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Liquidity Stress Tests for Fixed-Income Mutual Fund: an application for Chile[1]

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Resumen

Implementamos una metodología de prueba de tensión para fondos mutuos chilenos de renta fija, además documentamos la evolución de la liquidez de estos fondos y entregamos evidencia sobre la estrategia de liquidación de los administradores. Los principales resultados son los siguientes. Primero, encontramos que los fondos mutuos cumple con la condición de resiliencia luego de una prueba de tensión de liquidez. Sin embargo, las necesidades de ventas de los fondos pueden generar presiones significativas en ciertos segmentos de los mercados de renta fija, especialmente en bonos bancarios y corporativos. Segundo, se observa una caída generalizada en las medidas de liquidez de la industria de fondos de renta fija, impulsada por una fuerte reducción en la exposición a instrumentos de intermediación financiera. Tercero, a pasea de que la evidencia empírica no es concluyente respecto a la estrategia de liquidación preferida por los fondos mutuos chilenos, los resultados sugieren principalmente que los administradores han enfrentado los rescates mediante la venta de activos líquidos (instrumentos de intermediación financiera y bonos soberanos), lo que es consistente con una estrategia de liquidación de tipo cascada parcial, en la que en promedio, los administradores tienden a satisfacer las solicitudes de rescate vendiendo primero sus activos más líquidos.

Abstract

We implement a stress testing methodology for fixed-income Chilean mutual funds, while also documenting the evolution of these funds' liquidity and providing evidence regarding managers' liquidation strategy. Our main results are as follows. First, we find that mutual funds satisfy the resilience condition following a liquidity stress test. However, the selling needs by funds may cause significant pressure in certain sectors of financial fixed income markets, especially for bank and corporate bonds. Second, we observe a generalized decline in liquidity measures across the fixed-income fund industry, which has been driven by a sharp fall in exposure to money market instruments. Third, while our evidence is not conclusive regarding the liquidation strategy favored by Chilean mutual funds at all times, our results tend to suggest that managers have met redemption requests by selling liquid assets (money-market instruments and sovereign bonds), which is consistent with a partial waterfall liquidation strategy.

[1] We are grateful for the comments and suggestions received by participants at the Central Bank's seminars. We also benefited from insightful comments made by the referee. The views expressed are those of the authors and do not necessarily reflect the views of the Central Bank of Chile or its board members. Remaining errors are our own.

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1 – Introduction

Open-end mutual funds are among the largest institutional investors, with global Assets Under Management (AUM) that reached almost USD $ 75 trillion by the end of the third quarter of 2024 (see ICI, 2024). These funds are classified according to their investment strategies and types of assets in which they invest. Fixed-income funds are among the biggest in terms of AUM and play a relevant role in markets, allowing their investors to access relatively low-risk opportunities. Moreover, savings in mutual funds are usually liquid, featuring a mix of money market assets and bonds, and allowing investors access to funds on a short notice. From the perspective of bond issuers, the funds provided by institutional investors are useful for financing investments, working capital, as well as for debt refinancing.

Notwithstanding the beneficial role that mutual funds can play in financial markets, there are times in which they may originate financial volatility as consequence of unexpected massive redemptions. A non-comprehensive list of this type of episodes includes: the July 2013 "Taper Tantrum" (Feroli et al., 2014, IMF, 2014, Sinha and Smolyansky, 2022), the "Dash-for-Dash" episode of March 2020 (FSB, 2020, Claessens and Welrick, 2021, Falato et al., 2021, Haddad et al., 2021, Vissing-Jorgensen, 2021),[4] and the UK Gilt market turmoil (Cunliffe, S., 2022, Pinter, 2023, Pinter et al., 2024). Focusing on Chilean markets, November 2019 witnessed an episode during which relevant selling pressure was experienced in local bond markets, particularly for bank and Sovereign bonds, accompanied by increased volatility in local interest rates as well as considerable surges in bank bonds' spreads (Central Bank of Chile, 2019, 2020).

During episodes such as the ones mentioned, the existence of massive redemptions motivated by political, social, or economic shocks, creates the need to raise liquidity by selling assets. This may affect particularly funds that use leverage (Vivar et al., 2023) and those who have exhibited poor performance and hold illiquid assets (Goldstein et al., 2017). The consequence of these shocks may be the existence of fire-sale episodes, which are more likely to happen after an unexpected shock or if fund managers try to anticipate redemption shocks by hoarding cash (Morris et al, 2017). As a result, asset prices may be affected (Chernenko and Sunderam, 2016), and interest rates may increase (Ma et al, 2022, Kim and Randall, 2023), leading to lower availability of financing for issuers, and generating contagion to other intermediaries (e.g. banks) and markets, both domestically and across jurisdictions (Ng et al., 2019, IMF, 2022). These dynamics have the potential to affect financial stability, thus leading to efforts by international bodies, such as the Financial

[4] For a detailed review of the evidence regarding the developments around COVID-19 and financial markets, including both equity and fixed-income instruments, see the survey by Gormsen and Koijen (2023).

Stability Board to issue high-level guidelines to address the liquidity mismatch present in open-end funds (see FSB, 2017, 2023).[5]

Recent evidence suggests that liquidity risk continues to be present in jurisdictions such as Europe (Dekker et al., 2022). Also, as we report later, this risk has increased for the Chilean case, since fixed-income mutual funds have experienced a secular decline in their money-market holdings in recent years.

Our paper is related to the literature that develops stress testing methodology to evaluate the liquidity risk faced by open-end funds, such as Bouveret (2017) and Bouveret and Yu (2021).[6] As part of our liquidity assessment, our work is also closely related to the literature that analyses the liquidation strategy used by institutional investors facing redemption shocks, such as Dick-Nielsen et al., (2012), Ben-Rephael (2017), Zeng (2017) and Szabo (2022).

We contribute to the existent literature by analyzing the investment trends for Chilean mutual funds, particularly fixed-income funds, as well as developing a liquidity stress testing procedure to evaluate their resilience and possible liquidation needs in local financial markets. Closest to our work is Álvarez et al. (2018). We view our work as complementary, since Álvarez develops a monthly-horizon exercise, while we calibrate our model using higher frequency data. Moreover, while we also use a regression methodology to calibrate the stressed redemption shock, our work is accompanied by results using a statistic approach based on the historic distribution of net flows. Additionally, as part of our analysis, we also provide evidence regarding the strategy used by Chilean mutual funds to meet their redemption needs. We do this by exploiting fund-level daily and monthly data provided by the Chilean Financial Market Commission (CMF for its Spanish acronym – *Comisión para el Mercado Financiero*).

Our main results are summarized as follows. First, we find that the mutual funds under analysis satisfy the resilience condition following a liquidity stress test. However, the selling needs by funds may cause significant pressure in certain sectors of financial markets, especially for bank and corporate bonds. Second, we observe a generalized decline in liquidity measures across the fixed-income fund industry during the last years, which has been driven by a sharp fall in holdings of money market instruments, although liquidity has recovered recently. Third, our evidence shows that the liquidation strategy favored by Chilean mutual funds is, on average, of the waterfall type, since managers tend to meet

[5] For a contrasting view, see Choi et al. (2020), who provide evidence suggesting that corporate bond funds do not produce price pressure. This would be related to managers using waterfall liquidation strategies (i.e., selling their most liquid assets first in order to meet redemption requests).

[6] In our analysis, we abstain from quantifying the price effects that may be associated to periods associated with large outflows from mutual funds. This topic is considered, for instance, in Baranova et al., (2021).

redemption requests by selling first their most liquid assets (money market instruments and Sovereign bonds).

The rest of this document is structured as follows. Section 2 describes the institutional setup and data used in our study. The following section details the methodology used in order to stress and evaluate the adequacy of the liquidity levels maintained by fixed-income mutual funds. Section 4 summarizes our main findings. The last section concludes and suggests relevant areas for future research.

2 – The Data

2.1 Chilean Mutual Fund Market

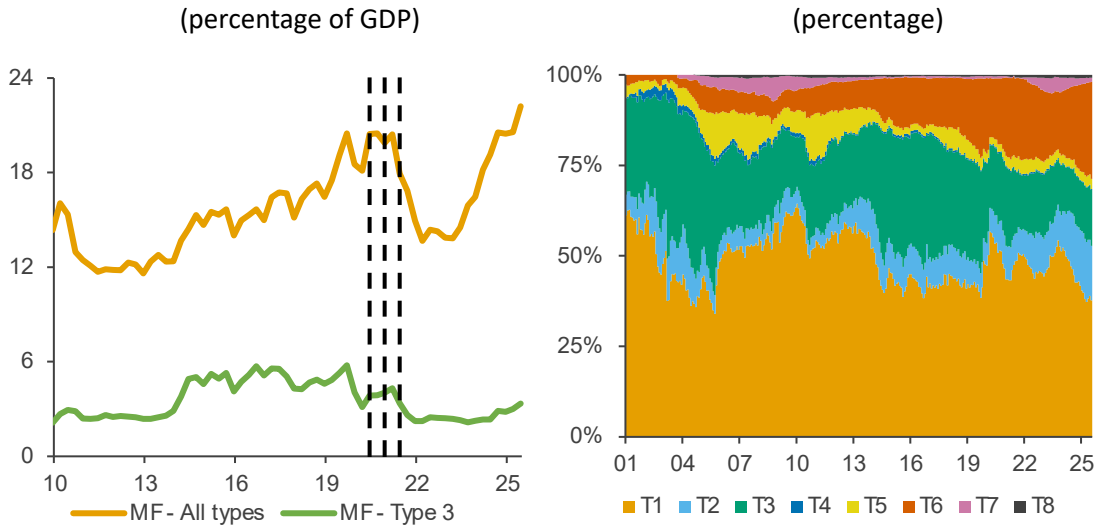
The Chilean mutual fund market has experienced considerable growth during the last years. As the left panel in **Figure 1** shows, assets under management (AUM), measured as a percentage of GDP, reached a maximum of approximately 20% during 2019-2021. After the COVID-pandemic, and probably because of liquidity needs from investors and valuation losses caused by interest rates rises, AUM fell below 15% of GDP. In the last months, the industry has experienced a recovery, with AUM reaching a new peak of 22.2% of GDP as of June 2025. The same panel shows AUM for fixed income funds, which experienced considerable growth between 2014 and 2019, reaching a maximum of almost 6% of GDP. Fixed income funds suffered a sharp drop in AUM afterwards and remain well below their pre-pandemic levels, with AUM equivalent to roughly 3% of GDP.

