Commission de Surveillance du Secteur Financier

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The Impact of COVID-19 on Large Redemptions in the Luxembourg Investment Fund Market

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Abstract

This paper documents the large daily/weekly net redemptions (net outflows larger than 10% of the net asset value of the funds) in the Luxembourg investment fund industry as notified to their supervisory authority, the *Commission de Surveillance du Secteur Financier,* as from the peak of the COVID-19 crisis in March 2020, up to December 2020. We go beyond the traditional flow-return relationship by exploring the complementary fund-specific risk drivers behind the Large Net Redemptions (LNRs) such as fund size, leverage, liquidity shortage and concentration of the investors' basis, as based on supervisory data. The empirical setup relies on logit/Poisson/fractional regression models and on a control group of funds that were not subject to LNRs over the same period. We finally study the determinants of the use of Liquidity Management Tools (LMTs) by funds facing LNRs, based on the same fund specific risk drivers and on the size of net redemptions. The COVID-19 context allows to contrast the crisis specific features of these LNRs by comparing the March subset to the "back-to-normal" April-to-December subset. The results provide valuable information for risk-based-approach supervision systems. We first find that the small leveraged funds with a concentrated investors' basis and with poor past performance are more likely than others to have LNRs. We find that the size of the net redemptions (in percentage of the NAV) is higher for smaller funds and for funds with higher equity share of top 5 investors; e.g. a 10 percentage points increase of the investors' concentration leads to 2 percentage points higher net redemption level. As to the COVID-19 specificity, we find that the profile of the funds having LNRs in March was to a large extent similar to the one of funds having LNRs the rest of the year, except the overrepresentation of bond and mixed funds. Finally, we note that most LMTs are used as exceptional instruments. The probability of using them (gates, borrowing, redemptions in kind) in case of LNRs was larger in March than in other months, except for swing pricing, which turns out to be more frequently used over the second half of 2020.

JEL Classifications : G11, G18, G23, G28

Keywords : Investment Funds, Leverage, Liquidity, Net flows, Redemptions, LMTs

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1. Introduction

The COVID-19 pandemic and the strict confinement measures implemented for public health protection by governments, have deeply affected the global financial markets in late February and March 2020. The pan-European STOXX600 lost around 35% from its pre-crisis level to its bottom value.[3] The assets under management of the euro area investment funds dropped by 1.2 trillion EUR due to large valuation losses and to elevated outflows of investors across a wide range of fund types (ESRB, 2020a). Based on EFAMA (2020) data on the European jurisdictions, the net outflows, that is, the net redemptions[4], amounted in March 2020, at the height of the COVID-19 crisis, to 2.9% of Undertakings for Collective Investments in Tradable Securities (UCITS) total net assets (TNA), not far from to the Luxembourg developments where March net outflows for Undertakings for Collective Investment (UCIs) amounted to 2.7% (CSSF, 2020).

In this context, the *Commission de Surveillance du Secteur Financier* (CSSF), asked the 60 largest Investment Fund Managers (IFMs) of the Luxembourg investment fund industry, representing around 80-85% of total TNA of Luxembourg UCITS and regulated AIFs (Alternative Investment Funds), to start providing on a daily basis, as from 9 March 2020, a specific reporting containing information on the Luxembourg funds they manage and, in particular, the daily net redemptions exceeding 10% of the Net Asset Value (NAV), the weekly net redemptions exceeding 30% of the NAV, the portfolio responses to these net redemptions and finally information on the use of Liquidity Management Tools (LMTs). We will refer as from now to this ad hoc reporting as the Large Redemption Reporting (LRR).

This original dataset first provides a unique opportunity to document the evolution of Large Net Redemptions (LNRs) over time and to better understand the use of LMTs as a response to LNRs episodes. It also allows to study the potential determinants of such LNRs and of the use of LMTs by combining the LRR with complementary regulatory reportings for UCITS (UCITS Risk Reporting, or URR) and AIFs (AIFM Reporting) that provide information on the fund size, leverage, liquidity profile, concentration of the investors' basis, investment policy, to cite a few of them.

This analysis will address the following set of questions:

1) what are the fund-specific factors explaining that some funds are subject to LNRs and others not? Explaining the number of LNRs? And their size?

2) are these LNR factors different in March, at the peak of the crisis, from those effective in normal times?

3) what are the fund specific factors explaining the use of LMTs?

The empirical strategy followed to respond to these questions will combine logit models (Q1, Q2, Q3), Poisson regression models (Q1) and fractional regression models (Q1). This analysis sheds light on the characteristics of the funds subject to LNRs in both normal and stressed periods and thereby contributes to fund risk monitoring by improving ex ante risk identification and quantification. It also sheds some new light on the COVID-19 impact on the financial markets by contrasting the LNRs that occurred in March with those observed in more normal periods. More generally, this study contributes to the microprudential supervision of the fund sector by assessing the features associated with LNRs but also to the macroprudential one by highlighting the financial shock

[3] From its top level on 19 February 2020 to its bottom one on 18 March 2020, the STOXX600 lost 35,5%. It then took one year to recover, as it was back at its pre-crisis level on 31 March 2021.

[4] Investment funds issue and redeem shares directly for their investors, so that investor buys are referred to as the funds' inflows and the investor sells as the funds' outflows. The net outflow (or net redemption) is the difference between the fund's outflow and fund's inflow.

triggered by the COVID-19 event in March, the degree of resilience of the global LU investment fund sector in a context of important support measures from governments, central banks and supervisory authorities and the behavior of the funds based on their investment policies.

This analysis is organized as follows. Section 2 reviews the literature on LNRs. Section 3 presents the data and section 4 the methodology. We provide, and discuss, the results in Section 5 and conclude in Section 6.

2. Literature Review

This study lies at the border of two strands of research, as it relates firstly to investor flows determinants and secondly to the impact of financial crises on investment flows. We first shortly discuss both research fields and then discuss our contribution and show how we combine their approaches in our analytical framework.

Investor flows determinants. Investor flows in and out of investment funds have been extensively studied, with a preponderant focus on the relationship between flows and past returns. Empirical analyses show that good performers attract more investors than bad performers. Further, it is generally found that the difference between good performers matter more than the difference between bad performers. Flows are therefore said to be convex in performance (see the survey on performance flow relationship of Christoffersen et alii (2014)). Although this convexity was well documented for equity funds, Goldstein et alii (2017) found that convexity does not hold for corporate bond funds: on the contrary, for them concavity prevails, that is, the differences between bad performers matter more than differences between good performers (see similarly Ciccone et alii (2021) for the so-called "domestic" bond funds of the Luxembourg market). The key explanation of Goldstein et alii (2017) relates to the portfolio liquidity risk of corporate bond funds, a category that was particularly affected and scrutinized during the COVID-19 events (see the recommendations of ESRB (2020b) on corporate bond funds).

The literature on investor flows considers other "potential influences aside from performance, including marketing tactics, investor heterogeneity, and behavioral biases" (Christoffersen et alii, 2014) or even fees and charges (ESMA, 2017), but surprisingly gives only limited space to the risk profiles of the funds as a set of determinants. The concavity of the fund flow-performance relationship suggests that risk factors, such as the liquidity risk, could contribute to understanding investor flows. Among the few exceptions, Fong et alii (2018) consider the financial instability associated with the flows of investors into equity mutual funds in Hong-Kong and include in their analysis fund specific variables such as its size, age, cash ratio or the change in debt-to-capital ratio.

Liquidity stress tests. Investor flows can also be considered in the specific context of a financial stress. A lot of supervisory work has developed over the last years (Bouveret, 2017; ESMA, 2019; ESMA 2021) to simulate the impact of extreme redemption scenarios and see the ability of individual funds to cope with redemption pressure in order to assess the general resilience of the overall fund industry. Such simulations are then compared to real life events, such as the COVID-19 crisis, and refined based on this experience (ESRB 2020c). Liquidity stress tests are either built on exogeneous macro models where a scenario leads to certain large net outflows or on an assumption on rates of outflows typically based on historical observations. These outflows then lead to redemption pressure, impacts on underlying asset markets and further potential second round effects. Once these scenarios are established, fund-based stress tests require fund managers to assess the impact of the scenario on their specific funds. These assessments necessarily rely on the fund profile, its underlying portfolio and all its risk characteristics (such as e.g. its investor basis).

Our contribution relates to these two approaches by incorporating, in the net flow modelling, the risk factors that are highlighted in the liquidity stress test exercises currently implemented in Europe. One originality of the paper is its focus on the way fund characteristics, including their risk profiles, affect the net investor flows across all investment policies.

