assets to mature, rather than selling them in secondary markets. However, even though MMFs are generally perceived as safe and liquid investments, they are subject to credit and liquidity risks, in particular when investing in less frequently traded instruments such as commercial paper and certificates of deposit issued by the private sector (Financial Stability Board (2020), Bouveret and Danieli (2021)).

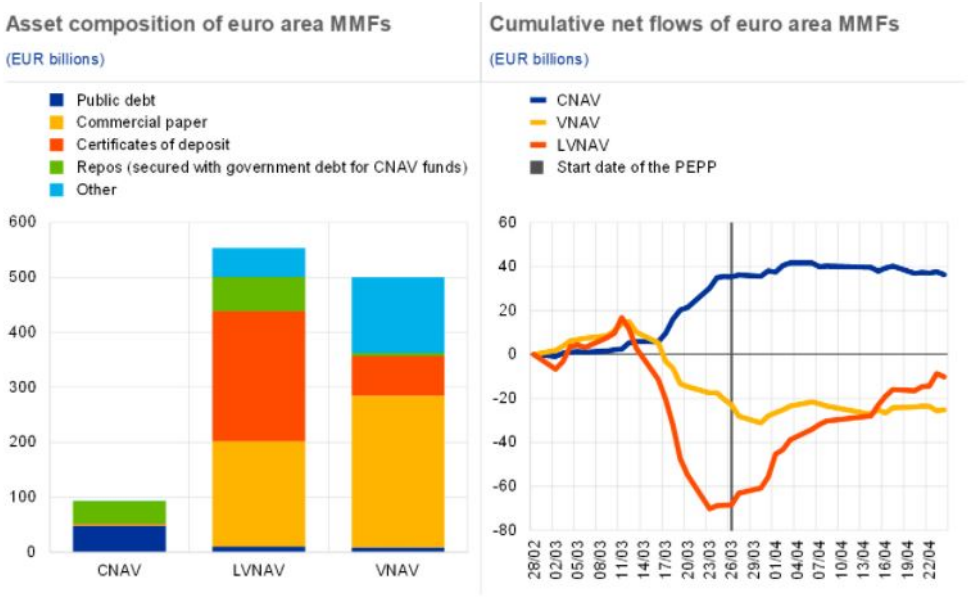
The 2008 global financial crisis highlighted several key vulnerabilities through which MMFs can amplify risks in the financial system (International Organization of Securities Commissions (2012)). A prominent example is the Reserve Primary Fund in the US. When the Reserve Primary Fund's share price fell below its constant share price ('broke the buck'), other prime funds also suffered severe outflows and falling returns (McCabe (2010)). Since then, legislators in Europe and the US have adopted new rules to make the sector more resilient. In 2017, the EU adopted the MMF Regulation, which among other rules (i) requires constant NAV (CNAV) funds to invest in public debt; (ii) introduces an additional fund type (LVNAV) that aims to offer a stable NAV while investing in a broader range of instruments; and (iii) introduces daily and weekly liquidity requirements with a view to strengthen MMFs' ability to meet redemptions and mitigate procyclical asset sales.[1]

Despite the experience of the 2008 global financial crisis and the new regulatory framework, the COVID-19 turmoil has been challenging for MMFs' liquidity management. Following the onset of the crisis in early 2020, private debt MMFs (meaning variable NAV (VNAV) and LVNAV funds) experienced significant outflows, while public debt CNAV funds saw net inflows (Figure 1, right-hand side). At the same time, the liquidity of money market instruments on the asset side of many MMFs deteriorated. This was particularly the case for VNAV and LVNAV funds, which invest largely in commercial paper and certificates of deposit (Figure 1, left-hand side). While the level of stress stabilised following central bank interventions, this episode highlighted important vulnerabilities in the sector. At the same time, it raised questions about the EU MMF Regulation's effectiveness to ensure that private debt MMFs are capable of meeting large and unexpected outflows without spillovers to the MMF sector and the broader financial system.[2] This paper assesses the effectiveness of the EU MMF Regulation in safeguarding financial stability, with a particular focus on the developments during the COVID-19 turmoil.

[1] See Annex 1 for a summary of some key elements of the EU MMF Regulation.

[2] For instance, the European Securities and Markets Authority (2021) and the Financial Stability Board (2021) initiated work streams to analyse potential regulatory reforms that could enhance the MMF sector's resilience. In October 2021, the Financial Stability Board published its final report on policy proposals to increase money market fund stability (Financial Stability Board (2021)).

Figure 1: Cumulative net flows and portfolio composition of European MMFs



The left-hand panel shows the aggregate composition of different types of MMF on 28 February 2020. The total assets of each type of fund are based on data from Refinitiv Lipper, while the composition of those portfolios is based on information from Crane Data. The right-hand panel shows cumulative daily net flows between 28 February and 22 April 2020. The vertical line denotes 26 March 2020, which was the start date of the ECB's pandemic emergency purchase programme (PEPP).

We run multivariate panel regressions to study several hypotheses about the behaviour of investors and fund managers during the COVID-19 turmoil. First, we test whether investors redeem more strongly from funds which hold less liquid portfolio assets during the stress period. In response to large redemptions, private debt MMFs may be forced to sell assets at a discount to accommodate those redemptions. However, the secondary market liquidity for commercial papers and certificates of deposit usually depends on the willingness of the issuing banks to buy back their own paper, which can be hampered in a stress scenario. Investors may anticipate this and redeem more strongly from funds which invest in less liquid assets, as these assets are harder to sell in a stress scenario. Next, we focus on certain rules under the EU MMF Regulation to further explain investor behaviour. LVNAV funds are required to switch from a stable to a variable NAV if they breach a certain valuation threshold. Since investors value MMFs for their stable NAV, under a second hypothesis, we test whether LVNAVs face higher outflows if they approach their regulatory threshold for a stable NAV. Third, funds with liquidity buffers below a certain regulatory threshold are required to consider liquidity gates or similar measures to improve their liquidity management. Since this can restrict investor redemptions, we test whether funds with lower liquidity buffers (and higher risk of employing liquidity management tools) face stronger outflows in crisis times. Fourth,

we look at the behaviour of fund managers who may be anticipating investor responsiveness to the fund's liquidity level. We study if funds with low liquidity levels are reluctant to use their liquidity buffers when facing redemptions in an attempt to avoid further outflows.

Our empirical tests are based on a large and granular dataset containing fund-level information from Crane Data, with daily observations of EU MMFs between January 2019 and May 2020. The sample covers around 70% of the EU MMF sector. This allows us to run our regressions at a high frequency and take a detailed look at the fast-moving developments in the MMF sector around the COVID-19 shock. The data also enables us to control for a wide array of potentially confounding factors such as past returns, past volatility of returns, fund age and size, fund currency, as well as portfolio illiquidity. In addition, all our regressions include fund and time fixed effects to capture additional factors which we cannot control for directly. Furthermore, we cluster standard errors at a fund level to account for heteroskedasticity and autocorrelation across observations.

Our results identify three key vulnerabilities in the EU MMF sector. First, investment in private debt assets exposes MMFs to heightened risk of outflows during stress. We find that investors in MMFs investing in less liquid assets redeem more strongly than other investors during the COVID-19 turmoil. Second, LVNAV funds are particularly vulnerable to liquidity shocks as they invest in non-public debt assets while offering a stable NAV. During crisis periods, outflows are around 1.8-2.4 percentage points larger for LVNAV funds that were close to the lower valuation threshold on the previous day, relative to other LVNAV funds. The prospect of breaching the regulatory NAV limit may have incentivised outflows among some LVNAV investors during the March 2020 turmoil. Third, although some LVNAV funds experienced large outflows, fund managers did not draw down on their weekly liquid assets to the same extent, suggesting low levels of buffer usability. According to the MMF Regulation (MMFR), a breach of liquidity requirements can lead LVNAV and CNAV MMFs to consider applying extraordinary measures, which may incentivise investors to redeem early. We find that investors redeem more strongly from MMFs with lower liquidity buffers than from funds with larger buffers. At the same time, we find that funds with lower levels of weekly liquidity buffers use their buffers less than funds with higher buffers, suggesting a preference for those funds to sell other (often less liquid) assets,[3] possibly to avoid getting too close or falling below the regulatory threshold. These findings point to fragilities in the EU MMF sector and underline the need for enhanced MMF regulation.