Chilean regulation establishes a series of conditions for a fund to be considered as a mutual fund. Importantly, redemption requests must be fulfilled during the course of ten calendar days.[7] Moreover, there are eight types of mutual funds, according to their investment objective. These are: Type 1 funds, which are basically money-market funds, since they invest in short-term debt with up to 90-days maturity; Type 2 funds, with portfolios composed of short-term debt with up to 365-days maturity; Type 3 funds, or bond funds, which invest medium and long-term debt with more than 365-days maturity; Type 4 funds or mixed funds, with portfolios that include short-, medium- and long-term debt, plus stocks; Type 5 funds, with 90% or more of AUM invested in equity; Type 6 funds, which feature flexible-investment guidelines; Type 7 funds, which are structured investment vehicles, usually featuring a return target; and Type 8 funds, which are restricted to qualified investors.[8] As the right panel in **Figure 1** shows, money-market mutual funds (Type 1) are the largest mutual funds, measured by AUM. In our study, we focus on Type 3 funds, which invest in fixed income securities and currently have AUM equal to 3% of GDP.

[7] As we discuss in the following sections, some restrictions may apply to this requirement.

[8] Under current regulation, qualified investors may be both institutional investors, and individuals who satisfy net worth, investing experience, or financial knowledge requirements.

Figure 1: Mutual Fund Assets Under Management and Portfolio (*)



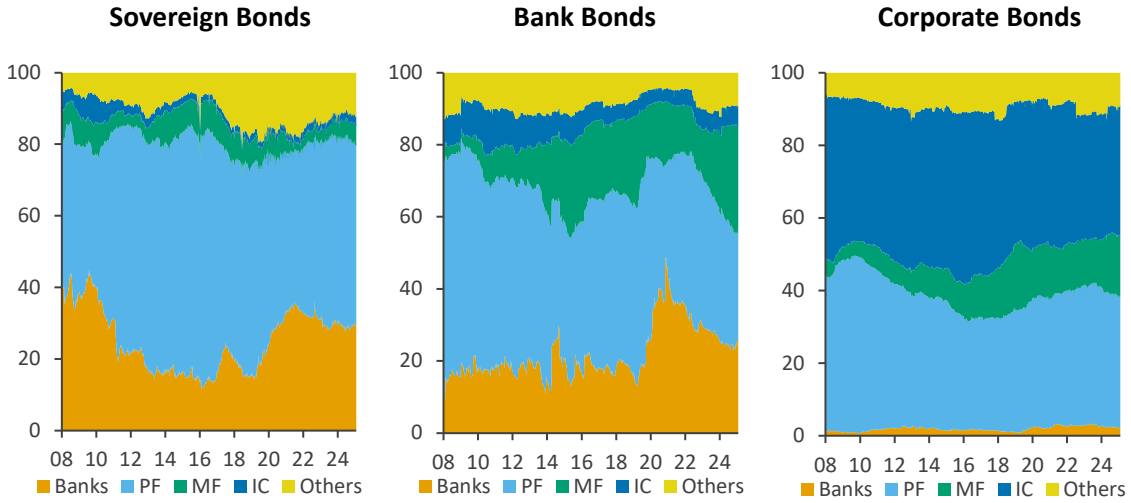
(*) Vertical lines denote pension fund withdrawals. (2) T1: short-term debt with up to 90-days maturity, T2: short-term debt with up to 365-days maturity, T3: medium and long-term debt with more than 365-days maturity; T4: mixed funds (short-, medium- and long-term debt, plus equity (stocks), T5: funds with 90% or more of AUM invested in equity; T6: flexible-investment funds; T7: structured funds; T8: qualified investors funds.

Source: authors' estimations based on data from the Financial Market Commission.

While mutual funds are not the largest institutional investors in the Chilean fixed income market, they have sizable positions. During the last year, mutual funds held on average, 4.9%, 27.3% and 16.2% of local sovereign, bank, and corporate bonds, respectively. Even though pension funds have the largest positions in the fixed income local market, mutual funds are key players if we consider those securities with low-medium term maturity (up to ten years) holding a market share of 7.1%, 30.8% and 23.5% for sovereign, bank and corporate bonds, respectively. **Figure 2** below shows the relative importance of mutual funds, among other investors, in different categories of local bond markets. As it can be seen, mutual funds have a relevant presence, especially in the corporate and bank bonds markets.[9]

[9] These figures show fixed-income holdings for all types of mutual funds. Nevertheless, type 3 funds (fixed-income funds) are the main bond holders for this class of institutional investors.

Figure 2: Institutional Investors' Share in Bonds Markets (*)



(*) PF: Pension Funds; MF: Mutual Funds; IC: Insurance Companies. The figures include information of bonds in Chilean pesos (CLP) and Chilean Unidad de Fomento (CLF) which is a local currency indexed to inflation. Mutual fund holdings consider all types of mutual funds.

Source: authors' estimations based on Central Securities Depositary Data.

2.2 Mutual Fund Liquidity Regulation

Mutual funds in Chile currently face two liquidity requirements. First, they must process redemption requests within ten calendar days after receiving them. Second, if a mutual fund is not designed for qualified investors, its portfolio must hold less than 50% of assets that don't meet liquidity and market depth criteria.[10]

In addition to the conditions cited above, mutual funds are expected to develop and use risk management tools, such as stress tests. However, the regulator has not developed specific guidance regarding the characteristics that these tools should possess.

At the international level, the European Securities and Markets Authority (ESMA) has required UCITS[11] to develop liquidity stress test policies since 2020, and it is currently refining its regulation by working on the design of guidelines on liquidity management tools

[10] In the case of local or foreign debt securities issued by banks or financial institutions or states, these must be issued in a State with anti-money laundering as well as prevention of financing of terrorism regulation. For equity investments, whether these are made directly or through funds, these must comply with at least one of three conditions: having considerable trading activity in a stock exchange or having average daily transactions of at least USD 50,000 during the last 90 days; or having a redemption period of no longer than 10 calendar days.

[11] "*Undertaking for collective investments in transferable securities*" abbreviated by UCITS, is the generic term used in the Euro Zone to refer to investment vehicles such as open-ended mutual funds.

for open-ended funds (see ESMA, 2024). In the US, liquidity requirements for mutual funds with assets above 1 billion is specified by rule 22e-4, which was introduced in 2018. This regulation aims to ensure that fund managers develop adequate liquidity risk management systems, and that pertinent information is available for investors. Mangers are required to classify their investment portfolio according to each securities' liquidity and investments in illiquid assets must not surpass 15% of the portfolio.[12]

2.3 Data

In our study, we focus on type 3 mutual funds. These are funds that invest in debt instruments with more than 365-days maturities, considering the weighted average of the portfolio's maturity. While there are other types of mutual funds with larger AUM, particularly the money market funds (type 1), the data for Chile shows that such instruments trade in liquid markets, making these funds less susceptible to experience liquidity shortages. Moreover, the evidence of past stress episodes shows that the behavior of fixed income funds has been relevant as a source of volatility and forced asset sales (see, e.g. Vissing-Jorgensen, 2021) in the local bonds market. Due to the duration of their portfolios, type 3 funds are the most susceptible to experience negative flows and liquidity needs as result of sudden changes in interest rates.[13] In general, we use daily data spanning from January 2001 through July 2025.[14]

In order to avoid excess volatility in our estimations, we restrict our sample to funds with more than three years of existence. Moreover, for funds with age above this threshold, we discard the first three years of operations, if they fall within our window sample. This leaves us with an initial total of 103 funds.

Additionally, we consider mutual funds whose operating currency is the Chilean peso (CLP). This condition is met by 87 funds. The remaining 16 funds operate in different currencies.

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[12] Assets are classified in four categories, according to the number of days that it would take to transform them into cash without impact in its price. "Highly liquid investments" are esteemed to be transformable into cash within three days or less, with no impact on market prices; "Moderately liquid investments" should be sellable in a period of three to seven days; "Less liquid investments" are those which the fund manager expects to be able to sell within a period of up to seven days, even though the settlement of the transaction may be finalized after this period. Finally, "illiquid investments" are those that do not belong to any of the previous categories. For details see SEC (2018).

[13] The duration of type 3 funds (proxied as years remaining until maturity) is 6.9 years. For funds 1, 2, 4 and 6, which also have relevant bond investments, duration is 0.2, 1.7, 4.5, and 6.5, respectively. We leave for future work the implementation of a system-wide liquidity stress test that considers all types of funds, as the determinants of their net flows requires using a wider range of determinants and models compared to the ones we use in this work.

[14] The portfolio holdings for mutual funds constitutes an exception. This information is available at monthly frequency.

Moreover, from these funds, all but one are no longer in operation. Therefore, we are capturing practically all active funds in our exercise.

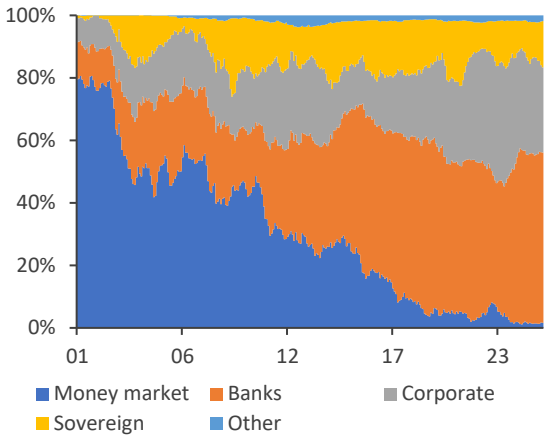
We focus on funds operating in CLP because these investment vehicles concentrate their portfolio in local securities. Since we are concerned about the potential effects that large sales of these assets can have on local prices, our sample design seems to be the most adequate for our purpose.[15]

The final filter we apply consists in leaving out some funds with outlier observations in terms of the net funds they receive (we define this variable in the following section). Applying these filters results in having 72 mutual funds, including both operative and non-operative funds. From these, there are still 38 active funds by the end of July 2025. These funds represent 95% of the industry's AUM.