3. Data

3.1 Large Redemption Reporting

The information on LNRs and on LMT use is based on the LRR, that is, the CSSF's crisis-related daily monitoring of the largest IFMs active in the Luxembourg investment fund industry introduced in March 2020. The CSSF data collection can be split in two successive phases. The first phase of the LRR started on 9th March 2020 and was limited to the 60 largest IFMs representing around 80-85% of total Luxembourg TNA. The IFMs were held to notify for their Luxembourg (LU) UCITS[5] and part of their LU regulated AIFs (the so-called "UCI Part 2" and "SIFs", at the exclusion of the "SICARs")[6] the value of daily net redemptions exceeding 10% of the NAV, weekly net redemptions exceeding 30% of the NAV, the portfolio responses (i.e. potential changes to the underlying portfolio structure) to these net redemptions and finally information on the use of LMTs, which include gates, swing pricing, redemptions in kind, borrowing and anti-dilution levies.[7] The second phase started on 2nd June 2020, as the LRR was extended to cover the 122 largest IFMs. At the same time, the thresholds triggering the notification requirement were lowered to 5% and 15% for daily and weekly net redemptions, respectively.

In view to have a harmonized coverage over the time-period spanning 9 March 2020 to 31 December 2020, we merge the 2 phases into a unique LRR dataset by restricting the set of information to their common denominator. We thus limit the analysis to the 60 largest IFMs that were identified in phase 1 (and were still considered in phase 2; we do thereby not consider the LNRs notified by the 62 additional IFMs of phase 2). We further restrict the analysis to the daily net redemptions exceeding 10% of the NAV (we thereby discard the net redemptions collected in phase 2 larger than 5%, but lower than 10%) and to the weekly net redemptions exceeding 30% of the NAV (we thereby discard the net redemptions collected in phase 2 larger than 15% but smaller than 30%).[8]

3.2 UCITS Risk Reporting

The CSSF UCITS Risk Reporting (URR) has been introduced in 2016 and requests reporting from

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[5] UCITS are established under Part I of the law of 17 December 2010 on Undertakings for Collective Investments in Transferable Securities (the 2010 Law).

[6] AIFs are defined under the Law of 12 July 2013 on Alternative Investment Fund Managers (the 2013 Law). UCI Part 2 are established under Part II of the 2010 Law, SIFs are established under the law of 13 February 2007 relating to Specialized Investment Funds (the 2007 Law) and SICARs are established under the law of 15 June 2004 relating to the Investment company in risk capital (the 2004 Law).

[7] Suspensions are usually seen as part of the liquidity management toolbox. They are not included in this analysis as 1) they were not directly collected under the LRR, 2) their number was very low and 3) the majority of suspended LU funds in March 2020 were related to a single IFM who had to suspend a wide set of its fund range due to the COVID-19 driven volatility and to some particular specificities of its market.

[8] Though globally consistent, the two phases still have some potential sources of discrepancies: 1) the data collection process was operated via transmission of excel files for phase 1 and via eDesk, the CSSF digital portal, for phase 2; 2) the instructions in phase 2, though similar, were more detailed than in phase 1; 3) weekly net redemptions had to be calculated every day on rolling basis in phase 1, while it had to be calculated on the basis of calendar weeks only in phase 2.

management companies/self-managed investment companies.[9] It aims at collecting mainly risk information on Luxembourg-domiciled UCITS, falling under the 2010 Law, on a half-yearly basis. The URR is broken down into 8 different sections and gathers information on key investment strategies, global exposure and leverage, efficient portfolio management techniques, stress testing, counterparty risk, liquidity risk and credit risk. As of the reference reporting date, all Luxembourg-domiciled UCITS must report information from "Section I" of the URR with a limited number of fields such as TNA, global exposure method, average leverage based on commitment approach. As to the other sections ("Sections II to VIII" in the CSSF URR terminology), only those UCITS meeting one or both of the following criteria need to provide the requested information:

(i) UCITS with a TNA at reporting reference date equal to or higher than 500 million EUR;
(ii) UCITS using the Value-at-Risk (VaR) methodology for calculating the global exposure, with an arithmetic average leverage (calculated as the sum of notionals of the derivatives used) over the reference semester greater than or equal to 250% of the UCITS TNA.

We refer to those LU UCITS being in the full reporting scope of the CSSF URR (including "Sections II to VIII") as the "URR UCITS".

In our analysis, we will rely on URR information as reported on 31/12/2019 using variables from Section I for the scope applicable to all UCITS and from Sections II to VIII for the restricted scope of URR UCITS.

3.3 AIFM Reporting

The AIFM Reporting is the periodical reporting required from Alternative Investment Fund Managers according to Annex IV of the Commission Delegated Regulation (EU) No 231/2013 supplementing Directive 2011/61/EU on Alternative Investment Fund Managers, transposed into Luxembourg legislation via the 2013 Law.

As from a Luxembourg perspective, the following entities qualify as AIFs: (i) all Undertakings for Collective Investment established under Part II of the 2010 Law; (ii) Specialized Investment Funds established under the 2007 Law if they fulfil the criteria of Article 1(39) of the 2013 Law; (iii) SICARs established under the 2004 Law if they fulfil the criteria under Article 1(39) of the 2013 Law; and (iv) any entity not regulated under the 2010 Law, the 2007 Law or the 2004 Law that also meets the criteria of Article 1(39) of the 2013 Law. Given the scope of the LRR, only AIFs (i) and (ii) are considered in this analysis.

The AIFM reporting[10] gathers AIFM-specific information and, mostly relevant to this paper, also AIF-specific information, which comprises amongst others information on the predominant AIF type, the TNA, the concentration of the investors' basis, the share of investor specific profiles, liquidity risk, and leverage. In our analysis, we will rely on AIFM Reporting information as reported on 31/12/2019.

3.4 Preliminary view on the large redemption data

The large redemption data, to summarize it, consists of the daily net redemptions exceeding 10% NAV and of the weekly net redemptions exceeding 30% NAV of the LU UCITS and LU regulated AIFs (UCI Part 2 and SIFs) managed by the 60 largest IFMs over the period from 9 March 2020 to 31

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[9] A full description of the information contained in the CSSF URR can be found on the CSSF website under the following link: http://www.cssf.lu/en/legal-reporting-for-ucits/

[10] A full description of the information contained in the AIFM Reporting can be found on the CSSF website under the following link: http://www.cssf.lu/en/legal-reporting-for-aifm/

December 2020.[11] We report in Table 1 an overview of the dataset at the fund level for the left part (with breakdowns per fund category AIF, UCITS and UCITS subject to the URR as detailed in Sub-Sections 3.2 and 3.3 and per investment policy as based on BCL classification) and at notification level for the right part, as both perspectives will be used in the empirical analysis.

	Sample size	%
# Funds	7.830	100,0%
# AIFs	1.058	13,5%
# UCITS	6.772	86,5%
of which: # UCITS URR	*1.679*	*21,4%*

	Sample size	%
# Funds	7.830	100,0%
# MMF	113	1,4%
# HFND	452	5,8%
# BOND	2.354	30,1%
# MIXED	1.891	24,2%
# EQUITY	2.858	36,5%
# REST	55	0,7%
# OTHER	107	1,4%

	D. 10% LNR	%	W. 30% LNR	%
# Notifications	2.377	100,0%	649	100,0%
# AIFs	185	7,8%	102	15,7%
# UCITS	2.192	92,2%	547	84,3%
# UCITS URR	404	17,0%	72	11,1%
# Gates	26	1,1%	8	1,2%
# Swing pricing	623	26,2%	147	22,7%
# Redempt. in kind	33	1,4%	9	1,4%
# Borrowing	52	2,2%	54	8,3%
# Antidil. levy	56	2,4%	6	0,9%

Table 1 – Large redemption reporting overview

We see from Table 1 that 1) a large majority of the funds managed by the 60 IFMs are UCITS; 2) bond, equity and mixed funds account together for around 90% of the funds; 3) there were around 11 (3) notifications per working day for daily (weekly) LNRs of minimum 10% (30%) NAV; 4) LMTs were used as response to LNRs in 1% to 3% of the cases only (except for swing pricing which has been much more commonly used); 5) borrowing to meet redemption request was relatively often used for the weekly LNRs of 30% NAV (8% of the notifications versus only 2% for daily one of 10% NAV). We also report in Figure 1 the proportion of funds (globally as well as per fund categories) that were subject to one or more LNR notifications in 3-12/2020. We see that 16.9% (4.6%) of the funds notified at least one daily (weekly) net redemption of minimum 10% (30%) NAV. It also turns out that UCITS are relatively more subject to experiencing LNRs than AIFs, especially in relation to the daily net redemptions. This may reflect the lower frequency of redemption offered by a part of the AIFs, the type (investment policy / strategy) and probably also the resulting attitude and profile of AIF investors.