The remainder of this paper is structured as follows. Section 2 reviews the literature on MMF vulnerabilities and the regulatory framework. Section 3 develops the hypotheses. Section 4 describes the dataset, while section 5 presents the analysis and empirical findings. Section 6 concludes.

[3]Less liquid assets in this context refer to the assets that are not part of the fund's weekly liquid assets.

2 Literature review

Our paper contributes to several strands of the literature. From a more general point of view, our findings contribute to a better understanding of vulnerabilities arising from liquidity mismatch and risk-taking in MMFs. In light of the COVID-19 turmoil, our results confirm some of the previous findings in the literature studying MMFs in the US. We consider some unique features of the European market structure allowing us to identify liquidity mismatch and possible breaches of regulatory thresholds as relevant drivers of investor redemptions. We focus on LVNAV funds, a hybrid structure between a constant and variable NAV fund, to study some specific vulnerabilities arising from the regulation of these funds.

First, our paper is related to the literature on payoff complementarities and run risk in mutual funds and MMFs in particular. A key vulnerability of MMFs arises from liquidity and maturity transformation (Ansidei et al. (2012)). Moreover, MMFs may engage in risk-taking behaviour triggered by investors which reward funds that offer higher nominal returns by increasing the amounts invested in those funds (Chernenko and Sunderam (2014), Kacperczyk and Schnabl (2013)). Liquidity transformation and incentives for risk-taking exposes MMFs to credit and liquidity risks which can give rise to first-mover advantages among MMF investors. Such first-mover advantages are prevalent in constant net asset value (CNAV) funds, as these funds are at risk of 'breaking the buck'. However, similar vulnerabilities exist also among funds that offer a variable NAV. Late redeemers face the risk of a decline in share price, and hence a lower payoff, if the fund needs to sell assets at a discount to meet redemption requests (McCabe (2010)). Therefore, MMFs holding a larger share of risky assets tend to experience higher outflows during crises periods than other MMFs that hold a less risky portfolio (Baba et al. (2009), Jank and Wedow (2015), Strahan and Tanyeri (2015)).[4]

We demonstrate that these mechanisms were also at play in European money market funds during the COVID-19-turmoil. Exposure of MMFs to liquidity risk is of particular concern in the European case, where Bouveret and Danieli (2021) show that private-debt MMFs display a large and concentrated exposure to private money market instruments, which "are not very liquid even in normal times" (p.65). We demonstrate empirically that excess levels of liquidity transformation (proxied by the level of investment in illiquid assets) will lead to higher outflows from funds that are subject to the EU money market funds regulation. More specifically, we demonstrate that investors redeem particularly strongly from funds with high investment in illiquid assets (as well as from funds with low liquidity buffers).[5]

Second, our paper contributes to the literature on liquidity requirements, their effectiveness, and their side effects during crisis periods. Focusing on the COVID-19 turmoil, our paper complements recent work by Li et al. (2021), Dunne and Raffaele (2021), and the Investment Company

[4]Goldstein et al. (2017) and Chen et al. (2010) document this phenomenon for bond and equity funds more generally.

[5]By contrast, the findings of Darpeix (2021) suggest that the portfolio structure does not explain the redemptions during March 2020 experienced by French MMFs, which are exclusively VNAV funds.

Institute (2020), highlighting the role of low liquidity buffers in amplifying redemptions for both US and EU MMFs. The existence of such side effects has been demonstrated already before the COVID-19 turmoil, as Hanson et al. (2015) and Cipriani et al. (2014) show that runs are amplified through the introduction of liquidity fees or gates once certain liquidity buffer requirements are not met. As buffers approach the regulatory threshold, investors fear that liquidity fees or gates may be imposed and therefore react with higher outflows. The study of buffers' usability is therefore important, especially during a stress period. Avalos and Xia (2021) study the use of liquidity buffers over time to investigate the selling behaviour of US MMFs. They demonstrate that during the March 2020 turmoil, US prime MMFs preferred to preserve their weekly liquid assets in response to contemporaneous flows, rather than dipping into their liquidity buffers to meet redemptions. Focusing on EU MMFs and the COVID-19 turmoil, our findings suggest that despite large outflows for some funds, fund managers did not draw down on their weekly liquid assets to the same extent, suggesting low levels of buffer usability for EU MMFs. We add to the results of Avalos and Xia (2021) by analysing EU private-debt MMFs and by showing that the use of liquid assets is influenced by the pre-crisis levels of liquidity buffers.

Third, in addition to the role played by the level of liquidity buffers in explaining the redemption pressures, we demonstrate that the risk of possible conversion from stable to variable NAV for LVNAV funds also acted as an amplifying mechanism of redemptions during the COVID-19 turmoil. More specifically, to the best of our knowledge, this paper is the first to demonstrate that a LVNAV MMF that is close to breaching its constant NAV properties will experience larger outflows. This finding also adds to the discussion on how to regulate MMFs and mitigate run risks related to a constant NAV structure. Following the global financial crisis, regulators considered that the constant NAV framework encourages pre-emptive redemptions (Lewis (2016)). The outflows during this period were larger for funds with a constant NAV than for funds with a floating NAV structure (Witmer (2016), Schmidt et al. (2016)). In this context, the International Organization of Securities Commissions (2012) recommended regulators to require MMFs to convert to a floating NAV if possible. Since 2016, the US Securities and Exchange Commission (SEC) requires institutional prime and municipal MMFs to migrate from a stable NAV to a floating NAV. The EU MMFR (2017) introduced the LVNAV structure, which offers a stable NAV as long as its NAV at amortised cost does not deviate from the corresponding market value by more than 20 basis points. If the fund breaches the valuation threshold, it is required to trade at a variable price.

However, even if first-mover advantages are more prevalent in constant NAV funds, they also exist among floating NAV MMFs. In floating NAV funds, the first-mover advantage among investors exists as direct and indirect costs related to a portfolio rebalancing in response to outflows are borne by the remaining investors in the fund (Chen et al. (2010), Witmer (2016) and Schmidt et al. (2016)). Therefore, investors are incentivised to redeem before others do. Moreover, a mandatory switch to a floating NAV structure increases the risk-taking behaviour of institutional prime MMFs in a bid to retain investors (Alnahedh and Bhagat (2017), Baghai et al. (2022)). Cipriani and La Spada (2021) and the Investment Company Institute (2020) demonstrate that in-

vestors value the money-like properties of MMFs and that the US regulation incentivised investors to withdraw from prime MMFs (which lost their constant NAV feature) and switch to government MMFs (which were not impacted by a mandatory move to a floating NAV).

Our paper contributes to this literature by studying the financial stability implications of the LVNAV structure which was introduced with the MMFR. Focusing on the LVNAV regulatory framework, Baes et al. (2021) build a stylised model to demonstrate that under certain conditions for outflows and asset liquidity, it may be difficult for LVNAVs to simultaneously respect two crucial regulatory constraints: minimum liquidity buffers and a maximum deviation of 20 bps between the constant NAV and the marked-to-market NAV. Our paper complements the work of Baes et al. (2021) by empirically analysing the drivers of investors' outflows during the COVID-19 turmoil and showing that approaching the regulatory thresholds related to the constraints mentioned by Baes et al. (2021) incentivises outflows. Indeed, our findings suggest that the prospect of breaching the regulatory NAV limit may have amplified outflows among some LVNAV investors during the March 2020 turmoil, contributing to the large outflows among those funds relative to other funds.

Overall, our paper adds to the analysis of redemption drivers during the COVID-19 turmoil by studying European MMFs, while the majority of papers so far has studied the stress experienced by US MMFs (Li et al. (2021), Cipriani and La Spada (2020), Avalos and Xia (2021), Investment Company Institute (2020) among others). Despite a number of similarities between US and EU MMF regulations, the existence of the LVNAV structure in the European MMF framework adds a new angle to the previous findings and allows us to identify critical rules of the MMF regulation more generally. Our analysis thus provides not only insights into the vulnerabilities displayed by EU MMFs, but it may also inform the policy discussions in an international context.