Figure 3 shows the portfolio allocation for all type 3 mutual funds. Starting in 2001, money market instruments accounted for almost 80% of the portfolio, followed by bank and corporate bonds. Over the next decades, bank bonds' importance grew in the funds' portfolio, and currently represent 53.9% of investments. This is followed by corporate and Sovereign bonds, which account for 27.1% and 16% of investments, respectively. Money market instruments have reached historically low levels, representing merely 1.7% of AUM. These trends explain part of the evolution in mutual funds' resilience to liquidity shocks.[16]

Figure 3: Type 3 Mutual Funds portfolio (*)

(percentage)



[15] The Chilean mutual funds industry holds small positions in foreign investments. Indeed, these positions peaked at USD 9.3 billion in December 2021. Most of these investments, 91% to be precise, were made in US dollars, and were concentrated in type 6 funds (this is, flexible-investment funds). Type 3 funds held only 0.07% of foreign investments. Currently, foreign investments in type 3 funds represent merely 0.07% of AUM. There are only three active funds with these type of securities in their portfolios.

[16] However, as Schmidt et al. (2016) show, even money-market mutual funds may be subject to run-like episodes of large redemptions.

(*) Mutual funds' portfolio is classified in money market instruments (maturities up to 365 days), bank bonds, corporate (non-financial firms) bonds, Sovereign bonds, and others (e.g. stocks, long-term deposits, etc.).

Source: authors' estimations based on data from the Financial Market Commission.

3 – Methodology

A liquidity stress test framework for mutual funds requires: calibrating redemption shocks, estimating funds' liquid assets, determining the funds' liquidation strategy, and evaluating their resilience. This section describes the strategy used to tackle each of these tasks.

3.1 Calibration of Redemption Shocks

The first step in the liquidity stress test consists in calibrating the redemption shocks that will be faced by mutual funds. To do this, we use daily data to build 10-day cumulative flows since, by law, mutual funds are obliged to fulfill redemption requests in a horizon that is measured in (10 calendar) days.[17]

We build net flows at the fund level. Since each fund usually has different share series (e.g. retail investors, institutional investors, etc.), we use daily Net Asset Value (NAV), at the share level, to build daily returns. We then use these returns, along with information of the number of shares for each series to build the daily weighted average returns for fund i during period t ($r_{t,i}$).[18] We then estimate daily net flows ($NFd_{i,t}$) as follows:

$$NFd_{i,t} = NAV_{i,t+1}\left(1 + r_{t,i}\right) - NAV_{i,t} = NAV_{i,t+1}\left(1 + r_{t,i}\right) - 1 \qquad (1)$$

Using the results from (1) we proceed to build cumulative flows for a 10-days horizon, $NF_{i,t}$, and, in line with the literature, these flows are then expressed as a percentage of fund's i average in $t-10$, $\overline{NAV}_{i,t-10}$:[19]

$$NF_{i,t} = \frac{\sum_{j=1}^{10} NFd_{i,t-j+1}}{\overline{NAV}_{i,t-10}} \qquad (2)$$

[17] The literature on liquidity stress test for mutual fund usually employs monthly or quarterly data (see, e.g. IMF 2015, 2016b, 2017). We argue that the calibration of redemption shocks on a daily frequency is better suited for the horizon that Chilean mutual funds face under current regulation. Nevertheless, full sets of results using monthly data are available from the authors upon request.

[18] The results are very similar if each series return is weighted by its net asset value.

[19] The results from the exercise are affected by this choice in a straightforward way. Indeed, using single-day net flows results in smaller magnitudes for our stressed redemption shocks and progressively moving to 10-day flows or monthly figures results in larger shocks. As previously argued, we justify our choice of using 10-day cumulative flows as being consistent with the maximum number of days that mutual funds have to fulfill redemption requests.

Table 1 shows a summary of the main statistics for net flows at the industry level. As it can be seen, the mean and median of flows were 0.1% and 0.4%, respectively. However, there are episodes of high volatility, with inflows (outflows) reaching up (down) to 12.2% (-23.7%) over a 10-day period. In what follows, we use the "term 10-day cumulative flows" and "net flows" interchangeably.

Table 1: Industry-Level Net Flows Descriptive Statistics

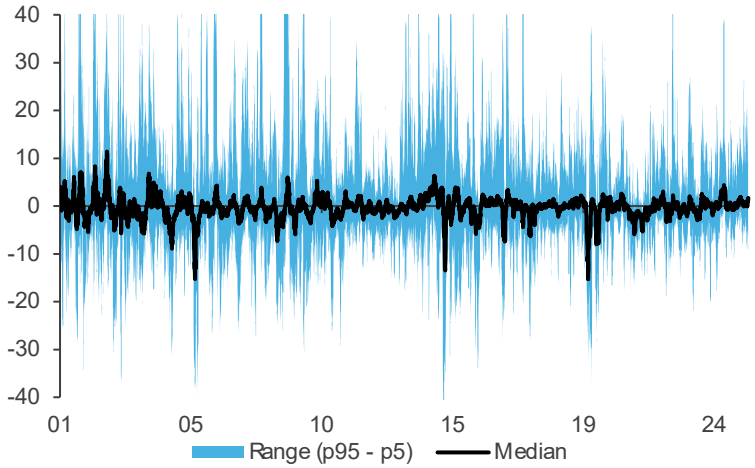
(percentage of AUM)

Statistic	Net Flows
Max	12.2
P99	8.0
P95	4.6
P75	1.9
Average	0.1
Median	0.4
P25	-1.5
P5	-5.4
P1	-10.5
Min	-23.7
Standard Deviation	3.3
Observations	5,247

Figure 4 shows the evolution of net flows at the fund level, as well as its cross-sectional dispersion. As it can be seen, there is considerable volatility in the flow series both between funds and across time. This evidence shows that, usually, not all funds experience positive or negative flows simultaneously. This is relevant, as it suggests that an analysis focused on the industry level may mask relevant information about the state of particular funds.

Figure 4: Median and Net Flow Range for Type 3 Funds

(percentage)

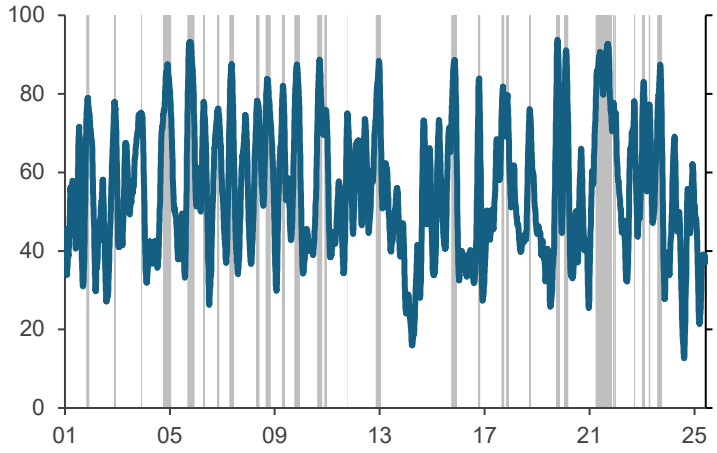


(*) The area showed corresponds to the difference between the 95th and 5th percentile of the fund-level net flow distributions. For expositional purposes, the vertical axis has been truncated at a 40% maximum value.

Even though determining the joint dynamics of net flows for the industry is beyond the scope of this study, we do provide some evidence on this subject. **Figure 5** shows that the percentage of funds experiencing negative flows simultaneously is quite volatile, ranging from almost 0 up to nearly 100%.

Figure 5: Funds with Negative Net Flows (*)

(% of total)



(*) The blue line shows the 30-day average percentage of funds with negative net flows. The gray areas show periods during which more than 75% of mutual funds experience negative net flows simultaneously.

Source: Authors' estimations.

We also estimate the pairwise correlation of fund' net flows for all funds that are present in our sample. The average correlation is rather small, measuring 0.05. However, in for some subsets of funds, daily correlation is considerably higher, reaching values above 0.7.

We use a regression methodology, similar to the one employed by IMF (2017) where the 10-days cumulative net flow of the industry is the dependent variable.[20] The right-hand side variables include: the lagged value of net flows, and changes in the short and long-term interest rates, financial market volatility (proxied by the VIX index); the term-structure slope, and Chile's country risk premium.[21] Our empirical specification is showed in Equation (3):

$$NF_t = \beta_0 + \beta_1 NF_{t-10} + \beta_2 \Delta r_{s.t.,t} + \beta_3 \Delta r_{l.t.,t} + \beta_4 \Delta vix_t + \beta_5 \Delta slope_t + \beta_6 \Delta risk_{cl,t} + u_{i,t} \quad (3)$$

We expect the coefficients accompanying the lagged values of flows to be positive, since this would be consistent with inertia regarding the fund's participants investment decisions. An increase in interest rates (both short and long-term, represented by $r_{s.t.,t}$ and $r_{l.t.,t}$, respectively) would tend to decrease the mutual funds' NAV, leading to negative returns. In turn, this could make investors increase their redemptions. Therefore, we expect the coefficients associated to interest rates to be negative. An increase in the spread between long and short-term rates should make fixed income funds more appealing, ceteris paribus, to money market funds. Therefore, the coefficient associated with the term-structure slope ($slope_t$) would be positive. Finally, an increase in volatility (vix_t) and/or country risk ($risk_{cl,t}$) could lead investors to reallocate their portfolios towards safer alternatives. For instance, we would expect equity funds to experience outflows. While fixed income can be considered a less risky alternative, so would money market funds, which also feature lower durations and are thus less exposed to interest rate risk. It could be argued then that the effect of higher volatility and risk on net flows is ambiguous for fixed income funds. Thus, we expect the coefficients associated to lagged flows, β_1 to be positive; β_2 and β_3 to be negative, β_5 to be positive, while β_4 and β_6 could show either positive or negative signs.

As **Table 2** shows, most coefficients have the expected signs. Moreover, a joint (unreported) test confirms the model's significance.

[20] We also perform a calibration of stressed flows and liquidity stress test for funds based on the 1st percentile of each funds' net flow distribution. The results, available in the appendix, show that this variation of shocks results in higher outflows.

[21] For the short-run rate, we use a 30-day nominal rate (e.g. a rate in Chilean pesos), while for the long-term rate se use the 10-year sovereign bond yield. The term spread slope is proxied by the difference between the 10 and 2-year sovereign bonds' yields. Finally, the country risk premium is proxied by Chile's EMBI spread.