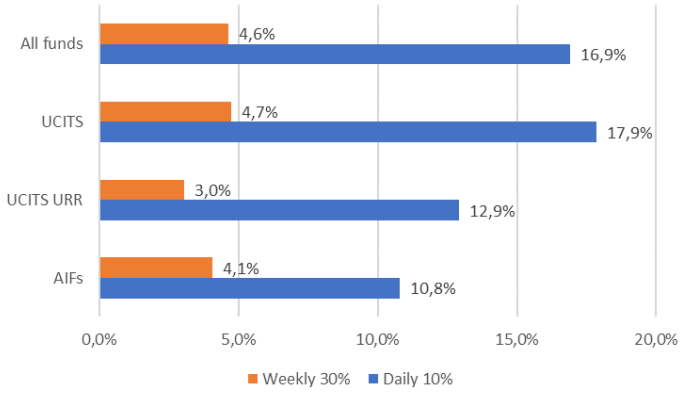


Figure 1 – Percentage of LU funds with minimum one LNR notification in 3-12/2020

[11] Given our objective of relating the LNRs with the URR and AIFM reporting, we only keep in our final sample the funds for which we have information either from the AIFM Reporting or from the UCITS Risk Reporting Section I as at 12/2019. Incidentally, AIFs of non-LU AIFMs subject to the LRR are excluded from our analysis as their AIFM reporting is not communicated to the CSSF but to the competent national authority of the non-LU AIFM. This exclusion concerns less than 3% of the TNA AIF covered by the LRR.

We now focus on investment policies and document their respective LNR intensity and their specific behavior in March 2020. We first present in Figure 2.a the average annual number of notifications per fund for each investment policy[12] as well as the March relative effect, so-called March multiplier (by dividing the daily (weekly) notification frequency in March by the daily (weekly) notification frequency in April to December 2020). We observe that 1) money market funds (MMFs) are the funds with most frequent LNRs at daily horizon, which is relatively normal given their role of a short term cash management vehicle ; 2) the funds are subject to daily LNRs exceeding 10% NAV every 2.7 years on average[13], MMFs have daily net redemptions exceeding 10% NAV more than once per year on average; 3) March, as the month at the heart of the COVID-19 crisis, was associated with much more frequent LNRs, 3.1 (5.4) times more frequent notifications of daily (weekly) LNRs of 10% (30%) NAV than LNRs in normal times (other months of the year) as can also be seen from Figure 2.b[14]; 4) the March multiplier was above average for mixed and bond funds for daily LNRs and for mixed funds as regards weekly LNRs; 5) the types of funds that were most subject to a higher March multiplier are those (bond and mixed funds) that were characterized by an otherwise below average number of LNRs over the whole observation period in 2020, as is well illustrated in Figure 2.a.

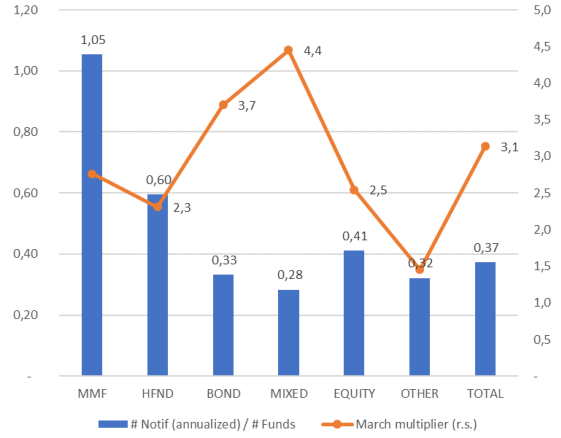


Figure 2.a – Annualized notifications of daily LNRs exceeding 10% NAV per fund type (bars) and relative intensity of March notifications (line)

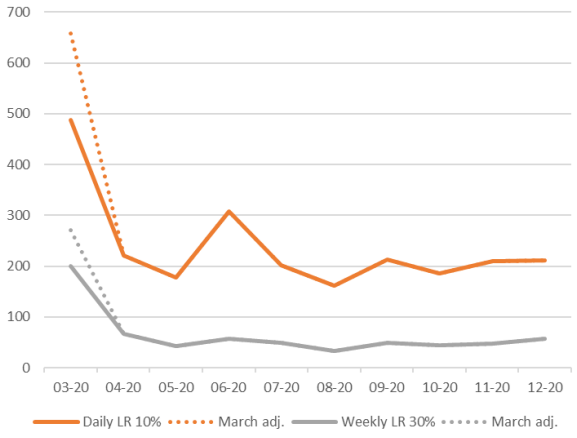


Figure 2.b – Notifications of daily (weekly) LNRs exceeding 10% (30%) NAV per month (with adjustment for March where data collection started on the 9th)

3.5 Scope of the analysis

We will consider different scopes/perimeters of analysis that will determine the size/nature of the samples and the variables available for the estimation, as illustrated by the 4 scopes/boxes/perimeters in Figure 3:

- The widest scope, labelled 1 in Figure 3, covers all LU UCITS managed by the 60 main IFMs and

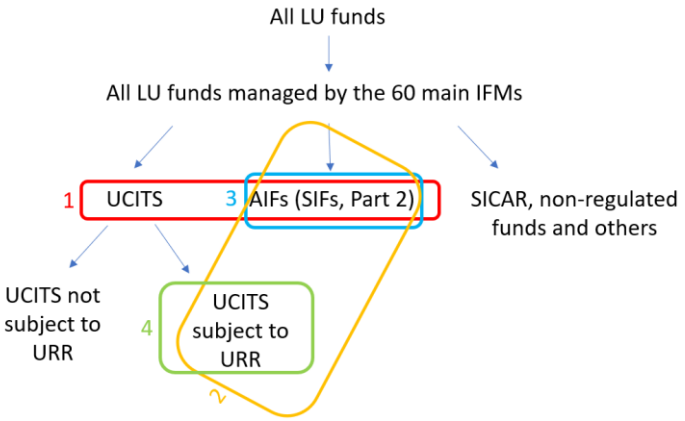
[12] We annualize by scaling up the number of notifications by a factor of 365/297 to account for the 9 March 2020 as first notification day.

[13] 1/0.37=2.7

[14] The temporary bump for daily large net redemptions exceeding 10% NAV in June is not observed for weekly notifications, and if found to be smoother for equivalent data obtained from external data vendor. The bump can partially be explained by the minor inconsistencies between phases 1 and 2 of the LRR, as already mentioned above.

all LU AIFs (SIFs and Part 2). The large extent of the scope comes at a double cost, a) as we only have a limited number of explanatory variables that are available for both UCITS and AIFs and b) as the harmonization of these variables, defined differently in their respective reporting frameworks, requires arbitrary assumptions that are per se not immune to critics (see Appendix for details)

- The second perimeter, labelled 2, is a variant of the scope 1, as it covers the same set of AIFs, but restricts the UCITS to those funds that are subject to the URR reporting. By restricting the universe of UCITS to the so-called URR UCITS, we considerably expand the set of variables available for the estimations but, as above, the harmonization of these variables requires arbitrary assumptions not immune to critics
- The third and fourth scopes, labelled 3 and 4, correspond to the two subsets of funds that make up scope 2.



Variables	Scopes			
	1	2	3	4
Large redemptions	X	X	X	X
Use of LMTs	X	X	X	X
Log TNA EUR	X	X	X	X
Leverage	X	X	X	X
Investment policy	X	X	X	X
Liquidity profile		X	X	X
Investors' concentration		X	X	X
Share of investors' groups		X	X	X
Past performance				X
Past volatility				X
Sample size	*7.830*	*2.737*	*1.058*	*1.679*

Figure 3 – Scopes of analysis

4. Empirical approach

The different questions we raise in this analysis require different empirical setups based on the nature of the dependent variables (binary, count or percentage), on the respective data subsets (at fund level or at notification level) and on the availability of variables for given scopes of analysis (UCITS, URR UCITS, AIFs or combinations thereof). Let's see in more details the empirical setup for each research question.

4.1 What is the profile of the funds subject to LNRs?

Probability of large net redemptions. The empirical setup consists in contrasting the profile of those funds that notified LNRs with the profile of the funds that did not notify LNRs over the same period. We therefore model the probability of a fund being subject to one (or more) LNR in 2020 as a function of a set of explanatory variables. We rely on the logit specification, defined as follows:

$$P(Y_i = 1|X) = E(Y_i|X) = \Lambda(X\beta) = \frac{e^{X\beta}}{1 + e^{X\beta}} \quad (1)$$

where Y_i is a binary variable equal to 1 if the fund *i* was subject to a LNR in 2020 and to 0 otherwise (depending on the variants, the LNR is defined on a daily basis or a weekly basis, with thresholds at 10%, 20%, 30% or 40% of the NAV), where β is the coefficient vector, X is the vector of explanatory

variables as set at 12/2019 (size, leverage, liquidity profile etc., depending on the sample scope) and $\Lambda(.)$ is the standard logistic distribution function. Relying on a distribution function, like the logistic, ensures that we get values between zero and one, as we expect from a probability. As outcome, we expect to identify those factors that are significantly associated with the probability that a fund be subject to a LNR. To ease the interpretation, we will report in the results' tables the marginal effects instead of the estimation coefficients. As an illustration, if the marginal effect of X on $P(Y_i = 1|X)$ is 0.10, then, it means that a unit variation of X results in a rise of 10 percentage points of the probability of a LNR (for a fund with characteristics set at their mean values).