3 Hypotheses

One of the key goals of the MMF Regulation was to ensure that private debt MMFs can face strong and unexpected outflows, and therefore limit the likelihood that stress is spread from the MMF sector to the broader financial system. However, the COVID-19 market turmoil in March 2020 was challenging for MMFs and raised questions about the MMF Regulation's ability to tackle systemic risks effectively. Some elements of the MMF Regulation may have the potential to increase incentives among investors to redeem before others do, especially during crisis periods. One example is the requirement for LVNAV and CNAV funds to consider temporarily suspending or limiting redemptions or applying liquidity fees where weekly liquid assets fall below 30% of total assets and the fund experiences daily redemptions totalling more than 10% of total assets. In times of market stress, this can prompt investors to withdraw money from funds that are close to the 30% threshold. Anticipating this, fund managers may be reluctant to use their liquidity buffers (meaning the stock of liquid assets that MMFs hold on an ongoing basis to meet cash needs).

We construct our first four hypotheses to test whether certain elements of the EU MMF regulation exacerbate the strategic complementarities in MMFs. The existence of strategic complementarities is well acknowledged in the mutual fund literature. Goldstein et al. (2017) argue that investors face stronger strategic complementarities in less liquid funds relative to liquid funds. The same should apply to MMFs, as some MMFs do not only invest in high quality short-term assets such as public debt, but also in higher-risk money market securities. This is the case for VNAV and LVNAV funds, which invest to a large extent in commercial paper and certificates of deposit. Therefore, in these private debt funds, the first-mover advantage is expected to be larger than in funds investing purely in public debt, resulting in higher outflows during crisis periods.

Hypothesis 1: During crisis periods, investors redeem more strongly from more illiquid funds investing in private debt, relative to more liquid funds.

While funds investing in illiquid assets may be more prone to runs in general, the newly introduced LVNAV fund structure may particularly amplify the first-mover advantage in investors' redemption decisions. Both VNAV and LVNAV funds are allowed to invest in riskier money market securities in addition to public debt, but LVNAV funds need to maintain a constant NAV. In contrast, VNAV funds have a floating NAV. The risk of breaching the valuation threshold may be a source of run risk in LVNAV funds (see also Hypothesis 3). Furthermore, unlike VNAVs, LVNAV funds may impose redemption fees or gates if their liquidity buffers fall below a certain level. Therefore, during crisis periods, investors may want to redeem from LVNAV funds before other investors in order to avoid liquidity fees or losses triggered by a move to a floating NAV. Outflows in LVNAVs would then be higher than in other types of MMFs during periods of stress.[6]

Hypothesis 2: During crisis periods, LVNAV funds experience higher outflows than other types of MMFs.

In LVNAV funds, the possibility of breaching the valuation threshold and switching to a floating NAV is one of the key risks that could incentivise investors to redeem before others. If the marked-to-market NAV falls by more than 20 basis points below the fixed NAV, a LVNAV fund loses its money-like properties and investors incur losses. The threshold for conversion from a constant to a variable NAV is considerably lower for LVNAV funds than for public debt CNAVs (20 basis points compared to 50 basis points) because LVNAV funds are allowed to invest in higher risk securities compared with public debt CNAVs. In March 2020, a number of LVNAV funds were close to breaching the valuation threshold, in which case these funds would have needed to trade at a variable price, resulting in mark-to-market losses for investors. This may have contributed to

[6]Throughout the paper, we often use terms such as *periods of stress* or *crisis periods*. Since our sample only includes the recent COVID-19 turmoil, we use this market shock as a case study to draw conclusions from our findings about the behaviour of MMF managers and investors in crisis times more generally.

additional outflows and liquidity shortages in LVNAV funds.[7]

Hypothesis 3: During crisis periods, LVNAV funds approaching the regulatory NAV threshold experience higher outflows than other LVNAV MMFs.

The EU MMFR introduced daily and weekly liquidity requirements to strengthen MMFs' ability to handle redemptions and mitigate procyclical sales. The liquidity requirements are higher for public debt CNAV and LVNAV MMFs than for VNAV funds. If the liquidity requirements fall below a certain threshold, the board of the MMF can decide to introduce gates or liquidity fees.[8] The purpose of the liquidity requirements is to allow funds to deal with large-scale redemptions without having to sell less liquid assets under unfavourable market conditions. They may therefore provide a stabilising role during stress periods by allowing fund managers to use the liquid asset buffers when facing large redemptions. However, if managers use their liquidity buffers to accommodate redemptions, liquidity buffers decrease and the risk of falling below the regulatory threshold increases. Investors may then be incentivised to redeem before the buffers drop below the threshold to avoid facing redemption gates or liquidity fees.

Hypothesis 4: During crisis periods, funds with lower liquidity buffers face higher outflows than funds with higher buffers.

Fund managers can respond to outflows in different ways. On the one hand, they can sell their liquid assets first, thus avoiding potential losses from selling illiquid assets at a discount during crisis periods. On the other hand, they can sell their illiquid assets first to preserve their liquidity buffers. During stress periods, investors may favour a fund with higher liquidity buffers compared with a fund that has lower buffers. This would suggest that funds with low liquidity buffers would prefer not to dip into their buffers and instead sell illiquid assets to accommodate outflows (Hypothesis 5a).

Hypothesis 5(a): During crisis periods, funds with low liquidity buffers are reluctant to use their buffers to accommodate redemptions.

In contrast, funds with large buffers may be more willing to dip into their buffers also under

[7]Stronger outflows in LVNAV funds could also be due to higher investor risk aversion since risk-averse investors self-selected more into LVNAVs instead of VNAVs. To control for this feature, our regressions include fund fixed effects. To the extent that more risk-averse investors self-select into specific MMFs, fund fixed effects control for differences in flows due to these investor attributes.

[8]CNAV and LVNAV funds are required to hold at all times at least 10% of their portfolio invested in daily maturing assets and 30% of their portfolio in weekly maturing assets. If a fund falls below these regulatory thresholds, the board of the fund can take corrective measures which include the establishment of liquidity fees on redemptions, redemption gates or suspension of redemptions. For VNAV funds, the thresholds are 7.5% of their portfolio invested in daily maturing assets and 15% of their portfolio invested in weekly maturing assets respectively. However, in contrast to CNAV and LVNAV funds, VNAV funds are not required to take similar corrective actions in case they breach the regulatory thresholds.

adverse market conditions (Hypothesis 5b).

Hypothesis 5(b): During crisis periods, funds with high liquidity buffers use them to accommodate redemptions.

4 Data

We obtain daily data on European MMFs from Crane. Our sample is from 01/01/2019 until 28/05/2020 and contains information on fund returns, weekly liquid assets (WLA), NAV and marked-to-market NAV at a share level. According to the MMF Regulation, the WLA are comprised of weekly maturing assets, reverse repurchase agreements which are able to be terminated by giving prior notice of five working days or cash which is able to be withdrawn by giving prior notice of five working days. In addition, for CNAV and LVNAV MMFs, a certain level of weekly liquid assets can be constituted of government paper with a residual maturity of 190 days that can be settled within one working day.[9]

A fund can be composed of multiple shares that cater to different types of investors and have different characteristics (such as fees and minimum initial investment). Since the assets under management (AuM) are not available at a share level, we pursue our analysis at a fund level. We average across the shares the values of the previously mentioned variables in order to aggregate them to the fund level. In addition, the dataset contains information on the regulatory type of the MMF (CNAV, LVNAV or VNAV), the inception date, the currency of the fund and its domicile. Furthermore, it also contains end of month data on the share of the portfolio invested in government securities, repos, commercial papers, certificates of deposit and other instruments. This allows us to construct an *Illiquidity* variable which represents the share of the portfolio invested in commercial papers and certificates of deposit.

The final sample comprises 63 funds [10] subject to the MMF Regulation between January 2019 and end of May 2020, with assets totalling €810 billion at the end of February 2020 (around 70% of the total assets of all euro area MMFs). It is worth noting, however, that VNAV funds are underrepresented in the Crane dataset.[11] In order to provide an accurate picture of the assets

[9] For VNAV funds, a certain level of weekly liquid assets can be composed of money market instruments or units or shares of other MMFs "provided they are able to be redeemed and settled within five working days" (article 24 (1)(h)).

[10] Of these 63 funds, 16 are CNAV funds, 41 are LVNAV funds and 6 are VNAV MMFs. At the end of February 2020, LVNAV funds manage most of the assets in our sample (€660 billion), CNAV funds manage €111 billion, while VNAV funds manage approximately €39 billion. In terms of currency decomposition, 13 funds are EUR-denominated, 16 funds are GBP-denominated and 29 funds are USD-denominated, while the rest of 5 funds are denominated in other currencies.