Table 2: Net flows regression results (*)

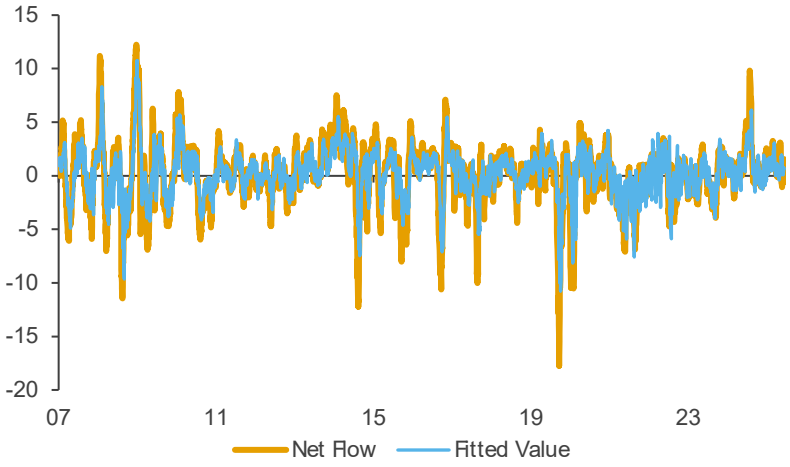
Variable	Coefficients	
NF_{t-10}	0.639	***
	(0.014)	
$\Delta r_{s.t.}$	-0.538	***
	(0.162)	
$\Delta r_{l.t.}$	-4.650	***
	(0.235)	
$\Delta slope_t$	1.537	***
	(0.153)	
Δvix_t	-0.070	***
	(0.010)	
$\Delta embi_{cl,t}$	0.008	***
	(0.003)	
α	0.062	*
	(0.032)	
R^2 (%)	50	
N	4,590	

(*) Standard errors in parentheses. Regression results at the industry level were obtained by OLS with robust standard errors. *, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Figure 6 plots the time series of net flows, as well as its predictive value. Overall, our displays acceptable results in terms of tracking the direction of net flows, although it falls short of reproducing the most extreme flows (both positive and negative) that are present in our sample.

Figure 6: Net Flows Predicted Values

(percentage of AUM)



Source: Authors' estimations. Actual and predicted values are showed at the industry level.

The last step needed to calibrate the stressed mutual fund redemptions for our model is to use the estimated regression model, stress the right-hand side variables, and use the predicted value for the dependent variable as our stressed net flow for each mutual fund. **Table 3** shows the values we use in order to stress Equation (3), as well as the resulting net flows shocks. We show two sets of results. For the "Stress" scenario, we use an extreme percentile value of the historic distribution for our independent variables. Specifically, we use the 99th percentile values for changes in the short-term and long-term interest rates, as well as for the VIX and the EMBI spread. For the term structure, we use the 1st percentile value. For the "Severe Stress" scenario, we use the historic maximum and minimum values instead of the 99th and 1st percentiles, respectively. For both scenarios, we assume that the lagged value of net flows equals zero.[22] As it can be seen below, the stressed scenario consists of a 4.8% of AUM being redeemed by investors, while under the severe stress scenario, this figure changes to a redemption shock of 13.1% of AUM. Both shocks' magnitudes are considerable. For instance, the stress scenario shock of 4.8% is equivalent to 1.5 standard deviations, while the severe stress scenario shock represents 4 standard deviations.

Table 3: Absolute Values of Stressed Net Flows (*)

(percentage of AUM)

Variable	Stress	Severe Stress
NF_{t-10}	0	0
$\Delta r_{s.t.}$	0.87 %	4 %
$\Delta r_{l.t.}$	0.52 %	1.4 %
$\Delta slope_t$	-0.84 %	-1.8 %
Δvix_t	15	49
$\Delta embi_{cl,t}$	41 bps	199 bps
Calibrated Shock	**4.8 %**	**13.1 %**

(*) The table shows the values used to stress Equation (2), as well as the resulting net flows shocks. For the "Stress" scenario, we use an extreme percentile value of the historic distribution for our independent variables. Specifically, we use the 99th percentile values for changes in the short-term and long-term interest rates, as well as for the VIX and the EMBI spread. For the term structure, we use the 1st percentile value. For the "Severe stress" scenario, we use the historic maximum and minimum values instead of the 99th and 1st percentiles, respectively.

3.2 Measuring Liquid Assets

The second step in the implementation of our exercise is the estimation of the liquidity buffer that mutual funds possess in their portfolios to meet redemption requests. We adopt

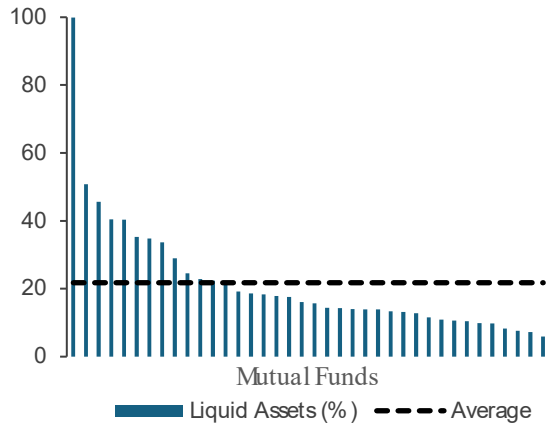
[22] A quick glance at Table 2 suggests that stressing lagged net flows would have a considerable effect on the calibrated shock. Our choice of setting this lagged value to zero is consistent with a situation in which the fixed-income mutual funds are starting the stress exercise from a neutral state in terms of net flows.

the tiered approach in our analysis. Specifically, we consider the following assets as "liquid": local and foreign Government and Central Bank bonds and notes, and money market instruments, such as bank deposits and corporate notes.[23]

As **Figure 7** shows, average liquid assets reached 21.8% of AUM by the end of our sample. However, this value is influenced by a couple of funds with large liquid asset holdings. Indeed, the median of liquid assets is lower, with a 15.9% value.[24]

Figure 7: Mutual Fund Liquid Assets (*)

(% of AUM)



(*) Liquid assets present in the funds' portfolios by the end of July 2025 include local and foreign Central Bank and Government bonds, bank deposits and Central Bank notes.

Source: authors' estimations.

3.3 Liquidation Strategy

Once the redemption shocks and liquid assets buffers are estimated, the next step in the liquidity stress exercise is to model how fund managers meet redemption requests.

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[23] As it is usual, we don't include cash in the liquid asset estimations. This item is usually a small part of funds' portfolios and may be already assigned to cover operational expenses (Bouveret, 2017). Alternative methodologies to estimate liquidity buffers include the use of a tiered approach where the methodology developed for banks in order to estimate their High Quality Liquid Assets (HQLA) is used for open-end funds (Bouveret, 2017, IMF, 2017, ESMA, 2019, ECB, 2019, Gehrend and Weber, 2020), as well as time-to-liquidation approaches (TTL), where the number of days to sell specific assets or asset classes is estimated, which makes it possible to forecast the time it would take a fund to fulfill a predetermined redemption shock (IMF, 2015, 2016a, 2016b).

[24] The heterogeneity in the liquid asset holdings among mutual funds is presumably related to the investment guidelines and risk appetite of each fund. As we will see below, liquid assets are the driving factor explaining the cross-sectional variance of mutual funds' resilience in our stress scenario. Studying the determinants of the funds' liquidity preferences is beyond the scope of our work.

The literature distinguishes two main liquidation strategies that fund managers may adopt. First, the waterfall (also known as horizontal slice) strategy, involves selling first the most liquid assets – such as money market instruments and Sovereign bonds – to minimize losses related to price pressure on less liquid assets. A downside of using this approach is that the funds' portfolio composition may become increasingly tilted towards illiquid assets following the redemption episode, which could amplify vulnerabilities until the fund rebalances its holdings.

The second approach is the pro-rata strategy (or vertical slice), wherein managers liquidate assets proportionally across the entire portfolio to meet redemption demands. While this method preserves the portfolio's original composition and duration, it may lead to significant losses if less liquid assets must be sold under unfavorable market conditions or there is a lack of buyers to absorbs the liquidation. Moreover, large-scale adoption of this strategy may pose systemic financial stability risks, as market prices could be heavily impacted due to fire sales of illiquid instruments.

Existing evidence regarding the choice of liquidation strategy is mixed, with patterns varying across asset classes and market conditions. For instance, Ouellet Leblanc and Arora (2018), and Jiang et al. (2021), document that fixed-income mutual funds tend to favor waterfall strategies during periods of low market volatility but shift to pro-rata approaches under heightened uncertainty. This shift reflects the increasing challenge of managing liquidity when market conditions deteriorate. Similar patterns have been observed for equity funds, where managers adjust liquidation strategies in response to changing redemption pressures and market dynamics (Popescu and Xu, 2023; Szabo, 2022).

To shed light on this topic, we first adopt a non-parametric approach, analyzing how mutual funds reacted to three episodes of large outflows at the industry level. Namely: October 2005 through November 2005 (Episode 1); October 2019 through November 2019 (Episode 2), and March 2020 through April 2020 (Episode 3). AUM for the industry fell by 25%, 19%, and 16% during these episodes, respectively. Moreover, the average percentage of type 3 funds that experienced negative flows during episodes 1, 2, and 3 reached 91%, 76%, and 83%, respectively.