Number of large net redemptions. As a complement, we also explore whether some variables are associated with the number of LNRs for those funds that are subject to at least one LNR in 2020. As the dependent variable is a count variable with strictly positive integers as potential values (fund *i* had, for example, 3 LNRs in 2020), we rely on the Poisson regression model (Cameron and Trivedi, 2005), which is defined as follows:

$$P(Z_i = z\,|X) = \frac{e^{-\mu}\mu^z}{z!} \quad (z = 1, 2, 3 \ldots)$$
$$\mu = E(Z_i|X) = e^{X\beta} \tag{2}$$

where Z_i is the number of LNRs of fund *i* in 2020, where μ is the intensity parameter, than can also be interpreted as the conditional expectation of Z_i[15], where β is the coefficient vector, X is the vector of explanatory variables as set at 12/2019 (size, leverage, liquidity profile etc., depending on the sample scope). As outcome, we expect to identify those factors that are significantly associated with the funds' expected number of LNRs. To ease the interpretation, we will report in the results' tables the marginal effects instead of the estimation coefficients. As we focus on the number of LNRs, the sample is restricted to the funds with at least one LNR notification. We therefore exclude from this Poisson regression model all the funds managed by the 60 largest IFMs that did not notify any LNR in 2020.

Size of large net redemptions. As a second complement, we also investigate whether some variables are associated with the magnitude of the notified LNRs (expressed in percentage of NAV), for those funds that notified at least one LNR in 2020. As the dependent variable now is a proportion defined and observed only on the standard unit interval (i.e., $0 \leq W_i \leq 1$), also called a fractional variable, we will estimate a fractional regression model (FRM), as proposed in Papke and Wooldridge (1996):

$$E(W_i|X) = G(X\beta) = \frac{e^{X\beta}}{1 + e^{X\beta}} \tag{3}$$

where W_i is the magnitude of the notified actual net redemptions of fund *i* in 2020 (or the magnitude of the largest actual net redemption if a fund notified more than one LNR), where $G(.)$ is some nonlinear function satisfying $0 \leq G(.) \leq 1$ (we use the logit function for simplicity, as made explicit in the last term of Equation (3))[16], where β is the coefficient vector, X is the vector of explanatory variables as set at 12/2019 (size, leverage, liquidity profile etc., depending on the sample scope). Although Equation (3) looks similar to Equation (1), there are three differences: (i) the dependent variable of the logit model is a binary variable taking values 0 or 1, while the dependent variable of

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[15] The intensity parameter, μ, can also be interpreted as the conditional variance of Y_i thanks to the so-called equidispersion property (equality of mean and variance) of the Poisson distribution. An alternative model (negative binomial model) that relaxes the equidispersion assumption has been as well considered. The results (sign, size and significativity) remain largely unchanged (and are available upon request).

[16] The potential specifications for $G(.)$ include any cumulative distribution function, including the standard logit and probit, loglog and complementary loglog. Contrary to logit and probit, which are symmetric functions around the point 0.5, the loglog and complementary loglog are asymmetric functions: the former (later) increasing more sharply (slowly) at small values of $G(.)$ and slowly (sharply) at values close to 1.

the fractional regression model is a fraction with values in the standard unit interval as mentioned above; (ii) the logit model is estimated by maximum likelihood, while the fractional regression model must be estimated by quasi-maximum likelihood (in other words, we use robust errors from the sandwich estimator in the latter case); (iii) the logit model is estimated on the full universe of funds managed by the 60 main IFMs (including those that did not notify any LNR in 2020), while the fractional regression model is estimated on the subset of funds notifying at least one LNR in 2020.[17] As outcome, we expect to identify those factors that are significantly associated with the funds' expected magnitude of net redemptions. To ease the interpretation, we will report in the results' tables the partial effects instead of the estimation coefficients. As an illustration, if the marginal effect of X on $E(W_i|X)$ is 0.10, then, it means that a unit variation of X results in an expected rise of 10 percentage points of the LNR level in terms of NAV (for a fund with characteristics set at their mean values). As we focus on the magnitude of LNRs, the sample is restricted to the funds with at least one LNR notification, as for the above analysis on the expected number of LNRs.

4.2 Was their profile different in March?

The empirical strategy here consists in contrasting the profile of the funds that notified LNRs at the heart of the crisis, in March, with the one of funds that notified LNRs in other months. We thereby aim at identifying those explanatory variables that were especially associated with the crisis episode and not generally to LNRs in normal times. We therefore model the probability (of a fund notifying at least one LNR in 2020) of a fund being subject to a LNR in March as a function of the explanatory variables by relying on the logit specification. The model is similar to the one defined in Equation (1) that we reproduce here for convenience:

$$P(M_i = 1|X) = E(M_i|X) = \Lambda(X\beta) = \frac{e^{X\beta}}{1 + e^{X\beta}} \quad (4)$$

where M_i is a binary variable equal to 1 if the notifying fund *i* was subject to one (or more) LNR in March 2020 and to 0 if the fund was subject to LNRs in the other months of the year only (with threshold at 10% for daily frequency and 30% for weekly ones), where β is the coefficient vector, X is the vector of explanatory variables as set at 12/2019 (size, leverage, liquidity profile etc.) and $\Lambda(.)$ is the standard logistic distribution function. As outcome, we expect to identify those factors that are especially associated with the probability that a fund was subject to a LNR at the heart of the crisis. To ease the interpretation, we will report in the results' tables the marginal effects instead of the estimation coefficients.

4.3 What is the profile of the funds using LMTs?

The last section of the LRR relates to the potential reactions of the funds in the context of LNRs. The funds notifying LNRs were also asked to report whether they responded to large outflows by borrowing money, by using redemptions in kind or by the use of other LMTs such as swing pricing, gates and anti-dilution levies (we refer to these responses collectively as to "LMTs" for simplicity). As the use of one of these LMTs is a binary variable (yes/no), we rely again on standard logit models, that we write again explicitly for exhaustivity:

$$P(L_{k,j} = 1|X) = E(L_{k,j}|X) = \Lambda(X\beta) = \frac{e^{X\beta}}{1 + e^{X\beta}} \quad (5)$$

[17] As an alternative, we could have estimated both logit and fractional regression models in a unique step by relying on a two-stage fractional regression model (see Ramalho et alii, 2011 for details).

where j=1, 2… 5 refers to a specific LMT (borrowing, redemption in kind, gating, anti-dilution levy or swing pricing), where $L_{k,j}$ is a binary variable equal to 1 if the daily LNR 10% notification *k* reports the use of LMT *j* and to 0 otherwise, where β is the coefficient vector, X is the vector of explanatory variables as at 12/2019 and $\Lambda(.)$ is the standard logistic distribution function. As outcome, we will estimate separate regressions for each LMT *j*. We expect to identify those factors that are especially associated with the probability of using an LMT as response to a LNR. Again, to ease the interpretation, we will report in the results' tables the marginal effects instead of the estimation coefficients.

4.4 Methodological overview

We summarize in Table 2 the empirical setups considered for our different questions, where we list the definitions of the dependent variables, the choice of the model, the estimation unit and finally the scope. The approaches will be complemented by some variants related to the frequency to be considered (daily or weekly), the relevant thresholds (minimum 10% for daily LNRs and minimum 30% for weekly LNRs) and the scopes of analysis (UCITS, URR UCITS, AIFs or combinations thereof) as the respective scopes determine the trade-off between the number of variables available and the sample size.