[11] For articles on VNAV funds and in particular those that are domiciled in France, see Darpeix and Mosson (2021) for a study on the portfolio shift during the COVID-19 crisis and Darpeix (2021) for an analysis of redemptions' drivers during the COVID-19 turmoil.

managed by VNAV funds and of their evolution we use Refinitiv Lipper to build Figure 1.[12]

Table 1 shows the summary statistics for our sample of European MMFs from January 2019 until end of May 2020. On average, there are small daily inflows into European MMFs (0.09%). However, during a few days over the COVID-19 turmoil, they experienced high outflows (the fifth percentile ranges between -5.4% and -3.33%). CNAV funds experience higher inflows compared to their other counterparts (for CNAV MMFs the 95^{th} percentile is 6.19% compared to 4.26% and 3.42% for LVNAVs and VNAVs MMFs). The median performance of CNAV MMFs is higher (1.94% on an annualised basis) than the one displayed by LVNAVs (0.86%) or by VNAVs (-0.26%). This can be explained by the currency of denomination of these funds (USD-denominated assets display a higher return than EUR-denominated assets). CNAVs in our sample are mostly denominated in USD, while LVNAVs and VNAVs are largely denominated in EUR and GBP. If we restrict the analysis only to USD-denominated funds, LVNAVs and VNAVs display a larger median of returns than USD CNAVs (2.44 % and 2.59% respectively compared to 2.24%).

VNAVs and LVNAVs also hold lower weekly liquid assets on average (around 43% is invested in securities maturing in less than 5 days) than CNAV MMFs (which hold on average 73% weekly liquid assets). This finding reflects the fact that non-public debt MMFs invest in assets with a longer maturity in order to potentially increase their returns. LVNAV funds display a median age of around 17 years compared to approximately 11 years for VNAVs and CNAVs. LVNAV MMFs are also the largest: on average, these funds manage approximately €11 bn compared to €7 bn and €3 bn for CNAVs and VNAVs, respectively. On average, VNAV funds hold the largest share of the portfolio invested in commercial paper and certificates of deposit: 64% compared to 55% for LVNAV MMFs. As required by the regulation, CNAV funds do not hold any commercial papers or certificates of deposit.

[12]While VNAV funds are better represented in the Refinitiv Lipper database, we do not use this dataset in our main empirical analysis as it does not include important data points, for instance on the weekly liquid assets, which is one of the key variables in our analysis.

Table 1: Summary statistics

Panel A: All funds	Mean	Std dev	P5	P25	P50	P75	P95	N
Flows (in %)	0.09	2.77	-4.29	-1.05	0.02	1.19	4.61	19,633
Returns (in %)	1.18	1.21	-0.47	0.37	0.88	2.33	2.62	19,633
WLA (in %)	50.35	17.92	31.45	37.79	44.11	57.91	93.3	19,633
Ln(age)	2.67	0.62	1.54	2.4	2.92	3.06	3.29	19,633
Ln(TNA)	22.03	1.77	18.38	20.76	22.39	23.25	24.53	19,633
Illiquidity (in %)	57	21	0	52	62	71	85	1,649
Panel B: CNAV MMFs	**Mean**	**Std dev**	**P5**	**P25**	**P50**	**P75**	**P95**	**N**
Flows (in %)	0.15	3.33	-5.44	-1.14	0.03	1.33	6.19	4,770
Returns (in %)	1.56	0.98	-0.51	0.72	1.94	2.36	2.55	4,770
WLA (in %)	72.65	18.58	43.76	57.47	71.21	89.58	99.99	4,770
Ln(age)	2.32	0.76	0.44	2.35	2.41	2.49	3.33	4,770
Ln(TNA)	21.23	2.17	17.39	19.69	21.51	23.12	24.15	4,770
Illiquidity (in %)	0	0	0	0	0	0	0	340
Panel C: LVNAV MMFs	**Mean**	**Std dev**	**P5**	**P25**	**P50**	**P75**	**P95**	**N**
Flows (in %)	0.08	2.61	-4.09	-1.12	0.03	1.26	4.26	12,703
Returns (in %)	1.11	1.09	-0.45	0.35	0.86	2.15	2.64	12,703
WLA (in %)	43.12	9.59	30.97	36.78	41.12	47.62	61.58	12,703
Ln(age)	2.81	0.47	2.02	2.75	2.97	3.05	3.19	12,703
Ln(TNA)	22.44	1.58	19.73	21.66	22.63	23.44	24.59	12,703
Illiquidity (in %)	55	21	0	49	62	70	79	1,020
Panel D: VNAV MMFs	**Mean**	**Std dev**	**P5**	**P25**	**P50**	**P75**	**P95**	**N**
Flows (in %)	0.07	2.35	-3.33	-0.55	0	0.64	3.42	2,160
Returns (in %)	0.75	1.32	-0.48	-0.39	-0.26	2.53	2.62	2,160
WLA (in %)	43.63	12.85	30.02	34.86	38.92	49.49	72.65	2,160
Ln(age)	2.67	0.69	1.59	1.88	2.79	3.2	3.49	2,160
Ln(TNA)	21.42	0.89	20.39	20.67	21.34	21.77	23.14	2,160
Illiquidity (in %)	64	19	0	58	66	77	84	289

This table presents the summary statistics for our sample of Money Market Funds under the MMF Regulation between January 2019 and May 2020. We report the mean, standard deviation (Std.Dev.), the 5th percentile (P5), the 25th percentile (P25), etc. as well as the number of observations. Illiquidity is at a monthly level, while all the other variables are reported at a daily level.

5 Empirical findings

5.1 Illiquid assets, LVNAV funds and flows

According to Hypothesis 1 and 2, more illiquid funds and especially LVNAV funds (due to their characteristics related to the constant NAV and minimum liquidity buffers) are expected to have higher outflows during crisis periods than other funds. To test these hypotheses, we perform the following regression:

$$\begin{aligned} Flows_{i,t} &= \alpha + \beta_1 Crisis_t + \beta_2 LVNAV_i + \beta_3 IlliqFund_{i,t-1} + \beta_4 Crisis_t \times LVNAV_i + \\ &+ \beta_5 Crisis_t \times IlliqFund_{i,t-1} + \gamma Controls_{i,t} + \delta_i + \lambda_t + \epsilon_{i,t}, \end{aligned} \quad (1)$$

where $Flows_{i,t}$ represents the net flows experienced by fund i in day t. $LVNAV_i$ is an indicator variable equal to one if the fund is classified as a LVNAV MMF and zero otherwise. We use the VIX as a proxy for stress in financial markets. $Crisis_t$ represents an indicator variable equal to

one if the VIX value is above its 90^{th} percentile of its distribution over our sample period. β_4 and β_5 represent our coefficients of interest as they show whether investors react stronger to the illiquidity of the funds' portfolios during crisis periods and to a fund being classified as a LVNAV MMF. Controls include a series of lagged variables that could influence funds' flows: $Return$ (fund's return in t-1), $StdDev$ (the standard deviation of the past 90 daily returns), $Log(age)$ (the natural lagged logarithm of fund's age expressed in years), $Log(TNA)$ (the lagged natural logarithm of fund's size measured as total net assets), WLA (the percentage of the fund's portfolio invested in weekly liquid assets in t-1), $Illiquidity$ (the percentage of the fund's portfolio invested in commercial papers and certificates of deposit), $IlliqFund$ (is a dummy variable which has a value of 1 if the fund is in the highest decile of all funds in the sample in terms of the illiquidity of portfolios), USD (an indicator variable equal to one if the fund is denominated in USD and zero otherwise). To control for the aggregate flows into MMFs we include day fixed effects. Fund fixed effects are introduced in order to account for unobserved time-constant fund characteristics. Moreover, we cluster standard errors by fund to allow for intertemporal dependence of regression residuals.