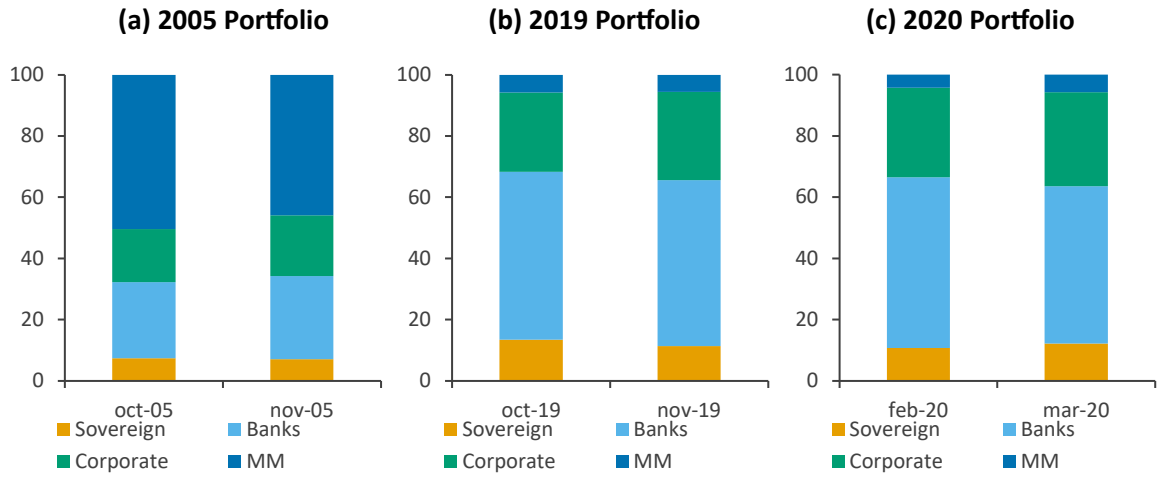
If mutual funds use a pro-rata liquidation strategy, we would expect portfolio composition to remain constant throughout these stress periods. The panels in **Figure 8** provide graphic evidence to explore this hypothesis. Panels (a), (b) and (c) show the industry-level portfolio composition during episodes 1, 2 and 3, respectively. A quick glance suggests that portfolio composition was more or less constant comparing the starting and ending points within each episode. This would provide support for pro-rata liquidation strategies.

However, the industry-level evidence may mask relevant heterogeneity at the fund level in terms of the approach used to meet unusually large redemption requests. In this line, **Figure 9** shows kernel estimates of the density function of portfolio adjustments at the fund level

for each asset class: sovereign bonds, bank bonds, corporate bonds, and money market instruments.[25] Panels (a), (b) and (c) show the fund-level portfolio adjustments during episodes 1, 2 and 3, respectively. If a pro-rata strategy is used, we would expect the densities for all asset classes to be fairly constant in response to the redemptions experienced in these periods. However, the figures reveal considerable heterogeneity in the strategy used by each fund. Unreported means tests fail to reject the null hypothesis of no portfolio adjustment, suggesting that, indeed, a pro-rata liquidation strategy was used by mutual funds during episode 1. However, the tests reject the null hypothesis of no portfolio adjustment for corporate bonds during episode 2, suggesting the presence of a waterfall strategy during this episode. Moreover, these tests also reject the null hypothesis of no portfolio adjustment for sovereign and bank bonds during episode 3, once again casting doubt on the use of pro-rata strategies.[26]

Figure 8: Mutual Fund Portfolio Composition (*)

(% of AUM)



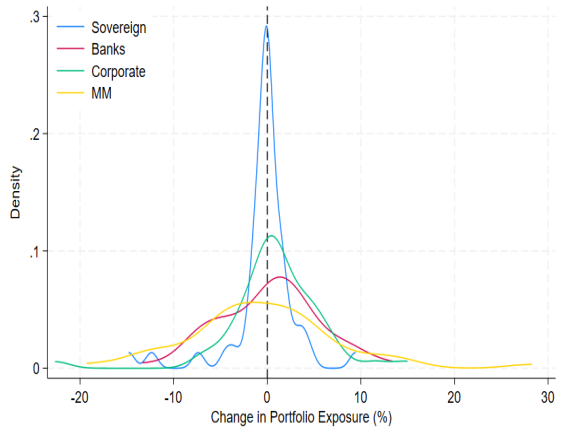
(*) Panels (a), (b) and (c) show the industry-level portfolio composition at the beginning and the end of liquidation episodes 1 (October 2005 and November 2005), 2 (October 2019 and November 2019), and 3 (February 2020 and March 2020), respectively. Asset classes included are: Sovereign, bank and corporate bonds and money-market instruments (MM).

[25] We omit from this analysis other instruments, such as foreign investments, as they represent a negligible part of these funds' portfolios. All results continue to hold if these instruments are included.

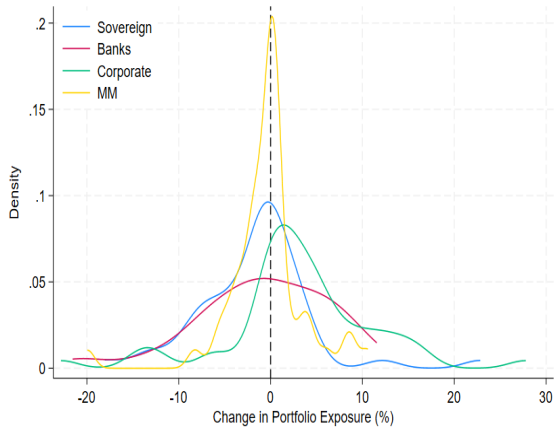
[26] The results from these tests have been omitted for brevity. They are available upon request.

Figure 9: Mutual Fund Portfolio Adjustments (*)

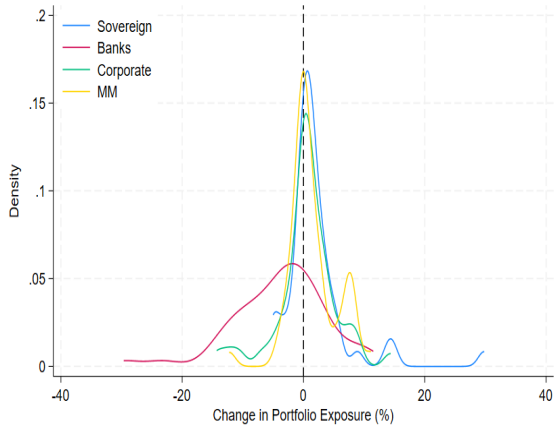
(a) 2005 Portfolio adjustment



(b) 2019 Portfolio adjustment



(c) 2020 Portfolio adjustment



(*) Panels (a), (b) and (c) show the fund-level portfolio adjustments during liquidation episodes 1 (October 2005 versus November 2005), 2 (October 2019 versus November 2019), and 3 (February 2020 versus March 2020), respectively. For episode 1, means tests fail to reject the null hypothesis of no portfolio adjustment, suggesting the use of a pro-rata liquidation strategy by mutual funds. The means tests for episode 2 reject the null hypothesis of no portfolio adjustment for corporate bonds. Finally, for episode 3, the means tests reject the null hypothesis of no portfolio adjustment for sovereign and bank bonds.

Since the non-parametric evidence regarding mutual funds' preferred liquidation strategy is not conclusive, we further assess the strategy used for portfolio adjustments, following the methodology of Chernenko et al. (2016), Ben-Rephael (2017) and Jiang et al. (2021), we estimate a panel regression to capture monthly changes in fund holdings across assets classes in response to investor redemptions (outflows):

$$\Delta Holding_{i,t} = \alpha_i + \tau_t + \beta_1 Inflow_{i,t} + \beta_2 Outflow_{i,t} + \gamma' X_{i,t-1} + e_{i,t} \qquad (4)$$

Where $\Delta Holding_{i,t}$ represents the change in the proportion of fund assets allocated to a particular asset class I by fund i between t and $t-1$ expressed as percentage of total AUM:

$$\Delta Holding_{i,t}^{I} = \frac{Asset_{i,t}^{I} - Asset_{i,t-1}^{I}}{AUM_{i,t-1}} \quad (5)$$

We consider four major asset classes: the most liquid assets,[27] bank bonds, Sovereign bonds and corporate bonds.[28] The variables $Inflow_{i,t}$ and $Outflow_{i,t}$ represent net fund flows as a percentage of AUM for found i during the time t, where inflows are net flow above zero and outflows are negative net flows. The control variables $X_{i,t-1}$ include fund characteristics such as past performance, the natural logarithm of total assets, fund age, and the number of assets held, among others. The regressions also include fund (α_i) and time fixed effects (τ_t), and the standard errors are clustered by fund manager.

The coefficient β_2 captures the effects of investor redemptions on changes in fund asset allocation. Our primary focus is on this coefficient, where a positive (negative) value implies that, in response to redemptions, fund managers employ a waterfall approach. On the contrary, a value equal to zero implies that a pro-rata strategy is used.

The baseline results presented in **Table 4** show heterogeneity across different asset classes in terms of the strategies adopted by fund managers when facing non-zero net flows. Over the full 2001-2025 sample, after a one standard deviation shock to outflows, managers reduce sovereign-bond exposure by 5.47%x27.83% = 152 basis points (bp), however the response for the other instruments are non-significant, suggesting the use of a pro-rata strategy. Interestingly, when we focus on the 2010-2025 sample, the results show that managers in this period are more prone to adopt a waterfall strategy to face redemptions. The lower panel shows that managers used their sovereign and bank bonds, which increase the exposure to more liquid instruments. This result suggests that managers may have adopted this approach more intensely in recent years.[29]

[27] The instrument categorized as most liquid are deposits and short-term notes, as well as Central Bank bonds.
[28] An alternative classification divides the categories in five major asset classes: the most liquid assets (Central Bank bonds), bank bonds, sovereign bonds, corporate bonds, and the remaining assets, which are classified as "other". The instrument categorized as other are equity securities and foreign instruments. The number of funds' holdings classified as "other" instruments is less than 1% of AUM, so we eliminate this category from the analysis. Our results are not affected by this adjustment.
[29] In the Appendix, there are two additional versions for calibrating stress periods: periods when net flows at the system level are in the 1st percentile and periods of crisis for the local economy as defined in Martínez et al. (2018). These results are qualitatively similar to the ones included in the main text.

Table 4: Liquidation Strategy Regression Results

Variables	(1) Most Liquid	(2) Banks Bond	(3) Sovereign Bond	(4) Corporate Bond
	Full sample (2001/2025)			
$Outflow$	-1.31	0.56	5.47***	-0.57
N	11,027	10,952	10,637	11,160
R^2 (%)	15.3	16.0	8.7	24.0
	Recent sample (2010/2025)			
$Outflow$	-2.87**	1.22***	5.00***	0.97
N	7,774	8,042	8,028	8,084
R^2 (%)	17.1	13.0	9.4	22.1
Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Exploring the impact of stress periods

To further explore how funds react during stress periods, we calibrated the redemption shock using the methodology discussed by Bouveret (2017), focusing on the 1st percentile of each fund's net flows (Equation 5).[30] All control variables and fixed effects from Equation (3) are incorporate in this specification.

$$\begin{aligned}&\Delta Holding_{i,t} \\ &= \alpha_i + \tau_t + \beta_1 Inflow_{i,t} * Stress\ Period_{i,t} + \beta_2 Outflow_{i,t} \\ &* Stress\ Period_{i,t} + \gamma' X_{i,t-1} \\ &+ e_{i,t}\end{aligned} \tag{6}$$

Table 5 shows that, in the post-2010 period, managers persistently favor to adopt a waterfall strategy, especially for most liquid instruments.[31]

[30] In the Appendix there is a version of the regression considering alternative definitions for periods of stress and crises.