Question	Depvar	Model	Data unit	Scope
What explains LNRs?	Y_i - Dummy equal to 1 in case of LNR notification, to 0 otherwise	Logit	Fund	All funds
What explains their frequency?	Z_i - Number of LNR notifications	Poisson	Fund	Notifying funds
What explains their magnitude?	W_i - Magnitude of LNRs (percentage of NAV)	FRM	Fund	Notifying funds
Was March different?	M_i - Dummy equal to 1 in case of LNR notification in March, to 0 otherwise	Logit	Fund	Notifying funds
What explains the use of LMTs?	$L_{k,j}$ - Dummy equal to 1 in case of use of LMT, to 0 otherwise	Logit	Notification	All notifications

Table 2 – summary view of the empirical strategies

5. Results

5.1 What is the profile of the funds subject to LNRs?

UCITS analysis - Daily LNRs exceeding 10% of NAV are associated with some key variables as detailed in Table 3 and discussed below for LU UCITS and LU AIFs. Let's start with UCITS:

- We first find that small UCITS (in terms of TNA) are more likely to be subject to LNRs. A doubling of the TNA size of a URR UCITS will decrease the probability that the fund will be faced with a LNR by 2.8 percentage points.
- Leverage is positively and strongly associated with LNRs. Looking specifically to the URR UCITS subset, we note that the source of this relationship mainly comes from the funds using the VaR approach, that is, those reporting the leverage based on notional values without taking into account netting or hedging effects. This is not a surprise as the funds that engage in more complex investment strategies and/or make a larger use of financial derivative instruments typically use the VaR approach rather than the commitment approach.
- Third, the equity share held by the top 5 investors, a proxy for investors' concentration, is

strongly associated with the probability of LNRs. A 10% increase of the equity share of the top 5 investors increases the probability that a URR UCITS gets a LNR exceeding 10% NAV by 1.49 percentage points.

- Fourth, the realized volatility and the realized performance of funds, variables only available for URR UCITS, are significantly associated with LNRs, positively for the realized volatility and negatively for the realized performance. These results are in line with the literature on the flow-return relationships (see the survey of Christoffersen et alii, 2014). Funds that exhibited high volatility and bad performance gave rise to net outflows. A past performance of -50% over the last semester of 2019 (as reported under the URR) will increase the probability of a LNR by 2.8 percentage points. This is smaller than the magnitude reported in the literature but can be partially explained by several factors: 1) the past performance is the one reported on 12/2019, which consequently does not incorporate the COVID-19 developments; 2) our estimate summarizes the effect of the different investment policies covered in our sample; 3) a specific set of risk related explanatory variables are used in our estimate, that are generally not used in other papers on the same topic.
- In terms of investment policy, we find that MMFs and hedge funds are significantly more likely to have LNRs than equity funds (the base category), even after controlling for size, leverage, liquidity profile, etc. The probability for an MMF to have a LNR is 15 percentage points larger than the one of an equity fund (all other explanatory variables being equal). As noted before, this result can be explained by the use of MMFs as short-term cash management vehicle. As to the bond funds, we see that the probability of LNRs is lower than for equity funds (the base category). This outcome does not change when we look more granularly to emerging markets and high yield sub-categories of bond funds.
- Finally, we find that the share in equity of some categories of investors (non-financial investors, pension funds, funds of funds, other financial institutions) is positively associated with LNRs (compared to the base category of bank investors).[18]

AIF analysis - The results for the AIF differ slightly from those found for UCITS and reflect the specific nature of AIFs as compared to UCITS in terms of investment policies (AIFs are much more heterogenous), size (AIFs are on average smaller than UCITS) and investor profile and attitude (well-informed/institutional investors versus retail investors). Our findings confirm, in the context of large redemptions, that UCITS and AIFs are different products designed for different investors with different risk profiles:

- First, the size is not negatively but positively associated with the LNRs (with a marginal effect of much smaller magnitude). This result illustrates how different UCITS and AIFs are, but it also reflects a compositional difference as the size average and standard deviation of UCITS URR are more than five times larger than those of the AIFs.
- Second, the leverage proxy (gross leverage) is not significantly related to the LNRs. This does not mean that leverage is not a relevant proxy variable for AIF risk assessments in general and from a macroprudential perspective such as the one embedded in the article 25 AIFMD framework on the imposition of leverage limits (ESMA, 2020a).

[18] *While IFM should do a look-trough to the beneficial owner on a best effort basis when reporting investor categories, the category of bank investors might, in addition to the share of funds held by banks for their own account, also comprise investments where the bank acts as intermediary for other investors including in particular retail investors.*

	Dependent variable : Dum_D_10pc			
	Full	AIF+URR	AIF	URR
	(1)	(2)	(3)	(4)
LogTNA	-0.016***	0.001	0.009**	-0.028***
	(0.002)	(0.003)	(0.005)	(0.006)
Lev_All	0.010***	0.007***	0.005	
	(0.002)	(0.002)	(0.004)	
URR_Lev_Commitm				-0.005
				(0.006)
URR_Lev_Notional				0.004*
				(0.002)
All_LiqShort7d		-0.078**	-0.077**	-0.027
		(0.035)	(0.038)	(0.054)
Top5_investors		0.100***	-0.010	0.149***
		(0.025)	(0.027)	(0.029)
URR_Real_Vol				0.048**
				(0.022)
URR_Real_Perf				-0.056**
				(0.028)
BOND	-0.027***	0.002	0.102**	-0.030*
	(0.010)	(0.016)	(0.050)	(0.017)
HFND	0.017	0.066**	0.118*	0.009
	(0.019)	(0.030)	(0.069)	(0.031)
MIXED	-0.080***	0.011	0.087**	-0.042**
	(0.009)	(0.017)	(0.039)	(0.018)
MMF	0.152***	0.183***	0.336	0.161**
	(0.045)	(0.064)	(0.205)	(0.064)
OTHR	-0.061**	-0.038	0.043	-0.043
	(0.027)	(0.033)	(0.070)	(0.050)
REST	-0.133***	-0.074***	-0.025	
	(0.022)	(0.025)	(0.039)	
Share_GENG		-0.024	-1.121	0.058
		(0.072)	(0.964)	(0.091)
Share_HHLD		0.034	0.011	0.011
		(0.029)	(0.041)	(0.034)
Share_INSC		0.033	0.024	0.011
		(0.028)	(0.026)	(0.049)
Share_NFCO		0.161***	0.076	0.201***
		(0.043)	(0.052)	(0.063)
Share_OCIU		0.098***	0.102**	0.051
		(0.028)	(0.042)	(0.035)
Share_OFIN		0.064***	0.077***	0.013
		(0.022)	(0.027)	(0.028)
Share_PFND		0.070**	-0.005	0.163***
		(0.032)	(0.035)	(0.046)
Share_UNKN		0.051**	0.018	0.030
		(0.024)	(0.023)	(0.042)
Constant				
Observations	7830	2737	1058	1679
Log Likelihood	-3.480,1	-948,8	-331,4	-574,1
Akaike Inf. Crit.	6.978,2	1.935,6	700,8	1.190,2

Note: *p<0.1; **p<0.05; ***p<0.01. Marginal effects of logit model - see Equation (1). Robust standard errors.

Table 3 – Determinants of daily LNRs exceeding 10% NAV

- Third, the liquidity shortage, a key concept capturing the potential lack of portfolio liquidity given the redemption possibilities of the investors, is found to be negatively associated with the probability of having a LNR. This unexpected result suggests either that 1) the liquidity shortage is not a high source of uncertainty triggering LNRs or that 2) the proxy integrates a subjective bias reflecting over-optimistic/pessimistic self-assessment made by the funds on their liquidity profile, or 3) that the liquidity shortage as a proxy is not measuring well the liquidity risk. Other proxies might be found as better alternatives.
- Finally, the share in equity of top 5 investors, a proxy for investors' concentration, is not related to AIFs LNRs.

Alternative thresholds and frequency - The results discussed so far were based on daily LNRs exceeding 10% NAV. We test the robustness of the results for some variants where the thresholds are set at 20% and 30% and for variants based on weekly LNRs with thresholds set at 30% and 40%. Let's note that the treatment group changes (fewer funds are subject to LNRs when the threshold is set at, say, 20% rather than at 10%) as well as the control group (more funds are now considered to have no LNR as the threshold is set at a higher percentage). As the URR UCITS scope offers the widest set of explanatory variables and a reasonably large proportion of LNRs, we only report our results on the URR UCITS perimeter in Table 4. The main complementary results are the following:

- The fund size always matters, but the larger the thresholds, the smaller the effect. We have the same outcomes (smaller effects) for investors concentration, realized volatility and realized performance. This is only partly surprising as we shift funds that were previously considered as subject to LNRs to the category of funds not subject to LNRs (as a result of higher required thresholds). This contributes to smoothing the marginal contribution of the explanatory variables.