Table 2 shows the results. The columns differ in the fixed effects used. Under Hypothesis 1 and 2, we expect β_4 and β_5 to be negative and statistically significant. During crisis periods, MMFs seem to attract inflows (column 1 and 3). This result is explained by the inflows experienced by CNAV funds, which benefited from a flight-to-safety investor behaviour. In contrast, we find that LVNAV funds experience higher outflows during crisis periods (the term $Crisis \times LVNAV$ being negative and statistically significant in all four columns). On average, during crisis periods, LVNAV funds suffer 0.8pp - 1.2pp higher outflows compared with other EU MMFs.[13] The result is also economically significant: if we aggregate this number over a month, LVNAV funds would experience 20 percentage points higher outflows (in terms of their total assets), relative to other MMFs. This also controls for the illiquidity of the assets held by LVNAVs. In this regard, and in line with Hypothesis 1, we find that illiquid funds experience 0.7pp-0.9pp higher outflows during crisis periods compared to funds with more liquid assets. However, the Crisis x LVNAV coefficients remains robust, suggesting that parts of the outflows experienced by LVNAVs can be explained by other mechanisms than the illiquidity of the underlying assets.

5.2 Valuation cliff effects and flows

LVNAV funds are particularly vulnerable to liquidity shocks, given that they invest in non-public debt instruments while offering a stable share price. A LVNAV fund offers a stable NAV as long as its NAV at amortised cost does not deviate from the corresponding marked-to-market NAV

[13] As a robustness check, we estimate the model using available data from Refinitiv Lipper. While Refinitiv Lipper does not provide data on weekly liquid assets or the composition of MMFs' portfolios, it has better coverage for VNAV funds. The coefficient derived from the Refinitiv Lipper dataset for the $Crisis \times LVNAV$ interaction term remains robust, suggesting that LVNAV funds have indeed seen larger outflows than other MMFs during the recent crisis period when controlling for other available variables. Note that it is not possible to replicate the coefficient for the illiquidity variable, given that this variable is not available in the Refinitiv Lipper dataset.

Table 2: The effect of crisis periods on flows

	(1) flows	(2) flows	(3) flows	(4) flows
Crisis	0.007***		0.010***	
	(4.35)		(4.46)	
LVNAV	0.001	0.001		
	(1.47)	(1.23)		
Crisis × LVNAV	-0.008***	-0.008***	-0.011***	-0.012***
	(-4.20)	(-4.18)	(-4.15)	(-4.32)
IlliqFund	0.000	0.000	-0.000	-0.001
	(0.23)	(0.26)	(-0.19)	(-0.66)
Crisis × IlliqFund	-0.007*	-0.007*	-0.009**	-0.009**
	(-1.85)	(-1.81)	(-2.12)	(-2.12)
Return	0.004	0.017	0.017	0.108
	(0.19)	(0.79)	(0.16)	(0.99)
Std Dev	0.061	-0.090	0.533	-0.136
	(0.33)	(-0.54)	(1.61)	(-0.41)
Log(age)	0.000	-0.000	0.012	-0.004
	(0.10)	(-0.10)	(1.59)	(-0.54)
Log(TNA)	-0.000	-0.000	-0.021***	-0.022***
	(-0.54)	(-0.45)	(-9.33)	(-10.15)
WLA	-0.003	-0.003*	-0.002	-0.006**
	(-1.64)	(-1.75)	(-0.81)	(-2.05)
Illiquidity	-0.002*	-0.002*	-0.002	0.001
	(-1.82)	(-1.79)	(-0.48)	(0.32)
USD	0.000	-0.000		
	(0.07)	(-0.05)		
Constant	0.003	0.004*	0.422***	0.508***
	(1.54)	(1.94)	(9.44)	(9.95)
Day FE	No	Yes	No	Yes
Fund FE	No	No	Yes	Yes
Cluster	Fund	Fund	Fund	Fund
Adj. R^2	0.003	0.03	0.01	0.04
Observations	19 518	19 518	19 518	19 518

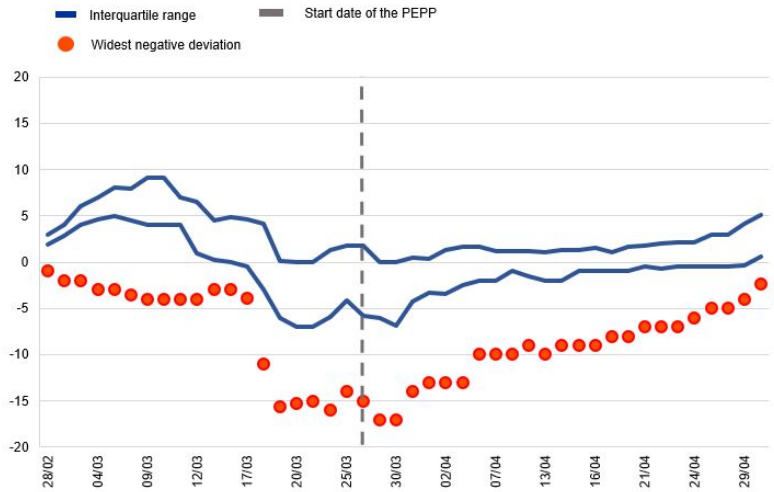
t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table shows the relationship between the fund net flows and the illiquidity of the assets and the MMF regulatory type from January 2019 until May 2020. The dependent variable is normalised fund flows. Crisis equals one if the daily VIX is above the 90th percentile in our sample. IlliqFund is one if the fund is in the highest decile of all funds in the sample in terms of the illiquidity of portfolios. The analysis is pursued at a fund level. Columns differ in the choice of fixed effects (fund and daily level). We cluster standard errors by fund. Standard errors are in parenthesis.

(MNAV) by more than 20 basis points. If the fund breaches that valuation threshold, it is required to trade at a variable price. A breach on the downside generally leads to losses for investors and the investment loses its cash-like properties. In mid-March 2020, a number of LVNAV funds – particularly US dollar-denominated funds – were close to breaching the regulatory threshold on the downside (as figure 2 shows). This may have encouraged investors in some LVNAV funds to withdraw their money, contributing to the large outflows for that fund type relative to other funds.

Figure 2: Gap between the NAV and the MNAV for US dollar-denominated European LVNAVs



The blue lines show the interquartile range of the NAV deviations for US dollar-denominated LVNAV funds. The red dots show the largest negative NAV deviations. The vertical line denotes 26 March 2020, which was the start date of the PEPP.

As described in Hypothesis 3, investors have an incentive to redeem if the moving NAV approaches the regulatory lower threshold. In order to test this hypothesis, we apply the following specification to LVNAV funds:

$$\begin{aligned} Flows_{i,t} &= \alpha + \beta_1 Crisis_t + \beta_2 NavLow_{i,t-1} + \beta_3 Crisis_t \times NavLow_{i,t-1} + \\ &+ \gamma Controls_{i,t} + \delta_i + \lambda_t + \epsilon_{i,t}, \end{aligned} \tag{2}$$

where $Flows_{i,t}$ represents the net flows experienced by fund i on day t. $NavLow_{i,t}$ is an indicator variable equal to one if the gap between the constant NAV and the marked-to-market NAV is larger than 5 basis points in absolute terms and zero otherwise. Therefore, $NavLow_{i,t}$ equals one if the fund is at a larger risk of breaching the valuation threshold. As above, we use the VIX as a proxy for stress in the financial system. $Crisis_t$ takes a value of one if the VIX value is above its 90^{th} percentile of its distribution and is zero otherwise. β_3 represents our coefficient of

interest as it shows whether investors react more sensitively to funds approaching the regulatory thresholds during crisis periods. Controls are defined as in section 5.1 and include a series of lagged variables that could influence funds' flows : $Return$, $StdDev$, $Log(age)$, $Log(TNA)$, WLA and $Illiquidity$. We also include fund and day fixed effects. Moreover, we cluster errors by fund to allow for intertemporal dependence of regression residuals.

Table 3 shows the results. Under Hypothesis 3, we expect β_3 to be negative and statistically significant. We find that during normal periods, funds approaching the lower NAV threshold by more than 5 basis points do not suffer higher outflows compared to other MMFs (the term $NavLow$ is close to zero and statistically insignificant in all columns). However, investors are sensitive to a possible breach of the valuation threshold during crisis periods. Under adverse market conditions, LVNAVs displaying a high (above 5 basis points) deviation between the constant NAV and the moving NAV suffer 0.9pp-1.8pp more outflows on average. This effect is robust across the different specifications. However, investors may redeem more the wider the gap between the constant and the marked-to-market NAV gets. In order to test the presence of such a non-linearity in investors' response, we apply the same specification (2), where $NavLow_{i,t}$ is an indicator variable equal to one if the gap between the constant NAV and the marked-to-market NAV is above 10 basis points and zero otherwise.[14] Table 4 shows the results for this specification. We find that during crisis periods, funds with a higher deviation suffer on average 1.5pp-2.4pp higher outflows than other MMFs.