[31] In our sample period, monthly adjustments to bank bonds' portfolio allocation have fluctuated between +/- 600 basis points, approximately, whereas sovereign bonds' allocation changes have moved between +/- 500 basis points.

Table 5: Liquidation Strategy for Stress Periods Results

Variables	(1) Most Liquid	(2) Bank Bond	(3) Sovereign Bond	(4) Corporate Bond
Full sample 2001/2025				
$Stress\ Period * Outflow$	0.64	-1.51	2.03	-3.12
N	11,027	10,952	10,637	11,160
R^2 (%)	15.7	16.3	8.7	25.1
Sample 2010/2025				
$Stress\ Period * Outflow$	9.55***	1.57	3.40	-10.86***
N	7,774	8,042	8,028	8,084
R^2 (%)	17.8	13.1	9.5	24.9
Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively.

We now extend the analysis for the 2005, 2019 and 2020 stress episodes introduced before. **Table 6** presents the fund-level rebalancing coefficients for each episode. During the 2005 stress, funds' behavior aligns with a pro-rata approach: portfolio shares remain largely unchanged. In contrast, the 2019 and 2020 episodes exhibit a clear tilt toward bank bonds—managers disproportionately sell these instruments while modestly increasing holdings of sovereign bonds, corporate bonds, and cash equivalents. These results broadly confirm the non-parametric analysis previously showed.

This selective liquidation of bank bonds departs from the textbook waterfall prescription, which would call for selling the absolute most liquid assets first. One plausible explanation, drawing on Vayanos (2004) and Ben-Rephael (2017), is that managers intentionally preserve extremely liquid securities (e.g., sovereign notes) to guard against subsequent redemptions, instead offloading relatively less liquid bank bonds. Alternatively, local market interventions may have influenced behavior: in both November 2019 and March 2020, the Central Bank of Chile established repo facilities specifically targeting bank bonds. By providing assured repurchase agreements on these instruments, the central bank effectively lent liquidity against bank bonds, incentivizing managers to sell them first. In this light, the observed pattern may reflect an opportunistic response to policy support rather than a pure liquidity-management rule.

Table 6: Liquidation Strategy for Stress Periods Results

Variables	(1) Most Liquid	(2) Banks Bond	(3) Sovereign Bond	(4) Corporate Bond
	November 2005			
$Stress\ Period * Outflow$	5.38	-1.89	-5.54***	-1.39
N	11,0270	10,952	10,637	11,160
R^2 (%)	15.3	16.0	8.7	24.0
	November 2019			
$Stress\ Period * Outflow$	-5.98***	5.65***	-7.21***	9.23***
N	11,027	10,952	10,637	11,160
R^2 (%)	16.7	17.3	8.8	29.1
	March 2020			
$Stress\ Period\ * Outflow$	-0.98	8.87*	5.23	-14.15***
N	11,027	10,952	10,637	11,160
R^2 (%)	15.3	16.1	8.7	24.2
Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Exploring the role of market volatility

We complement our previous results by exploring the impact that increased market volatility may have on fund managers' portfolio decisions. In performing this exercise, we are following the spirit of Vayanos (2004), who develops a model and shows that higher potential outflows, associated with increased aggregate uncertainty, may lead fund managers to place greater importance on liquid assets, thereby increasing their demand for liquidity. This hypothesis is supported by empirical studies such as Ben-Rephael (2017), Jian (2021) and Rzeznik (2017).

To test this possibility, we modify Equation (3) by replacing the stress period with a dummy variable that captures market volatility:

$$\begin{aligned}\Delta Holding_{i,t} = \alpha_i + \tau_t + \beta_{1,1} Inflow_{i,t} * LowVol_{i,t} + \beta_{1,2} Inflow_{i,t} \\ * HighVol_{i,t} + \beta_{2,1} Outflow_{i,t} * LowVol_{i,t} \\ + \beta_{2,2} Outflow_{i,t} * HighVol_{i,t} + \gamma' X_{i,t-1} \\ + e_{i,t}\end{aligned} \quad (7)$$

Where $LowVol_{i,t}$ and $HighVol_{i,t}$ are indicator variable that takes a value of 1 if market volatility, measured by the VIX index, is below or above its historical median over the past two years.

Table 6 reports these estimates. We focus on $\beta_{2,1}$ and $\beta_{2,2}$, which capture the incremental effect of high and low volatility on asset-class adjustments. When volatility is elevated, managers disproportionately reduce their holdings of sovereign bonds more aggressively than when the volatility is lower.

This pattern confirms that market volatility amplifies waterfall-style behavior: fund managers retreat into high-quality liquid assets precisely when uncertainty peaks. Importantly, the absence of a strong pro-rata adjustment under high volatility suggests that managers do not simply recalibrate proportionally across all holdings. Instead, they enact an active liquidity-preservation rule in line with both theory and past empirical work (Jiang et al., 2021; Rzeznik, 2017). Moreover, the heightened focus on sovereign bonds over bank or corporate bonds underscores the premium placed on ultimate safety and market depth during turbulent periods.

Collectively, these results illustrate that market volatility is not merely a background risk factor but a direct driver of liquidation strategy. By dynamically reallocating toward the highest-liquidity assets when uncertainty surges, managers enhance their capacity to weather redemptions, albeit at the cost of deviating further from strategic allocations. These insights emphasize the need for stress-test frameworks to incorporate volatility-conditioned rules rather than static liquidation assumptions.

Table 7: Impact of Volatility on Funds' Liquidation Strategy

Variables	(1) Most Liquid	(2) Banks Bond	(3) Sovereign Bond	(4) Corporate Bond
$Outflow * HighVol$	-0.40	-3.36***	7.06***	-3.42***
$Outflow * LowVol$	-1.83	0.98*	4.58**	0.18
N	11,027	10,952	10,637	11,160
R^2 (%)	15.5	16.4	8.8	24.7
Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Heterogeneity in funds' characteristics

To extend our analysis, in Appendix A.2 we evaluate whether the adoption of a particular strategy depends on the fund's observable characteristics. Specifically, we examine whether funds' proportion of liquid assets, performance and size react differently to redemptions during stress periods.

Our analysis demonstrates that mutual-fund liquidation strategies are neither uniform nor static. Managers dynamically balance waterfall and pro-rata approaches in response to asset class characteristics, market stress, volatility, and fund-specific constraints. These nuanced behaviors highlight the importance of incorporating both aggregate and fund-level insights into liquidity stress-testing frameworks.

4 – Liquidity Stress Test Results

We evaluate the resilience of mutual funds using the Redemption Coverage Ratio (RCR), which is commonly used in related literature. The RCR for fund i, in period t, is defined as the ratio of liquid assets ($Liquidity_{i,t}$) over the stressed redemption shock ($Shock_{i,t}$):

$$RCR_{i,t} = \frac{Liquidity_{i,t}}{Shock_{i,t}} \quad (9)$$

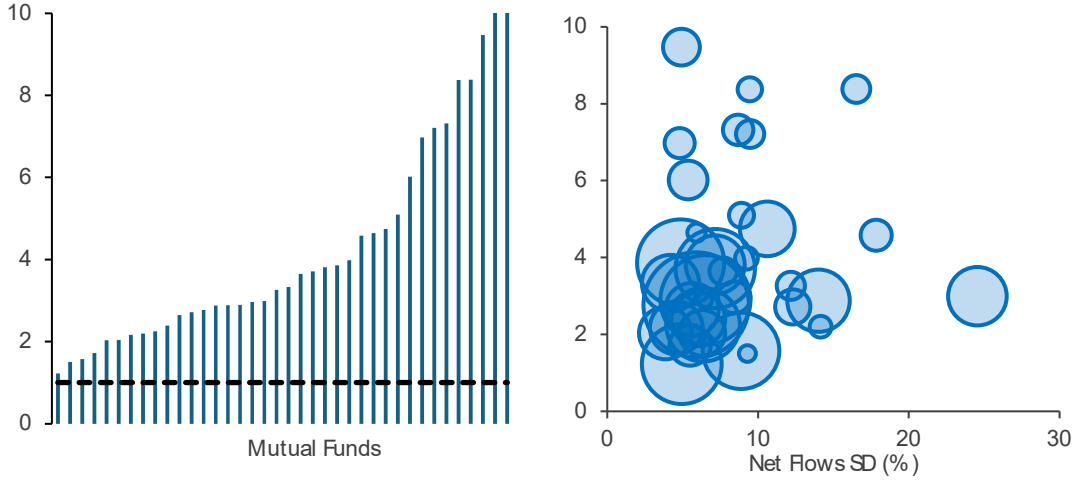
Currently, there are no regulatory requirements for Chilean mutual funds in terms of specific values of the RCR which funds must observe. However, the critical value for this indicator is usually defined as 1. Therefore, if fund has a $RCR_{i,t} > 1$ ($RCR_{i,t} < 1$), the fund has (does

not have) enough liquid assets to meet the expected redemption shock, and thus it would be (not be) resilient to liquidity shocks.

Figure 9 shows the resulting RCR values for funds under the "stress scenario" previously defined in **Table 3**. The left panel shows the RCR for every fund. As it can be seen, all funds under analysis pass the resilience test. The fund with the lowest ratio has a 1.2 RCR. At the other extreme, there is a fund with a ratio above 20 (the left axis is truncated at 10 in the figures below). The (simple) average of the RCR for the industry is 4.5. The right panel delves deeper into the results, by showing each fund's RCR (in the vertical axis), the standard deviation of net flows (in the horizontal axis) and the systemic importance of the funds (proxied by the size of each circle, which is proportional to each fund's AUM). The panel shows considerable heterogeneity in the net flows' volatility. Also, the largest funds seem to have adequate RCR values. Taken as a whole, the analysis suggests that the fixed income mutual fund industry should be able to withstand a liquidity stress episode taking place over a ten-days horizon. As the results in the appendix show, resilience would be considerably affected under both the "severe stress" and the 1st percentile shock scenarios.

