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Liquidity Management and Redemption Risk in Fixed-income Mutual Funds

Bachelor's Thesis
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Abstract of Bachelor's thesis

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Abstract

I analyze the liquidity management practices of U.S. open-end fixed-income funds between 1999 and 2021. Recognizing the mismatch in liquidity between funds' liquid claims and the underlying bonds, I present evidence that fixed-income funds prefer to use existing cash reserves to meet withdrawals but switch to liquidating assets across the entire portfolio during times of aggregate uncertainty and when the portfolio is particularly illiquid. I also show that fixed-income funds replenish liquidity buffers after periods of successive net outflows and do so especially conscientiously in a volatile macroeconomic environment.

Keywords Liquidity Management, Fixed-income Funds, Illiquidity Risk

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1 Introduction

Fixed-income mutual funds play an increasingly important role in the modern-day financial system. Due to changes in regulation and investor preferences, they have experienced persistent inflows since the change of the century, being interrupted only by periods of extraordinarily poor bond returns. The Investment Company Institute reports that U.S. bond mutual funds held $5.7 trillion in assets in 2021, equivalent to 25 % of the U.S. GDP or roughly 19 times the Finnish GDP (The World Bank, 2022). The magnitude of these holdings comes with significant risks to financial stability. Indeed, substantial outflows during events such as the 2008 Financial Crisis, the 2013 Taper Tantrum, and the 2019 COVID-19 downturn sparked concern about the liquidity of open-end mutual funds.

All open-end fixed-income mutual funds face the same dilemma: the securities they hold are often very illiquid, but by law, they must always be able to offer same-day withdrawals to their clients. Because of this mismatch, their ability to transform liquidity is significant not only at the fund level, but also on a macroeconomic scale. Since funds are largely unable to rely on being immediately able to liquidate bonds facing redemptions, they must hold an appropriately large portion of their portfolio in cash or cash-like liquid securities to pre-empt the possibility of a catastrophic fire sale. Funds must therefore consider the opportunity cost of holding cash instead of performance-improving risky assets. As I show in my analysis, changes in the relative sizes of the respective allocations are closely tied with certain fund characteristics and the perceived macroeconomic sentiment as well.

Observing these phenomena, it becomes interesting to discover how well these funds can manage their liquidity to prevent mass withdrawals but maintain the fund's performance amid stark competition. The dynamic liquidity management of open-end fixed-income funds has been documented before by several researchers, focusing especially on corporate bond funds (e.g., Jiang et al., 2021; Chernenko and Sunderam, 2017; Morris et al., 2017). This thesis expands on these papers by considering open-end fixed-income funds as a whole and examines a longer and more recent sample period compared to the existing analysis.

I investigate the liquidity management practices of 2301 unique U.S.-domiciled open-end fixed-income funds by using their quarterly holdings data between 1999 and 2021. My analysis focuses on the liquidity management behavior of these funds upon redemptions, i.e., outflows. First, I find that fixed-income funds prefer to meet withdrawals with existing liquid reserves, which temporarily tilts their portfolios toward more illiquid assets. Second, I find that funds with more

illiquid portfolios tend to sell assets across all liquidities to meet redemptions because they are more averse to mass withdrawals. I also investigate this relationship with funds that have volatile flows and discuss why the relationship is not as clear-cut. Third, I find that fixed-income funds become more averse to mass redemption risk during aggregate uncertainty and become more inclined to downscale their portfolios rather than depleting existing liquid reserves. Finally, I find that funds will try to replenish liquid reserves after periods of subsequent outflows, particularly carefully during times of macroeconomic uncertainty.

This thesis is organized as follows: Section 2 presents the main hypotheses of this thesis. Section 3 describes my sample and presents summary statistics of fund characteristics. Section 4 presents the results of my analyses, and Section 5 concludes with a short discussion of my results.

2 Hypothesis Development

This thesis explores the liquidity management practices of open-end fixed-income mutual funds. Acknowledging the liquidity mismatch between the funds and their holdings, I focus on the funds' strategies to meet investor redemptions. Jiang et al. (2021) identify two such strategies. They could use only liquid holdings, such as cash and short-term government bonds, which avoids the costs of premature liquidation and preserves short-term performance at the expense of being momentarily more prone to mass redemption risk. Alternatively, they can choose to sell assets proportionally across all levels of liquidity, which has the benefit of maintaining portfolio liquidity at the cost of near-term fund performance. This behavior should be particularly common in funds with more volatile flows and more illiquid holdings. These two strategies form the basis for my first two hypotheses.

Hypothesis 1: In general, funds will tap into liquid asset holdings in response to investor withdrawals, tilting their portfolios to more illiquid asset classes and increasing their exposures to run risk.

Hypothesis 2: To meet investor withdrawals, funds with higher flow volatilities and more illiquid holdings are more likely to scale down their portfolios to preserve liquidity.

Expanding on the second hypothesis, funds may be more likely to scale down their portfolios during times of heightened aggregate uncertainty. As uncertainty increases, liquidity generally decreases (Dick-Nielsen et al., 2012), which should make funds with risky bond portfolios more averse to liquidity risk. During these times, meeting investor redemptions with liquid assets and tilting the portfolio towards riskier assets is particularly perilous. This forms my third hypothesis:

Hypothesis 3: During times of heightened aggregate uncertainty, funds will scale down their assets more proportionally to meet investor outflows.

Following the first hypothesis, I expect funds to restore their level of liquid asset holdings after using them to meet investor redemptions. Since funds tend to have a target ratio of cash-like assets, this change should presumably be driven from within the fund as well. Furthermore, the speed at which the funds do this should be particularly quick during times of aggregate uncertainty. This observation motivates my fourth hypothesis.