5.3 Weekly liquid assets and flows

As described in Hypothesis 4, investors may redeem more in funds with lower levels of liquidity buffers. We apply the following specification to test this hypothesis to LVNAV and VNAV funds as they experienced important outflows during the COVID-19 crisis[15]:

$$\begin{aligned} Flows_{i,t} &= \alpha + \beta_1 Crisis_t + \beta_2 WLA_{i,t-1} + \beta_3 Crisis_t \times WLA_{i,t-1} + \\ &+ \gamma Controls_{i,t} + \delta_i + \lambda_t + \epsilon_{i,t}, \end{aligned} \tag{3}$$

where $Flows_{i,t}$ represents the net flows experienced by fund i on day t. WLA is the percentage of the fund's portfolio invested in weekly liquid assets in t-1. We use the VIX as a proxy for the financial conditions. $Crisis_t$ represents an indicator variable equal to one if the VIX value is above the 90^{th} percentile of its distribution. β_3 represents our coefficient of interest as it shows whether investors behave more sensitively to past levels of weekly liquid assets during crisis

[14] In unreported results, we also run the same regression with $NavLow$ defined as equal to one if the deviation between NAV and MNAV is larger than 15 basis points. The coefficient size increases further (in absolute terms), indicating the presence of non-linearities in outflows as the risk of breaching the valuation threshold increases. However, there is a too small number of observations with NAV deviations of this size, which is why it is not possible to estimate a sensible model.

[15] The result does not significantly change when considering all regulatory types of MMFs.

Table 3: The effect of the valuation threshold on flows: above 5 bp deviation

	(1) flows	(2) flows	(3) flows	(4) flows
Crisis	-0.002		-0.002	
	(-1.60)		(-1.64)	
NavLow	-0.001	-0.001	0.000	-0.000
	(-0.44)	(-0.60)	(0.09)	(-0.01)
Crisis × NavLow	-0.009**	-0.013***	-0.015***	-0.018***
	(-2.11)	(-2.77)	(-3.87)	(-4.34)
Return	-0.008	0.028	0.292**	0.353***
	(-0.35)	(1.02)	(2.45)	(3.45)
Log(age)	-0.000	-0.001	0.039***	0.018***
	(-0.24)	(-1.51)	(3.37)	(3.99)
Log(TNA)	-0.000	-0.000	-0.033***	-0.032***
	(-1.34)	(-1.45)	(-9.02)	(-8.24)
WLA	-0.003	-0.011***	0.003	-0.012**
	(-1.51)	(-3.91)	(0.42)	(-2.26)
Std Dev	0.520**	0.134	1.102**	0.195
	(2.61)	(0.63)	(2.33)	(0.50)
Illiquidity	-0.001	-0.001	0.004	0.008**
	(-0.23)	(-0.36)	(0.89)	(2.05)
Constant	0.008**	0.014***	0.623***	0.654***
	(2.48)	(3.38)	(8.61)	(7.32)
Day FE	No	Yes	No	Yes
Fund FE	No	No	Yes	Yes
Cluster	Fund	Fund	Fund	Fund
Adj. R^2	0.002	0.05	0.02	0.07
Observations	9 701	9 701	9 701	9 701

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table shows the relationship between the fund net flows and the proximity to the valuation threshold for LVNAV from January 2019 until May 2020. The dependent variable is normalised fund flows. Crisis equals one if the daily VIX is above the 90th percentile in our sample. NavLow equals one if the difference between the constant NAV and the marked-to-market NAV is larger than 5 basis points. The analysis is pursued at a fund level. Columns differ in the choice of fixed effects (fund and daily level). We cluster standard errors by fund. Standard errors are in parenthesis.

Table 4: The effect of the valuation threshold on flows: above 10 bp deviation

	(1) flows	(2) flows	(3) flows	(4) flows
Crisis	-0.002*		-0.002*	
	(-1.76)		(-1.90)	
NavLow	0.000	0.000	0.001	0.002
	(0.06)	(0.06)	(0.29)	(0.48)
Crisis × NavLow	-0.015***	-0.020***	-0.019***	-0.024***
	(-3.50)	(-4.17)	(-4.77)	(-5.32)
Return	-0.005	0.034	0.338**	0.415***
	(-0.20)	(1.20)	(2.52)	(3.58)
Log(age)	-0.000	-0.001	0.040***	0.019***
	(-0.29)	(-1.60)	(3.38)	(4.18)
Log(TNA)	-0.000	-0.000	-0.032***	-0.030***
	(-1.40)	(-1.51)	(-8.45)	(-7.83)
WLA	-0.003	-0.010***	0.003	-0.012**
	(-1.28)	(-3.55)	(0.47)	(-2.22)
Std Dev	0.452**	0.022	1.109**	0.207
	(2.27)	(0.10)	(2.19)	(0.49)
Illiquidity	-0.000	-0.001	0.004	0.008**
	(-0.12)	(-0.23)	(0.87)	(2.03)
Constant	0.009**	0.014***	0.597***	0.625***
	(2.48)	(3.30)	(7.69)	(6.78)
Day FE	No	Yes	No	Yes
Fund FE	No	No	Yes	Yes
Cluster	Fund	Fund	Fund	Fund
Adj. R^2	0.002	0.05	0.02	0.07
Observations	9 701	9 701	9 701	9 701

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table shows the relationship between the fund net flows and the proximity to the valuation threshold for LVNAV from January 2019 until May 2020. The dependent variable is normalised fund flows. Crisis equals one if the daily VIX is above the 90th percentile in our sample. NavLow equals one if the difference between the constant NAV and the marked-to-market NAV is larger than 10 basis points. The analysis is pursued at a fund level. Columns differ in the choice of fixed effects (fund and daily level). We cluster standard errors by fund. Standard errors are in parenthesis.

periods. Controls are defined as in section 5.1 and include a series of lagged variables that could influence funds' flows: $Return$, $StdDev$, $Log(age)$, $Log(TNA)$, $Illiquidity$ and $NavDeviation$ (the deviation between the constant NAV and the marked-to-market NAV measured in basis points). We also include fund and day fixed effects. Moreover, we cluster errors by fund to allow for intertemporal dependence of regression residuals.

Table 5 shows the results. Columns 1 and 3 show the effect during normal periods, while in columns 2 and 4, we interact the WLA with the crisis dummy. Under Hypothesis 4, we expect β_3 to be positive and statistically significant. Looking at row 2, we find that a higher level of liquidity buffers does not have a significant effect on net flows (the estimated coefficient is statistically insignificant in all four columns). However, column 4 shows that during crisis periods, funds with higher levels of liquidity buffers suffer less outflows. An increase of the WLA by one percentage points is associated with 0.022 percentage points lower outflows. The rationale could be that investors try to avoid liquidity fees or redemption gates which may be introduced if the regulatory thresholds of minimum liquid buffers are breached. Therefore, they tend to redeem more from funds having less liquid assets and a higher possibility to breach the minimum liquidity buffers.