Figure 9: Redemption Coverage Ratio – Stress Scenario (*)

(times)



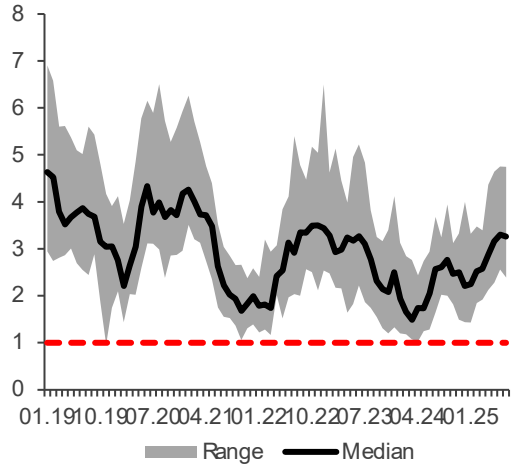
(*) The left panel shows the *RCR* for each mutual fund participating in the liquidity stress test, as well as a black dotted line showing the *RCR*=1 level. The right panel shows the standard deviation of net flows for each fund and its *RCR*. Each blue circle represents a resilient fund, and its size is proportional to its AUM. Both vertical axes have been truncated at 10.

Figure 10 complements the resilience analysis by showing the evolution of the *RCR* for active mutual funds. The stress exercise is done at the end of each month, from January 2019 until July 2025. As it can be seen, most funds comply with the resilience condition during this period. Interestingly, the *RCR* distribution began to shift downwards by mid-2023, reaching its lowest level during the first quarter of 2024. The industry has showed an upward trend in liquidity since then. By construction, redemption shocks have been constant throughout

this exercise, which implies that shifts in liquidity have been driven by changes in the funds' portfolio allocation.

Figure 10: Evolution of Redemption Coverage Ratio (*)

(times)



(*) The area showed corresponds to the difference between the 75th and 25th percentile of the *RCR* distribution.

Since we are interested in the possible implications for financial stability arising from redemption shocks in the mutual fund industry, we go beyond the individual fund level resilience analysis and estimate the implications of the stressed redemption shocks on key financial markets. Namely: money markets, sovereign, bank, and corporate bonds markets. The evidence for liquidation strategies discussed in Section 3 showed that Chilean fund managers tend to favor the use of waterfall liquidation. Nevertheless, for completeness, we perform our analysis considering both waterfall and pro-rata liquidation approaches.

Table 6, panel a), contains the resulting asset liquidation assuming managers use a waterfall strategy. In this case, and given the size of the stressed redemption shocks, only money market instruments and sovereign bonds are sold. Therefore, the corporate and bank bonds segments are unaffected. Since the money market is relatively deep, even if these instruments are heavily used by mutual funds, liquidation needs would reach less than 1% of usual market transactions. The Sovereign bond market, on the other hand would experience some pressure. Indeed, selling by mutual funds would come close to 24% of the average transactions over a 10-day horizon in this market. Another interesting point is that, once the stress episode has passed, the industry is left with practically no investments in the most liquid asset (money market instruments). The final portfolio composition is more tilted towards illiquid assets (bank and corporate bonds). A relevant factor would be how long would it take for managers to recompose their liquid assets holdings.

Panel b) in **Table 6** summarizes the effects of meeting redemption requests under a pro-rata strategy. In this case there is some pressure on the bank bond market, with liquidations reaching almost 19% of average transactions. The selling pressure on corporate bond markets is considerable as operations by mutual funds amount to almost 48% of average transactions. While outside the scope of our current work, it should be emphasized that there would be threats to financial stability if liquidation episodes of this magnitude should arise. Indeed, if selling pressure from fund managers lead to lower fixed-income prices (i.e. higher rates) there could be second-round effects since the funds' NAV would be negatively affected, which could trigger further redemption requests and give rise to subsequent selling waves. During the UK's 2022 gilt market turmoil, such market dynamics were stopped by the Bank of England's intervention in the gilt market (Pinter, 2023).

Table 6: Liquidation of Assets (*)

(USD million, percentage)

	Initial Portfolio	% AUM	Liquidation	Transactions	% transactions	Final Portfolio	% AUM
			a) Waterfall Strategy				
M. Market	142	1.3	127.2	16,515	0.8	14	0.1
Sovereign	1,574	14.5	394.5	1,627	24.2	1,179	11.4
Bank	6,243	57.4	0.0	1,600	0.0	6,243	60.3
Corporate	2,921	26.8	0.0	294	0.0	2,921	28.2
Total	10,883	100	521.8			10,362	100
			b) Pro-rata Strategy				
M. Market	142	1.3	6.8	16,515	0.0	135	1.3
Sovereign	1,574	14.5	75.4	1,627	4.6	1,499	14.5
Bank	6,243	57.4	299.4	1,600	18.7	5,944	57.4
Corporate	2,921	26.8	140.0	294	47.6	2,781	26.8
Total	10,883	100	521.8			10,362	100.0

(*) Columns 2 and 3 show the initial industry-level investments, in USD billion and as a percentage of AUM, respectively. The next three columns show the amount of each asset class that is sold to meet the stressed redemption requests, the average amount traded in each market over a 10-day horizon, and the liquidation need for each type of bond, as a percentage of average transactions. The last two columns show the final industry-level investments, in USD and as a percentage of AUM, respectively. In panel a) we assume a waterfall liquidation strategy is assumed in the following order: money market instruments, sovereign bonds, bank bonds, corporate bonds, and other instruments. In panel b), a pro-rata liquidation strategy is used.

5 – Discussion and Final Remarks

This work has focused on developing a liquidity stress test methodology for mutual funds, which are among the largest institutional investors. Specifically, we have aimed our efforts

at fixed-income funds. These funds play a useful role as part of investors' portfolios, as well as providing resources for financing investments, working capital, as well as for rolling over previous debt.

However, there are times in which the dynamics of portfolio adjustments and transformation of investments in cash may originate financial volatility, or may act as a transmission mechanism for shocks, threatening financial stability.

Our main results are summarized as follows. First, we find that mutual funds satisfy the resilience condition following a liquidity stress test calibrated at a 10-day horizon. However, the selling needs by funds may cause significant pressure in certain sectors of financial markets, particularly for bank and corporate bonds. Second, we observe a generalized decline in liquidity measures across the fixed-income fund industry, which has been driven by a sharp fall in exposure to money market instruments, although this situation has been partially reversed in the last observations in our sample. Third, an underlying these results, our evidence is not conclusive regarding the liquidation strategy favored by Chilean mutual funds at all times. However, our results tend to suggest that managers have met redemption requests by selling liquid assets (money-market instruments and sovereign bonds), which is consistent with a partial waterfall liquidation strategy.

In our analysis, we have assumed that the industry of fixed-income mutual funds receives a simultaneous liquidity shock. However, we have aimed our analysis to evaluate the fund-level resilience, as well as pressure on different segments of local bond markets. An interesting area for further research is the interconnectedness that stressed mutual funds may have, either with the banking sector, whether by being affiliated with banks as part of a financial conglomerate, or as holders of bank bonds (see, e.g. Oura, 2022, Bagattini et al., 2023, Sydow et al., 2024, and FSI, 2024 and the references therein) or with other funds, through cross-holdings (see, e.g. Fricke and Wilke, 2020).

A relevant issue that we leave for future research is the design and calibration of regulation aimed at preserving financial stability in a context where fire-sale of assets by mutual funds is a possibility. For instance, Dekker et al. (2023) shows that that euro-area mutual funds that held more liquid assets on the onset of the dash-for-cash episode of March 2020 were less prone to add selling pressure to bonds markets. However, Cucic (2021) uses a theoretical model to show that there are both costs (e.g. lower expected return of funds) and benefits (e.g. lower occurrence of fire-sale episodes) of policies such as minimum liquidity requirements, which suggests that careful assessment of policies is needed to improve market outcomes. Additionally, the methodology developed in this paper could be applied to other types of mutual funds, such as short-term fixed income and equity funds, among others.

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Appendix

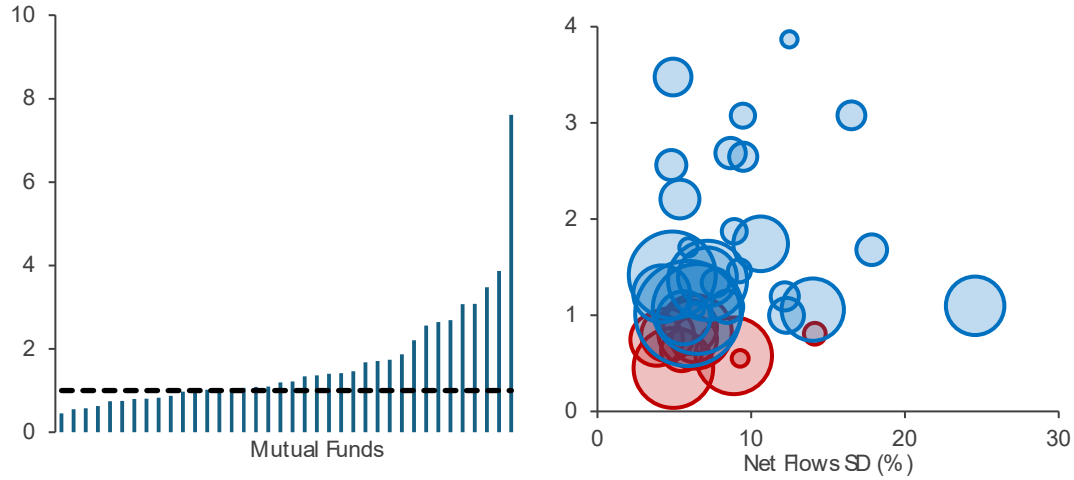
A.1 Results for alternative redemption shocks calibration

Results under the "Severe Stress" Scenario

Figure A 3 shows the results of the severe liquidity stress test. The left panel shows the RCR at the fund level. A total of 7 funds (31% of the industry's AUM) do not meet the resilience condition. The (simple) average RCR for the industry is 1.7. The right panel gives information regarding each fund's RCR (vertical axis), as well as the net flows' standard deviation for each fund (horizontal axis). Moreover, the size of each circle is proportional to the funds' AUM. For convenience, the figure shows non-resilient funds in red, while resilient funds are colored in blue.