	Dependent variable dummies				
	Daily10pc	Daily20pc	Daily30pc	Weekly30pc	Weekly40pc
	(1)	(2)	(3)	(4)	(5)
LogTNA	-0.028***	-0.012***	-0.005***	-0.005***	-0.002**
	(0.006)	(0.003)	(0.002)	(0.002)	(0.001)
URR_Lev_Notional	0.004*	0.001	0.0005*	0.001***	0.0002*
	(0.002)	(0.001)	(0.0003)	(0.0004)	(0.0001)
All_LiqShort7d	-0.027	-0.018	0.003	-0.009	-0.005
	(0.054)	(0.029)	(0.013)	(0.022)	(0.008)
Top5_investors	0.149***	0.081***	0.033***	0.035***	0.016***
	(0.029)	(0.013)	(0.008)	(0.010)	(0.005)
URR_Real_Vol	0.048**	0.014	0.003	0.008	0.003
	(0.022)	(0.011)	(0.004)	(0.006)	(0.002)
URR_Real_Perf	-0.056**	-0.021	-0.002	-0.006	-0.002
	(0.028)	(0.021)	(0.005)	(0.006)	(0.002)
(output on investment policies and shareholder shares omitted in the table for brevity)					
Observations	1,679	1,679	1,679	1,679	1,679
Log Likelihood	-574,3	-302,5	-164,3	-186,6	-122,5
Akaike Inf. Crit.	1.188,6	645,1	368,6	413,1	285,0

Note: *p<0.1; **p<0.05; ***p<0.01. Marginal effects of logit model – see Equation (1). Robust standard errors. Scope restricted to URR UCITS.

Table 4 – Determinants of LNRs – variants on frequency (d/w) / thresholds (X% NAV)

- Quite interestingly, it turns out that leverage remains slightly significant when the thresholds

are set at higher values (except for 20% daily). In terms of marginal effect, a rise of 100 percentage points of the leverage (sum of notionals) will increase the probability of a daily (weekly) LNR exceeding 10% (30%) by 1 percentage point (0.25 percentage point) for the UCITS URR that use the VaR method to calculate their global exposure.[19]

Number of notifications - As complements, we focus on the subset of funds that reported at least one LNR in 2020. We first examine what determines the number of notifications, that is, the number of LNRs. As a main outcome, based on the results reported in Table 5, we find that most variables (leverage, size, investors' concentration, realized volatility, realized performance) are no longer significant. In other words, these variables are good at explaining the probability of having one LNR, but cannot explain the number of LNR notifications. The funds that are subject to at least one LNR are quite similar (based on our set of explanatory variables) whatever the number of LNR episodes they got in 2020. The lower significance is also partially explained by the sample size, which is smaller than the ones in Tables 3 and 4 where funds with no LNR were included (cf sample size of columns (5) and (6) which are 99 and 51, respectively).

	Dependent variable: Number of LNR notifications					
		Daily10pc			Daily20pc	Weekly30pc
	Full	AIF+URR	AIF	URR	URR	URR
	(1)	(2)	(3)	(4)	(5)	(6)
LogTNA	0.048*	0.099	0.057	0.070	0.038	-0.067
	(0.027)	(0.063)	(0.052)	(0.097)	(0.082)	(0.156)
Lev_All	0.014	0.020	0.040			
	(0.015)	(0.015)	(0.040)			
URR_Lev_Notional				0.003	0.0002	0.030***
				(0.021)	(0.017)	(0.011)
All_LiqShort7d		-0.474	0.384	-0.781	-1.045**	-0.636
		(0.564)	(0.708)	(0.757)	(0.518)	(0.460)
Top5_investors		0.324	-0.408	1.159**	0.780	-0.135
		(0.355)	(0.317)	(0.523)	(0.495)	(0.703)
URR_Real_Vol				1.180	0.337	-1.202
				(0.757)	-1.656	(0.958)
URR_Real_Perf				-1.775	-0.547	1.429
				(1.108)	(1.995)	(1.162)
	(output on investment policies omitted in the table for brevity)					
Observations	1324	331	114	217	99	51
Log Likelihood	-2140,4	-537,8	-165,4	-363,2	-134,0	-64,4
Akaike Inf. Crit.	4298,8	1097,5	352,9	750,3	290,0	150,8

Note: *p<0.1; **p<0.05; ***p<0.01. Marginal effects of Poisson model – see Equation (2). Robust standard errors. Scope restricted to funds reporting at least one LNR in 2020.

Table 5 – Complement - Determinants of the number of LNRs episodes

Size of redemptions - As a second complement, we study the determinants of the level of net redemption in NAV percentage, as notified in the LRR. As based on Table 6, our main findings are the following:

- We first note that smaller funds are subject to larger levels of net redemptions. Doubling the

[19] *The effect of a 100 percentage points increase of URR_Lev_Notional is obtained by multiplying the coefficient 0.004 (for column 1) or 0.001 (for column 4) by the inverse of the proportion of UCITS-URR using the VaR method to calculate their large exposure (as they are in principle the UCITS-URR that report a potentially non-null value for the URR_Lev Notional, that is 1679/694), which results in 1% for daily 10% LNRs and in 0.25% for weekly 30% LNRs.*

size of a URR UCITS leads to an expected decrease of the level of net redemption by 3.6 percentage points.

- We then note that the larger the leverage of a fund, the larger the expected level of net redemption, but the magnitude is quite limited. Indeed, the partial effect is found to be around 0.01, which means that a 100 percentage points higher leverage (expressed in terms of NAV) will increase the expected net redemption level by one percentage point.
- We finally find that the investors' concentration is directly associated with the level of net redemption, with a partial effect of 0.203 for URR UCITS. A 10 percentage points increase of the investors' concentration leads to an expected 2.03 percentage points increase of the level of net redemption (in percentage of NAV).

	Dependent variable: Net redemption level (% of NAV)					
		Daily10pc			Daily20pc	Weekly30pc
	Full	AIF+URR	AIF	URR	URR	URR
	(1)	(2)	(3)	(4)	(5)	(6)
LogTNA	-0.029***	-0.006	0.014	-0.036***	-0.029	-0.011
	(0.005)	(0,010)	(0.014)	(0.012)	(0.018)	(0.022)
Lev_All	0.009***	0.010***	0.040*			
	(0.003)	(0.004)	(0.022)			
URR_Lev_Notional				0.008**	0.014*	-0.005
				(0.003)	(0.008)	(0.008)
All_LiqShort7d		-0.054**	-0.421***	0.111	0.251*	-0.092
		(0.088)	(0.146)	(0.090)	(0.132)	(0.139)
Top5_investors		0.176***	0.162	0.203***	0.269**	0.613***
		(0.052)	(0.108)	(0.057)	(0.115)	(0.178)
URR_Real_Vol				0.030	-0.063	0.164
				(0.087)	(0.348)	(0.283)
URR_Real_Perf				-0.077	0.025	-0.231
				(0.124)	(0.418)	(0.362)
	(output on investment policies and shareholder shares omitted in the table for brevity)					
Observations	1324	331	114	217	99	51
R-squared	0.060	0.224	0.304	0.270	0.311	0.421

Note: *p<0.1; **p<0.05; ***p<0.01. Partial effects of fractional regression model – see Equation (3). Robust standard errors. Scope restricted to funds reporting at least one LNR in 2020. R-squared calculated as the square of the correlation coefficient between the actual and fitted values of the dependent variable.

Table 6 – Complement - Determinants of the net redemption level (% NAV)

5.2 Was their profile different in March?

The CSSF large redemption data collection was implemented in March 2020 at the peak of the COVID-19 crisis. This database which covers the year of 2020 allows to distinguish the characteristics of the funds subject to the LNRs during the peak of the crisis in March 2020 with those of the funds that reported LNRs in other months of the year. As shown in Figure 2.a (and from complementary analysis based on data from an external data vendor), the number of large notifications comes back to normal level as from April 2020. We therefore contrast March notifications with the notifications for the rest of the year (April to December 2020). As detailed in Table 7, it turns out that most explanatory variables are not significant. In other words, the profile of the funds having LNRs in March is to a large extent similar to the one of funds having LNRs during the rest of the year. This

main result is to be nuanced as follows. First, liquidity shortage becomes significant for weekly net redemptions (but the sample size has only 51 observations). Second, the investors' concentration is negatively associated with the March notifications for AIFs. AIFs subject to LNRs in March had a significantly lower concentration than the ones having LNRs in the other months. Third, the investment policies of bond funds and mixed funds are significantly and positively associated with March notifications of LNRs. This is a statistical confirmation of the March multipliers that were documented to be large for bond and mixed funds in Figure 2.a.