Table 5: The effect of the weekly liquid assets on flows

	(1) flows	(2) flows	(3) flows	(4) flows
Crisis		-0.020***		
		(-4.44)		
WLA	0.007	0.000	-0.001	-0.006
	(1.29)	(0.09)	(-0.20)	(-1.12)
Crisis × WLA		0.041***		0.028***
		(4.02)		(2.77)
Return	0.460***	0.382***	0.447***	0.451***
	(3.20)	(3.23)	(3.77)	(3.87)
Log(age)	0.038***	0.041***	0.022***	0.019**
	(3.36)	(2.95)	(2.94)	(2.62)
Log(TNA)	-0.028***	-0.029***	-0.027***	-0.028***
	(-6.34)	(-6.33)	(-5.71)	(-5.97)
Std Dev	1.113*	0.918**	0.413	0.348
	(2.00)	(2.03)	(0.86)	(0.75)
Nav Deviation	0.000*	0.000**	0.000**	0.000**
	(1.80)	(2.10)	(2.12)	(2.10)
Illiquidity	-0.003	-0.002	0.000	-0.000
	(-0.45)	(-0.39)	(0.01)	(-0.03)
Constant	0.513***	0.531***	0.541***	0.569***
	(5.90)	(6.30)	(5.50)	(5.80)
Day FE	No	No	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Cluster	Fund	Fund	Fund	Fund
Adj. R^2	0.01	0.02	0.05	0.05
Observations	11 777	11 777	11 777	11 777

t statistics in parentheses

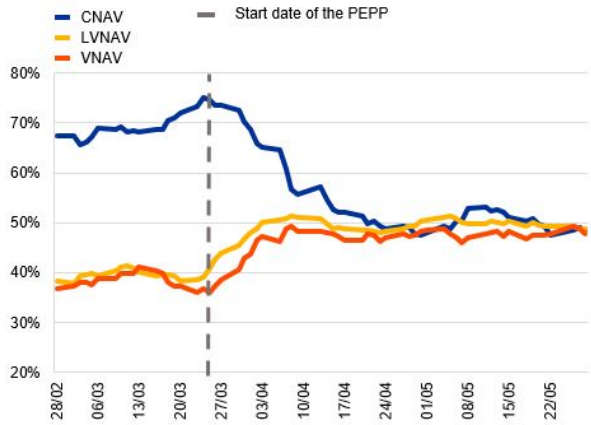
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table shows the relationship between the fund net flows and weekly liquid assets for LVNAV and VNAV funds from January 2019 until May 2020. The dependent variable is normalised fund flows. Crisis equals one if the daily VIX is above the 90th percentile in our sample. The analysis is pursued at a fund level. Columns differ in the choice of fixed effects (fund and daily level). We cluster standard errors by fund. Standard errors are in parenthesis.

5.4 Buffer usability in response to flows

Although large outflows were experienced by some funds, fund managers did not draw down on their weekly liquid assets to the same extent. As Figure 3 shows, between 11 and 25 March, LVNAV and VNAV funds reduced their holdings of weekly liquid assets only slightly – by 1 and 3 percentage points respectively on average. Given the large outflows for those funds in this period, the small reduction in liquid assets suggests that fund managers only used their buffers to a very limited extent. Moreover, although LVNAV funds experienced larger outflows than VNAV funds, they made less use of their liquid assets than VNAV funds. This suggests that VNAV funds may be more willing to use their weekly liquid assets than LVNAV funds, possibly because investors do not associate lower levels of liquid asset holdings with a higher risk of suspensions or liquidity fees.

Figure 3: Evolution of WLA of European MMFs



This chart shows the weighted mean of weekly liquid assets for each type of MMF. The vertical line denotes 26 March 2020, which was the start date of the PEPP.

The picture above does not fully reflect the possible heterogeneity in the use of liquidity buffers, in particular between funds with generally low and those with high levels of liquidity buffers. For instance, funds with low levels of liquidity buffers before the crisis might try to avoid using their buffers, for instance to prevent additional outflows.

Hypothesis 5 postulates that a fund's buffer usability is contingent upon its pre-crisis liquidity levels. In order to test this hypothesis, we apply the following specifications for LVNAV and VNAV MMFs[16]:

[16]The results of the regressions do not significantly change when considering all regulatory types of MMFs.

$$\begin{aligned}\Delta WLA_{i,t} &= \alpha_i + \beta_1 Flows_{i,t-1} + \beta_2 Small_i + \beta_3 Small_i \times Flows_{i,t-1} + \\ &+ \gamma Controls_{i,t} + \delta_i + \lambda_t + \epsilon_{i,t}, \end{aligned} \tag{4}$$

$$\begin{aligned}\Delta WLA_{i,t} &= \alpha_i + \beta_1 Inflows_{i,t-1} + \beta_2 Small_i + \beta_3 Small_i \times Inflows_{i,t-1} + \\ &+ \beta_4 Outflows_{i,t-1} + \beta_5 Small_i \times Outflows_{i,t-1} + \gamma Controls_{i,t} \\ &+ \delta_i + \lambda_t + \epsilon_{i,t}, \end{aligned} \tag{5}$$

where $\Delta WLA_{i,t}$ represents the difference between the weekly liquid assets on day t and t-1, respectively. $Flows_{i,t-1}$ represents the net flows experienced by fund i at day t-1. In specification 5, flows are further divided into inflows (defined as positive flows) and outflows (defined as negative flows). The Small indicator shows whether a fund entered the COVID-19 turmoil with low levels of liquid assets. We construct this indicator variable in two steps. First, for one month before the start of the turmoil (between the 12^{th} of February and the 12^{th} of March), we calculate the cross-sectional median of the portfolio share invested in assets maturing in less than 5 days for LVNAV and for VNAV funds respectively. The median is approximately equal between the two regulatory types (39% for LVNAV MMFs and 40% for VNAVs respectively). Second, $Small_i$ is an indicator variable equal to one if the fund was holding less than the aforementioned median in any of the seven days preceding the beginning of the crisis. β_3 in equation (4) (β_5 in equation (5) respectively) represent our coefficients of interest as they show whether fund managers use their liquid buffers differently in response to flows (outflows) in case their funds enter the crisis with low liquid buffers. Controls are defined in section 5.1 and include a series of lagged variables that could influence funds' flows: $Return$, $Log(TNA)$, and WLA. We also include fund and day fixed effects. Moreover, we cluster errors by fund to allow for intertemporal dependence of regression residuals.

Table 6 shows the results. Under Hypothesis 5, during the COVID-19 turmoil, we expect β_1 (β_4 respectively) to be positive and statistically significant in equation 4 (equation 5 respectively). Also, we expect β_3 (β_5 respectively) to be negative and statistically significant in equation 4 (equation 5 respectively). We are interested in analysing the response of fund managers to flows during different time periods. Accordingly, we split the sample in two parts and estimate equation (4) for each subsample. In order to test whether managers respond differently to inflows and outflows we apply specification (5). We consider the period from 12 March 2020 until 25 March (until the start of the PEPP by the ECB) as "run period", meaning the period where the MMF sector experienced the largest outflows during the turmoil. During this period, a decrease of one percentage point in the net flows is associated with a reduction in the first difference of WLA of 0.420 percentage points (column 1). This would suggest that fund managers use to a greater

extent their liquidity buffers in response to higher outflows.[17]

Columns 1 and 2 indicate that the use of weekly liquid assets depends on the pre-crisis levels. Funds with large liquidity buffers before the crisis respond to an increase in outflows by using more assets maturing in the next 5 days (the coefficient of the variable $Outflows$ in column 2 is positive and highly significant). Funds with below median liquidity buffers will tend to keep unchanged the share of their portfolio invested in weekly liquid assets (column 2 indicates that the term $Outflows + Small \times Outflows$ is positive and insignificant). It means that managers sell both liquid and illiquid assets on a pro rata basis. This finding suggests that under adverse market conditions, fund managers with low liquidity buffers are reluctant to use them in response to outflows, possibly also because they anticipate that investors may redeem more when the liquidity buffers approach the regulatory thresholds.

In order to demonstrate that the levels of liquidity buffers influence managers' behaviour mainly during crisis periods, we also run regressions (4) and (5) during a post-run period, which we define as starting on 26 March 2020 and lasting until 8 April 2020 (an identical period of 14 days is used as in the "run period" sample). Indeed, columns 3 and 4 show that the pre-crisis level of liquidity buffers does not influence managers' use of liquid buffers (the interaction terms $Small \times Flows$ and $Small \times Inflows$ or $Small \times Outflows$ are not statistically different from 0).

[17] A potential caveat of this analysis is that since we are working with shares of liquid assets, a decrease in WLA can mean either a sale of liquid assets (i.e. a use of the liquidity buffer) in response to past flows or a purchase of illiquid assets. In general, we consider it more likely that MMFs used their liquid assets rather than buying additional illiquid assets, as a response to outflows during the COVID-19 turmoil.