Figure A 1 1: Redemption Coverage Ratio – *Severe Stress* Scenario (*)

(times)



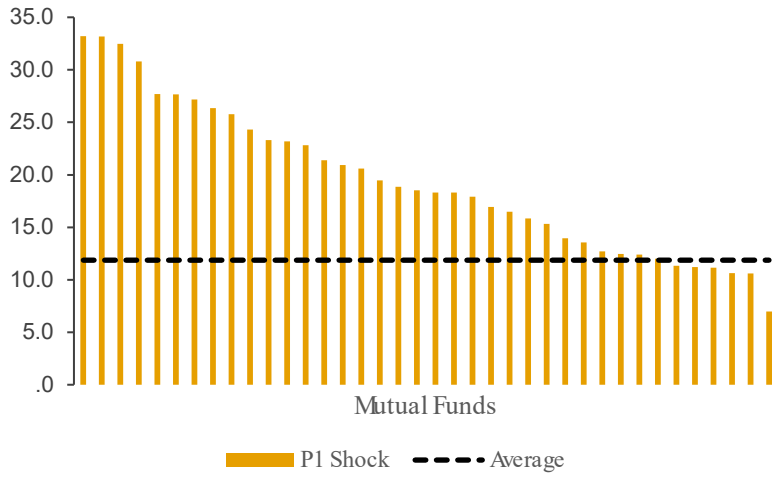
(*) The left panel shows the *RCR* for each mutual fund participating in the liquidity stress test, as well as a black dotted line showing the *RCR*=1 level. The right panel shows the standard deviation of net flows for each fund and its *RCR*. Each blue (red) circle represents a resilient (non-resilient) fund, and its size is proportional to its AUM.

Results with a 1st Percentile Redemption Shock

Following the methodology used by IMF (2015), (2016b) and (2017), we use the historical net flows distribution for each pension fund in order to determine its first percentile. **Figure A 2**, which shows absolute values, summarizes these results, which reflect considerable heterogeneity in the cross section of funds, with the percentile being as low as 7% for one fund, going all the way up to more than 33% at the other end of the figure. Overall, the average for this percentile reached 12%, more than double the average value of stress net flows using the regression methodology described in section 3.

Figure A 2 2: Stressed Net Flows – P1 (*)

(% of AUM)

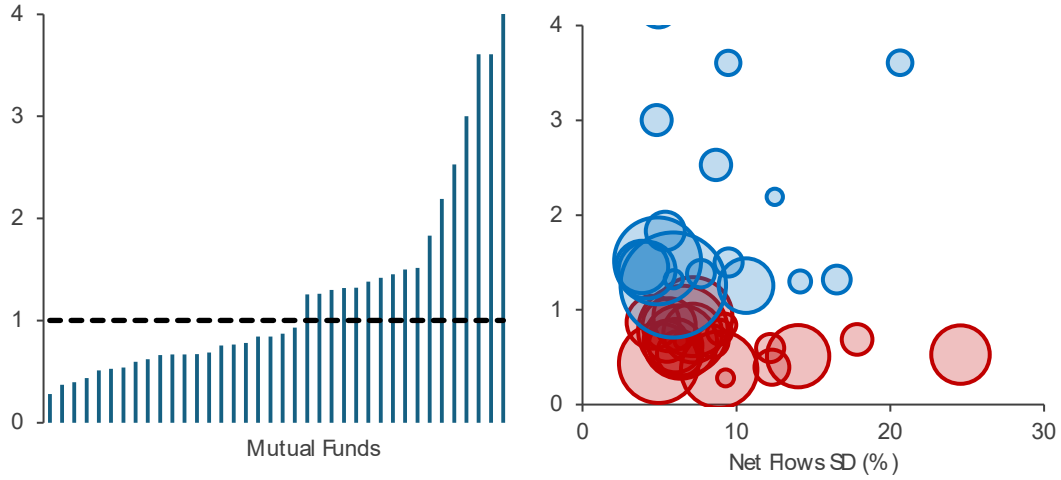


(*) The absolute values of the 1st percentile of net flows are showed for thirty-eight mutual funds, which were active by the end of April 2025.

Figure A 3 shows the results of the liquidity stress test. The left panel shows the RCR at the fund level. A considerable number of funds, 21 out of 38, do not meet the resilience condition. These funds represent 62% of the industry's AUM. The (simple) average RCR for the industry is 1.3. The right panel gives detailed information regarding each fund's RCR (vertical axis), as well as the standard deviation of its net flows (horizontal axis). The figure has the funds with *RCR* < 1 depicted in red.

Figure A 3: Redemption Coverage Ratio P1 (*)

(times)



(*) The left panel shows the *RCR* for each mutual fund participating in the liquidity stress test, as well as a black dotted line showing the *RCR*=1 level. The right panel shows the standard deviation of net flows for each fund

and its *RCR*. Each blue (red) circle represents a resilient (non-resilient) fund, and its size is proportional to its AUM.

A.2 Additional results for funds' liquidation strategies

Table A 1 and **Table A 2** show the results of the Liquidation Strategy for Stress Periods, using two alternatives to calibrate the stress periods. In **Table A 1**, the stress periods are defined as the periods during which the system experiences the 1st percentile of outflows. Recall that in **Table 5**, stress periods are defined for each fund based on 1st percentile or its historical distribution. In **Table A 2**, the stress periods are defined using specific historical events and crisis periods for the local economy, as outlined by Martínez et al. (2018).

Table A 1: Liquidation Strategy for Stress Periods based on 1st Percentile

	(1)	(2)	(3)	(4)
Variables	Most Liquid	Banks Bond	Sov. Bond	Corp. Bond
$Stress\ Period * Outflow$	5.34	4.28	-2.55	-9.82
N	11,027	10,952	10,637	11,160
R^2 (%)	15.3	16.0	8.7	24.3
Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Table A 2: Liquidation Strategy for Stress Periods based on Martínez et al. (2018)

	(1)	(2)	(3)	(4)
Variables	Most Liquid	Banks Bond	Sov. Bond	Corp. Bond
$Stress\ Period * Outflow$	0.64	-1.51	2.03	-3.12
N	11,027	10,952	10,637	11,160
R^2 (%)	15.7	16.3	8.7	25.1
Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively.

To further extend our analysis, we evaluate whether the adoption of a particular strategy depends on the fund's intrinsic characteristic. Specifically, we examine whether funds with a higher proportion of liquid assets (LA) or older funds react differently to redemptions during stress periods. To do this, we classify the funds into quintiles. Q1 and Q5 represent the funds in the first (least) and fifth (most) quintiles based on their holding of liquid assets relative to total AUM during each period, as well as funds in the first (younger) and fifth (older) quintiles measured by years since creation.

The decision on which type of strategy to adopt may differ between funds with a higher liquidity buffer and those with less liquidity. The scope of action may be influenced by the stress periods. For instance, funds with fewer liquid assets may adopt a pro-rata strategy to preserve liquidity, as they are more concerned about future redemptions, which leads them to prioritize maintaining the liquidity of the portfolio. In contrast, funds with larger liquidity buffers have more flexibility and may adopt a waterfall strategy.

To examine this heterogeneity, we conduct the following monthly panel regressions for individual funds:

$$\begin{aligned}\Delta Holding_{i,t} = {} & \alpha_i + \tau_t + \beta_1 Inflow_{i,t} * Stress\ Period_{i,t} * Quantile\ LA_{i,t}^{j} \\ & + \beta_2 Outflow_{i,t} * Stress\ Period_{i,t} * Quantile\ LA_{i,t}^{j} \\ & + \gamma' X_{i,t-1} + e_{i,t}\end{aligned} \tag{8}$$

Where $j = 1, \ldots, 5$ classifies funds according to their liquidity or age. **Table A 3** shows that, in response to a one standard deviation of outflows, funds with a higher proportion of liquid assets (LA) avoid using waterfall strategy. The adoption of a waterfall strategy is an option for less liquid funds (first quintile) when facing outflows during stress periods. In particular, less liquid funds tend to reduce their holding of most liquid instrument and bank bonds when they face outflows during stress periods. In contrast, the results suggest that funds with higher liquidity buffers (LA) adopt a pro-rata strategy compared to funds with lower LA[32]. Finally, **Table A 4** shows that a funds' observable treats (performance and size) is correlated with its liquidation strategy. For instance, funds in the best performance group tend to adjust their investments in their most liquid asset during times of stress, while those in the worst performance group also adjust their corporate bond holdings. Additionally, the statistical significance for waterfall strategies is showed for the largest funds, while for the smaller ones, the support for waterfall strategies fades, which would be consistent with the use of other liquidation strategies, such as pro-rata, for this group of funds.

[32] In the appendix there is a similar exercise but differentiating the funds by quintiles according to their performance (Returns) and size (AUM).

Table A 3: Portfolio Liquidity and Funds' Liquidation Strategy

Variables	(1) Most Liquid	(2) Banks Bond	(3) Sovereign Bond	(4) Corporate Bond
$Stress\ Period * Outflow * Q1$	9.83*	8.95**	-5.36*	-12.31***
$Stress\ Period * Outflow * Q5$	2.00	-4.41*	8.87	-3.14
N	11,027	10,952	10,637	11,160
R^2 (%)	20.5	24.7	12.9	34.6
Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively. Q1 and Q5 represent the funds belonging to the first (less) and fifth (most) quintiles of with a higher proportion of liquid assets (LA).

Table A 4: Funds' Characteristics and Liquidation Strategy

Variables	(1) Most Liquid	(2) Banks Bond	(3) Sov. Bond	(4) Corp. Bond
Panel A: Performance				
$Stress\ Period * Outflow * Q1$	-7.46**	-2.28	6.19	11.90***
$Stress\ Period * Outflow * Q5$	9.77**	-6.94	-8.53	6.25
R^2 (%)	17.9	17.6	8.9	30.4
Panel B: Size				
$Stress\ Period * Outflow * Q1$	1.84	-3.61	0.38	4.91
$Stress\ Period * Outflow * Q5$	10.47***	-8.00**	2.29	-6.30
R^2 (%)	17.5	17.8	9.0	31.0
N	11,027	10,952	10,637	11,160

Fund-Time FE	Yes	Yes	Yes	Yes

*, **, *** denote significance at the 10, 5 and 1% levels, respectively. Note: Q1 and Q5 refers to fund with less and most returns (age) at time t.

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