	Dependent variable March notification dummies:					
		Daily10pc			Daily20pc	Weekly30pc
	Full	AIF+URR	AIF	URR	URR	URR
	(1)	(2)	(3)	(4)	(5)	(6)
LogTNA	0.007	-0.007	-0.007	-0.037	0.001	0.020
	(0.007)	(0.014)	(0.004)	(0.026)	(0.025)	(0.034)
Lev_All	-0.0005	0.004	0.003			
	(0.006)	(0.006)	(0.002)			
URR_Lev_Notional				-0.003	0.004	0.005
				(0.010)	(0.005)	(0.007)
All_LiqShort7d		0.171	0.048	0.269	0.006	0.486**
		(0.148)	(0.036)	(0.183)	(0.306)	(0.211)
Top5_investors		-0.284***	-0.112***	-0.042	0.153	0.097
		(0.081)	(0.030)	(0.135)	(0.215)	(0.308)
URR_Real_Vol				0.064	-0.257	0.287
				(0.232)	(0.953)	(0.349)
URR_Real_Perf				-0.062	-2.060**	-0.284
				(0.318)	(0.821)	(0.438)
	(output on investment policies omitted in the table for brevity)					
Observations	1,324	331	114	217	99	51
Log Likelihood	-751,0	-171,0	-38,8	-117,4	-46,7	-16,7
Akaike Inf. Crit.	1.519,9	364,0	99,7	258,9	115,5	55,4

Note: *p<0.1; **p<0.05; ***p<0.01. Marginal effects of logit model – see Equation (4). Robust standard errors. Scope restricted to funds reporting at least one LNR in 2020.

Table 7 – March effect

5.3 What is the profile of the funds using LMTs?

The LRR includes information on the potential fund responses to the LNRs, including the use of LMTs. We therefore have yes/no information on the use of swing pricing, gates, redemptions in kind, anti-dilution levies and borrowing. The contrast between yes/no occurrences is not satisfactory for all LMTs: 26 notifications only refer to the use of gates and 33 ones to the use of redemptions in kind out of a total of 2377 notifications (see Table 1); in addition, some of these notifications relate to the same funds that used repeatedly LMTs as a response to their LNR episodes, which further reduces the number of funds that have used the LMTs. Keeping this limitation in mind, we now discuss the main determinants of LMT use as reported in Table 8:

- We first note that swing pricing and anti-dilution levies are distinct LMTs, often considered as liquidity management tools not exclusively used in stress periods, but more generally in fund

every days' life. As an illustration, we first find that swing pricing is mainly used by large and leveraged funds for relatively smaller large net redemptions. We also note that the expected probability of using swing pricing was, surprisingly, 5.6 percentage points lower in March than in other months. It turns out that the COVID-19 event has led many funds to integrate swing pricing in their toolbox on the one side, and to increase their use on the other side. In-house figures show that the proportion of UCITS URR that refer to the potential use of swing pricing in their prospectus went from 63% in 12/2019, to 64% in 6/2020 and to 68% in 12/2020. As a consequence, the availability and use of swing pricing slightly increased over the second semester and might be a contributing factor to this relatively lower percentage for March.

- We then find that the probability of using borrowing and, to a smaller extent, of using gates and anti-dilution levies was larger in March than in "normal" months. This comes as no surprise, as these tools are designed to be available and used mainly for stress periods.
- The leverage was negatively associated with the probability of using gates and redemptions in kind, but with very low magnitude. As noted above, the interpretation remains subject to caution given the small number of gates and redemptions in kind reported in the LRR.

	Dependent variable: LMT use dummy for Daily10pc notifications				
	Swing	Gates	RedKind	AntidilLevy	Borrowings
	(1)	(2)	(3)	(4)	(5)
LogTNA	0.033***	-0.00003	0.0002**	-0.0001	-0.001
	(0.006)	(0.00004)	(0.0001)	(0.0003)	(0.001)
Lev_All	0.011***	-0.001***	-0.0005**	-0.0004	0.0001
	(0.004)	(0.0002)	(0.0002)	(0.0003)	(0.0002)
NetRed_D_pc	-0.181***	0.001	0.001**	0.00003	0.001
	(0.045)	(0.0003)	(0.0004)	(0.001)	(0.003)
PrvBk_pc	-0.028	-0.0004	-0.001**	-0.001	0.006***
	(0.024)	(0.0003)	(0.0005)	(0.001)	(0.002)
Dum_March	-0.056***	0.002**	-0.001**	0.003**	0.015***
	(0.021)	(0.001)	(0.0002)	(0.001)	(0.004)
	(output on investment policies omitted in the table for brevity)				
Observations	2377	2377	2377	2377	2377
Log Likelihood	-1.299,5	-120,9	-146,1	-248,5	-213,8
Akaike Inf. Crit.	2.623,1	265,8	316,3	521,0	451,5

Note: *p<0.1; **p<0.05; ***p<0.01. Marginal effects of logit model – see Equation (5). Robust standard errors. Scope restricted to funds reporting at least one LNR in 2020.

Table 8 – LMT use

6. Conclusion

This analysis sheds some more light on the large daily and weekly net redemptions that characterized the life of LU UCITS and LU AIFs. We rely on an original dataset compiled since March 2020, at the peak of the COVID-19 crisis, up to December 2020 over the Luxembourg funds managed by the 60 largest investment fund managers of the Luxembourg fund industry and on fund specific supervisory data as at 12/2019 from the Luxembourg specific UCITS Risk Reporting and the EU-mandated AIFM Reporting. We assess whether the large net redemptions (LNRs) are associated with high fund

leverage, portfolio liquidity, size, past performance etc. We have therefore raised 3 core questions: on the key drivers of LNRs, on the COVID-19 crisis specificity and on the use of liquidity management tools (LMTs), for which the outcomes can be summarized as follows.

- As first outcome, we find that the small leveraged UCITS with a concentrated investors' basis are more likely than others to have LNRs. It is even more likely if their last annual performance was bad, thereby confirming the well-known performance-flow relationship. We also note, for the subset of UCITS subject to URR, that the leverage effect on LNRs is mainly explained by the leveraged based on notional values (that is, the leverage to be reported by the UCITS under a VaR approach, which are more prone to engage in more complex investment strategies). These findings are specific to UCITS (the largest share of the sample), but slightly different for AIFs, where the leverage and investors' concentration are not significantly associated with LNRs.
- As second outcome, we find that the liquidity proxy is unexpectedly not associated with LNRs. It suggests either that the liquidity risk does not matter for LNRs or, more likely, that the liquidity profile based on the funds' self-assessment does not fully reflect their genuine liquidity profile, or that the proxy used for assessing the liquidity risk is not satisfactory. We believe more research is needed to identify the best liquidity risk proxies. More generally, we note that the results between AIFs and UCITS differ quite substantially. In our view, this is driven by three factors. First, both categories cover quite heterogenous set of investment policies that are naturally driven by different factors. Second, the profile and attitude of the UCITS investors differ from the AIF ones. Third, the lack of uniformity in the reporting requirements and underlying definitions gives rise to discrepancies that we try to address with care, but that need to be kept in mind for interpretation.
- As a third outcome, we note that the profile of the funds (as captured by our leverage, liquidity, size etc. variables) does not vary significantly with the number of LNR episodes they had. However, we find that the size of the net redemptions (in percentage NAV) is higher for smaller funds (a doubling of the size leads to 3.6 percentage points lower net redemption level) and for funds with higher equity share held by top 5 investors (10 percentage points increase of the concentration leads to 2 percentage points higher net redemption level).
- We then addressed the question of the potential COVID-19 specificity. We find that the profile of funds having LNRs in March 2020 was to a large extent similar to the one of funds having LNRs during the rest of the year 2020. The only nuance here is that bond and mixed funds emerged in March as being overrepresented investment policies. Such categories had characteristics (not captured by our leverage, liquidity, size etc. variables) that made their investor flows more volatile than for others during the crisis. These bond funds (especially corporate debt funds, high yield and emerging markets bond funds), together with real estate funds and MMFs, were subject to ex post specific scrutiny by international institutions (see ESMA (2020b, 2021) on bond funds, ESMA (2020b) and CSSF (2021) on real estate funds, IOSCO (2020) and Darpeix and Mosson (2021) on MMFs). We expect that a better liquidity proxy could partially capture the specificity of these investment strategies. Nevertheless, the relative similarity of fund profile subject to LNRs in March and other months suggests that the COVID-19 shock was well absorbed by a relatively resilient fund industry in a context of important support measures from governments, central banks and supervisory authorities.
- Our results also highlight the specificity of MMFs, which are characterized by relatively frequent LNRs (daily LNRs exceeding 10% NAV occur more than once per year on average for MMFs). Even after controlling for size, leverage, liquidity profile, etc., we find that the

conditional probability of having a LNR exceeding 10% is 15 percentage points larger for MMFs than for equity funds. This volatility of the capital flows reflects the use of MMFs as cash management vehicle in general, but also the specific stress of March 2020. As detailed in IOSCO (2020), the March episode was characterized by large outflows from some MMFs due to the investors' need for cash (e.g. to meet margin calls and the usual financial commitments in a context of declining business activity), also so-called "dash-for-cash", and due to a "flight-to-safety" from private debt MMFs to public debt MMFs. We thus observed that LNRs were quasi 3 times larger in March than in the other months of the year.