Table 6: Buffer usability in response to flows

	(1) ΔWLA	(2) ΔWLA	(3) ΔWLA	(4) ΔWLA
Flows	0.420***		0.140***	
	(7.91)		(4.16)	
Small × Flows	-0.262***		0.059	
	(-3.63)		(0.69)	
Inflows		0.504***		0.129*
		(5.62)		(1.86)
Small × Inflows		-0.153		0.037
		(-1.07)		(0.29)
Outflows		0.341***		0.158*
		(4.33)		(1.75)
Small × Outflows		-0.324**		0.103
		(-2.65)		(0.59)
Return	1.084	0.994	-1.300	-1.223
	(1.03)	(0.98)	(-0.62)	(-0.57)
Log(TNA)	0.031	0.039	-0.024	-0.023
	(0.86)	(1.14)	(-0.46)	(-0.44)
WLA	-0.267***	-0.273***	-0.246***	-0.249***
	(-3.71)	(-3.78)	(-5.00)	(-4.94)
Sample	Run	Run	Post Run	Post Run
Day FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Cluster	Fund	Fund	Fund	Fund
Adj. R2	0.28	0.29	0.17	0.17
Observations	450	450	459	459

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table shows the relationship between the evolution of the WLA and past flows for LVNAV and VNAV funds. The dependent variable represents the difference between the weekly liquid assets on day t and t-1. Flows represents the net flows experienced by fund i at day t-1. In columns 2 and 4, flows are further divided into inflows (defined as positive flows) and outflows (defined as negative flows). Small equals one if the fund entered the COVID-19 crisis with low liquid buffers. As the sample spans only 14 days, we eliminated the past natural logarithm of age and illiquidity of the portfolio from the control variables due to their low variability. The analysis is pursued at a fund level. We include daily and fund fixed effects and cluster standard errors by fund. Standard errors are in parenthesis. While columns 1 and 2 analyse the "run" period, from 12 March 2020 until 25 March 2020, columns 3 and 4 show the results using the "post run" period, which spans from 26 March 2020 until 8 April 2020.

6 Conclusion

Our paper adds to the literature on vulnerabilities in MMFs and implications for financial stability. We use daily fund-level data for European MMFs to study the behaviour of fund managers and investors during the recent COVID-19 market turmoil. We identify several key vulnerabilities in the MMF sector. First, we find that MMFs that hold a higher share of less liquid assets are subject to increased outflows during periods of stress. Second, low volatility net asset value (LVNAV) funds, which invest in non-public debt assets while offering a stable net asset value, face higher redemptions than other fund types. The risk of breaching the regulatory NAV limit may have incentivised outflows among some LVNAV investors during the March 2020 turmoil. Third, MMFs with lower liquidity buffers relative to the regulatory threshold experience higher redemptions during crisis periods compared to funds with larger liquidity buffers, suggesting that investors are sensitive to a possible breach of liquidity thresholds. This may be aggravated by the fact that corrective measures (e.g. fees or gates) can be applied by the management board if LVNAV and CNAV funds breach their liquidity thresholds. Hence, fund managers typically try to avoid liquidity buffers from falling below the regulatory requirements. We find that funds with lower levels of liquidity buffers use their buffers to a lesser extent than funds with larger buffers, implying that fund managers prefer to sell assets rather than draw down their liquidity buffers.

Our findings provide useful lessons to inform the policy discussions in an international and European context. The results point to liquidity mismatch as the key vulnerability of MMFs which can be addressed, for instance, by increasing the levels of liquidity buffers and enhancing their usability, with the aim to increase the resilience against sudden and large outflows.[18] As our findings suggest, the possible use of corrective measures, such as the implementation of fees or gates ex-post, can exacerbate investor outflows and thus needs to be embedded cautiously in the regulation, while avoiding threshold effects. Specific vulnerabilities of the LVNAV structure call for significantly strengthening the funds' liquidity risk profiles and removing threshold effects.[19]

Importantly, any regulatory adjustment to address vulnerabilities in the MMF sector needs to be targeted and consider both benefits and costs. For instance, while adjustments to liquidity requirements for MMFs could allow funds to meet redemption requests more easily and reduce run risks during crisis periods, those requirements should be appropriately calibrated to not unduly reduce MMF returns or unnecessarily restrict funding of non-financial corporations.[20] Further research may address these issues to identify what an optimal regulation should achieve both in normal and in crisis times.

[18] See FSB policy proposals to enhance the resilience of the MMF sector, which among other things aim to reduce liquidity transformation (Financial Stability Board (2021)). See also the proposals by the Securities and Exchange Commission (2021) for US MMFs and the consultation document by the EU Commission on the functioning of the MMF Regulation (European Commission (2022)).

[19] See for instance the European Central Bank (2021) and the European Systemic Risk Board (2021)

[20] See, for instance, Grill et al. (2022) who study the possible impact of a mandatory public debt quota for EU private debt funds.

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Annex: MMF types under the EU MMF Regulation

In this annex we provide a short summary of MMFs (including a table summarising the main characteristics of the different types of MMFs). According to the EU MMF Regulation, there are three regulatory types of EU MMFs: CNAVs, LVNAVs and VNAVs[21].

CNAVs invest in public debt assets and transact at a stable NAV as long as the gap between the stable and marked-to-market NAV is lower than 50 bps. They are required to meet daily and weekly liquidity ratios. In case the fund does not meet the required weekly liquidity ratios, they may apply redemption gates and liquidity gates under certain conditions.

LVNAVs are allowed to also invest in commercial papers or certificates of deposit. Like CNAVs, LVNAVs also transact at a stable NAV, but the allowed gap between the constant and the marked-to-market NAV is set at 20 bps. The required daily and weekly liquidity ratios are set at the same values as for CNAVs, and they can also apply liquidity fees and redemption gates under certain conditions in case they do not meet the weekly liquidity requirements.

VNAVs are also allowed to invest in private debt money market instruments. In contrast to CNAVs and LVNAVs, VNAVs transact at a variable NAV. They need to meet lower requirements in terms of daily and weekly liquidity ratios and do not have to take corrective measures if the weekly liquidity requirements are not met.

The table below summarizes the previous paragraphs and provides a more detailed picture of the differences between the MMF regulatory types.

[21] In addition, VNAVs are split in two categories, standard VNAVs and short-term VNAVs respectively, which differentiate themselves by the maximum legal or residual maturity of the assets (standard VNAVs are allowed to hold assets with a longer maturity)

	Short-term MMF			Standard MMF
Types of MMFs	**Public Debt CNAV**	**VNAV**	**LVNAV**	**VNAV**
NAV	Stable – Units in the fund are purchased or redeemed at a constant price so long as the value of the underlying assets does not deviate by more than 0.5% (50bps) from par (i.e. 1.00).	Floating	Stable – Units in the fund are purchased or redeemed at a constant price so long as the value of the underlying assets does not deviate by more than 0.2% (20bps) from par (i.e. 1.00).	Floating
Eligibility requirements	99.5% of portfolio to be invested in public debt securities, reverse repo secured with government securities, and cash	Money market, instruments, securitisations and ABCP, deposits, derivatives, repo, reverse repo, MMF		
Legal/residual maturity of the assets of the MMF	< 397 days	< 397 days	<397 days	< 2 years
WAM of the portfolio	< 60 days	< 60 days	< 60 days	< 6 months
WAL of the portfolio	< 120 days	< 120 days	< 120 days	< 12 months
Daily liquidity ratio (daily maturing assets, reverse repurchase agreements that may be terminated by a one day notice, cash)	10%	7.5%	10%	7.5%
Weekly liquidity ratio (weekly maturing assets, reverse repurchase agreements that may be terminated by a five days' notice, cash)	30% (includes up to 17.5% of government debt with a legal or residual maturity of up to 190 days)	15% (includes up to 7.5% of money market instruments or shares of other MMFs that may be redeemed and settled within five working days)	30% (includes up to 17.5% of government debt with a or residual legal maturity of up to 190 days)	15% (includes up to 7.5% of market instruments or shares of other MMFs that may be redeemed and settled within five working days)
Liquidity Fee/ Redemption Gate	Optional if WLA falls below 30% and redemption requests reach 10% of the total net assets on any day. Mandatory if WLA falls below 10% as follows: (i) liquidity fees shall adequately reflect the cost to the MMF of achieving liquidity and ensure that investors who remain in the fund are not unfairly disadvantaged when other investors redeem their units or shares during the period; (ii) suspension of redemption up to 15 working days	None, unless at the discretion of the Fund and/or its asset management company, fees and gates are described under the prospectus	As for PDCNAV	None, unless at the discretion of the Fund and/or its asset management company, fees and gates are described under the prospectus

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