- We finally analyzed the liquidity management tools used by funds as a response to LNRs. We first note that most LMTs are used as exceptional instruments. The probability of using them (gates, borrowing, redemptions in kind) in case of LNRs was larger in March than in other months, except for swing pricing, which turns out to be an LMT more, and more frequently, used in normal market conditions. Only leverage was found to be negatively associated with the probability of using gates and redemption in kinds (but the very infrequent use of these LMTs calls for cautious interpretation).

More generally, these results should contribute to a better understanding of LNRs in times of stress relatively to normal times, to improve the ex-ante identification of the funds most likely to be subject to LNRs and potential liquidity pressure, thereby helping the supervisory activities, and finally to assess the way LMTs are used as potential responses to large redemption episodes.

This study is devoted to analyzing LNRs but is not designed to (and has not the objective of) understanding the determinants of liquidity stresses or crises. Whether LNRs give rise to liquidity stresses is not covered in our analysis. In addition, the factors driving the LNRs are not necessarily the same as the ones leading to liquidity stresses. As an example, leverage was found to be a non-significant driver of large redemptions for AIFs (but well for UCITS), but this does not imply that leverage has no impact on the funds' vulnerability to liquidity stresses (e.g. potential margin calls related to synthetic leverage).

To illustrate it further, we can consider the example of the funds' size. We found in our analysis that smaller funds are more likely subject to LNRs, but the intuition can work in an opposite way for liquidity issues: larger funds could face more pressing liquidity issues given their potential impact on the prices when their positions are large relative to the market. This example shows as well that some factors (the funds' size) relevant from the microprudential perspective (larger redemptions for small funds) might well operate differently from the macroprudential one (price impact for large funds). These questions, which relate to the interaction of large redemptions and liquidity stresses, are complementary ones, that would definitively be relevant topics of future research.

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Appendix – construction of variables

As detailed in "Section 3 Data", we use variables from different sources, namely the Large Redemption reporting (LRR), the UCITS Risk reporting (URR), the AIFM Reporting (AIFMR) and a combination of BCL and CSSF fund classification systems. As the definition of the data collected under the URR and the AIFMR are not aligned, and as the estimates are provided on different scopes (cf section 5.1), we will detail the construction of the variables separately for each reporting (URR and AIFMR) and then make explicit their aggregation/harmonization.

#	Name	Description/formula
		Large Redemption Reporting
1	Dum_D_"X"pc	Dummy equal to 1 if notification of daily net redemption >=X%, 0 otherwise (X=10, 20 or 30)
2	Dum_W_"X"pc	Dummy equal to 1 if notification of weekly net redemption >=X%, 0 otherwise (X= 30, 40 or 50)
3	Sum_D_"X"pc	Count of notifications of daily net redemption >=X% (at fund level) (X=10, 20 or 30)
4	Sum_W_"X"pc	Count of notifications of weekly net redemption >=X% (at fund level) (X=30, 40 or 50)
5	NetRed_D_pc	Value of daily net redemption (% NAV) or its maximum value if the fund notified more than 1 daily net redemption >=10%
6	NetRed_W_pc	Value of weekly net redemption (% NAV) or its maximum value if the fund notified more than 1 weekly net redemption >=30%
7	Dum_SwingPricing	Dummy equal to 1 if the notification reports the use of swing pricing, 0 otherwise
8	Dum_Gates	Dummy equal to 1 if notification reports the use of gates, 0 otherwise
9	Dum_RedKind	Dummy equal to 1 if notification reports the use of redemption in kind, 0 otherwise
10	Dum_AntidilLevy	Dummy equal to 1 if notification reports the use of anti-dilution levy, 0 otherwise
11	Dum_Borrowings	Dummy equal to 1 if notification reports the use of borrowings, 0 otherwise
12	PrvBk_pc	Percentage of net redemption for the account of mandate of private banking (% NAV)
13	Dum_March	Dummy equal to 1 if notification received in March, 0 otherwise
		AIFM reporting
14	Dum_AIF	Dummy equal to 1 if the fund is an AIF, 0 otherwise
15	LogTNA	Size of the AIF measured as the log of total net assets value of the AIF at the end of the reporting period (expressed in EUR) (AIFMR field 53)
16	Lev_Gross	Leverage of the AIF calculated under the gross method as percentage of the TNA (AIFMR field 294 as divided by field 53)
17	LiqShort7d	Liquidity shortage as percentage of TNA at horizon 7 days. Computed as the maximum of zero and of the difference between the percentage of equity that can be redeemed within 7 days and the percentage of the portfolio that can be liquidated within 7 days (Max(0;AIFMR fields 186+187-178-179))

18	LiqShort30d	Liquidity shortage as percentage of TNA at horizon 30 days. Computed as the maximum of zero and of the difference between the percentage of equity that can be redeemed within 30 days and the percentage of the portfolio that can be liquidated within 30 days (Max(0;AIFMR fields 186+187+188-178-179-180))
19	Top5_investors	Percentage of the AIF's equity that is beneficially owned by the five beneficial owners that have the largest equity interest in the AIF (AIFMR field 118)
20	Shareholder_"X"	Ownership of units/shares of the AIF in percentage of TNA by investor group (X=General government - GENG, Households - HHLD, Banks - BANK, Insurance corporations INSC, Nonfinancial corporations - NFCO, collective investment undertakings (OCIU), Other financial institutions - OFIN, Pension funds - PFND and others/unknown - UNKN). BANK is used in estimations as base category (AIFMR fields 208 and 209)
		URR reporting
21	LogTNA	Size of the UCITS measured as the log of total net assets value of the UCITS at semester-end (expressed in EUR)
22	URR_Lev_Commitm	Average level of leverage (based on the commitment approach) observed over the reference semester (% TNA). Only used for the UCITS using the commitment method to calculate their global exposure
23	URR_Lev_Notional	Average level of leverage (calculated as the sum of the notionals of the derivatives used) observed over the reference semester (% TNA). Only available for the UCITS using the VaR method to calculate their global exposure
24	Lev_All	Aggregation of (100%+URR_Lev_Commitm) for UCITS using the commitment method and (100%+URR_Lev_Notional) for UCITS using the VaR method. The addition of 100% is designed to better align the UCITS definition of leverage with the AIFMR definition of leverage which includes the base portfolio
25	LiqShort7d	Liquidity shortage as percentage of TNA at horizon 7 days. Computed as the difference between 100% (as we assume that all equity can be redeemed within 7 days) and the percentage of the portfolio capable of being liquidated within 7 days
26	LiqShort30d	Liquidity shortage as percentage of TNA at horizon 30 days. Computed as the difference between 100% (as we assume that all equity can be redeemed within 30 days) and the percentage of the portfolio capable of being liquidated within 30 days
27	Top5_investors	Percentage of the UCITS held by the 5 predominant shareholders at semester-end
28	Shareholder_"X"	Ownership of units/shares of the UCITS in percentage of TNA by investor group (X=General government - GENG, Households - HHLD, Banks - BANK, Insurance corporations INSC, Nonfinancial corporations - NFCO, collective investment undertakings (OCIU), Other financial institutions - OFIN, Pension funds - PFND and others/unknown - UNKN). BANK is used in estimations as base category

29	URR_Real_Vol	Annualized realized volatility of the TNA based on all the TNA data of the reference semester (subscriptions and redemptions are excluded from the calculation)
30	URR_Real_Perf	Performance realized over the reference semester (subscriptions and redemptions are excluded from the calculation)
		Harmonized variables
31	LogTNA	Aggregation of the variables "LogTNA" from AIFMR and URR reportings
32	Lev_All	Aggregation of the variables "Lev_Gross" from the AIFMR reporting and "Lev_All" from URR reporting
33	LiqShort7d	Aggregation of the variables "LiqShort7d" from AIFMR and URR reportings
34	LiqShort30d	Aggregation of the variables "LiqShort30d" from AIFMR and URR reportings
35	Top5_investors	Aggregation of the variables "Top5_investors" from AIFMR and URR reportings
36	Shareholder_"X"	Aggregation of the variables "Shareholder_"X"" from AIFMR and URR reportings
		Others
37	Inv_Pol	Investment policy as based on BCL classification: Money market funds (MMF), Hedge funds (HFND), Bond funds (BOND), Mixed funds (MIXED), Equity funds (EQUITY), Real estate funds (REST) and other funds (OTHR). EQUITY is used in estimations as base category
38	Inv_Pol2	Inv_Pol with Bond funds category split in emerging Markets (EM), High-yields (HY), Emerging market high yields (EM-HY) and Other bond funds (Other), as based on CSSF granular classification