Hypothesis 4: Funds will make a conscious effort to restore their liquid asset ratios following periods of outflows, particularly quickly during times of high economic uncertainty.

3 Sample Construction and Summary Statistics

My sample covers the period from 1999 Q1 to 2021 Q4, with data originating from several different sources. The primary data of interest is the quarterly holdings data of all U.S.-domiciled open-end fixed income funds, which I acquire from the Morningstar database. I supplement this data set with fund performance and characteristics from the CRSP Survivorship-Bias-Free Mutual Fund database. In addition, I retrieve macroeconomic data from the Federal Reserve Bank of St. Louis' FRED database. All datapoints are the quarter-end values of the respective indicator. I exclude all fund-quarter observations with a CRSP dead fund flag and require that

$$0.5 < \frac{TNA_{i,t}}{TNA_{i,t-1}} < 3$$

(as in Choi et al., 2020) for fund i in quarter t to eliminate funds undergoing exceptional changes in holding structures. I also omit fund-quarter observations with the fund's TNA being less than $1 million. The resulting dataset contains 81072 fund-quarter observations of 2301 unique open-end fixed-income funds.

The dependent variable in my analysis will be a measure of change in a fund's holdings during a specified period. Each specification will be indicated separately in the proximity of the analysis in question. The main independent variable of interest in the regressions that will follow is the flow that the funds in my sample experience each quarter. Following Coval and Stafford (2007), I define flow as the change in total net assets for fund i from the end of quarter $t-1$ to the end of quarter t, subtracting the fund's performance $r_{i,t}$ during the same quarter:

$$Flow_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1} * (1 + r_{i,t})}{TNA_{i,t-1}}$$

Table 1: Summary statistics of fund holdings

This table reports summary statistics of fund holdings and characteristics throughout the sample period of 1999-2022. Panel A reports statistics on holdings and characteristics of the entire sample, while Panel B reports median values separated by fund type.

Panel A: Aggregate Statistics								
	N	Mean	SD	p5	p25	p50	p75	p95
Cash/Assets (%)	55,097	1.36	29.49	0.00	0.05	1.26	4.13	15.12
Treasuries/Assets (%)	37,092	20.41	32.35	0.00	2.32	11.22	26.99	93.32
Cash-like/Assets (%)	63,038	13.20	37.76	0.00	0.69	4.85	19.04	76.75
Corporate/Assets (%)	47,525	40.53	35.11	0.49	14.30	34.40	64.80	93.63
Agency/Assets (%)	37,852	23.94	26.76	0.25	3.63	14.48	33.28	86.30
ABS/Assets (%)	36,311	12.72	15.21	0.14	1.77	7.51	18.21	43.38
Muni/Assets (%)	47,623	61.36	47.10	0.14	1.44	97.04	99.92	100.00
Mutual Fund/Assets (%)	32,952	9.89	21.64	0.05	1.05	2.96	7.03	71.82
Non-US Debt/Assets (%)	25,350	13.77	24.47	0.00	0.70	2.82	16.34	69.10
Equity/Assets (%)	24,741	3.04	10.56	0.00	0.00	0.01	0.02	12.77
TNA (M$)	81,072	212.05	9201.14	26.09	129.77	406.95	1317.83	7519.92
Quarterly Flow (%)	78,409	2.60	11.65	-11.18	-2.99	0.03	4.92	27.75
Quarterly Flow Volatility (%)	72,441	8.28	6.03	1.48	3.49	6.41	12.09	20.33
Quarterly Return (%)	81,072	1.03	2.85	-2.69	0.00	0.92	2.18	4.71
Fund Age (Years)	81,072	13.65	10.61	0.62	5.17	11.17	20.82	32.31
Expense Ratio (%)	69,905	0.75	0.32	0.12	0.59	0.79	0.93	1.21
Turnover Ratio (%)	69,779	99.32	198.61	8.00	21.00	45.00	100.00	392.00
Panel B: Median Holdings by Fund Type								
	IG	HY	UST	Agency	ABS	Muni	MF	Non-US
Cash/Assets (%)	1.33	1.62	0.69	1.95	1.85	0.73	0.30	2.19
Treasuries/Assets (%)	13.87	5.35	65.57	13.65	6.24	0.00	4.54	3.36
Cash-like/Assets (%)	13.94	3.68	65.24	13.11	6.89	0.72	1.10	4.34
Corporate/Assets (%)	34.93	77.93	20.67	17.69	22.04	0.82	12.40	19.40
Agency/Assets (%)	20.47	4.11	15.60	58.22	10.66	0.43	4.57	4.69
ABS/Assets (%)	13.43	2.33	5.19	10.21	46.85	0.45	3.10	3.31
Muni/Assets (%)	0.97	1.73	0.66	0.94	0.89	99.52	0.19	0.49
Mutual Fund/Assets (%)	2.82	3.06	1.53	2.90	3.91	1.78	99.32	3.91
Non-US Debt/Assets (%)	1.55	2.05	2.13	1.33	1.26	0.00	0.64	60.71
Equity/Assets (%)	0.34	1.18	0.14	0.29	0.32	0.19	0.33	0.08
TNA (M$)	648.24	400.93	563.53	557.79	530.51	275.02	208.16	388.16
Flow Volatility (%)	8.06	6.99	7.82	6.91	9.24	4.03	9.08	8.06
Fund Age (Years)	8.42	10.50	10.01	12.04	7.00	16.61	6.00	8.57
Expense Ratio (%)	0.70	0.95	0.57	0.76	0.80	0.75	0.92	0.99
Turnover Ratio (%)	86.00	63.00	82.00	112.00	61.00	19.00	63.00	83.00
Fund-Quarter Obs.	15,429	14,142	6,717	9,101	2,726	29,241	2,136	3,974

Table 1 and Figures 1 and 2 illustrate some central summary statistics of the funds in my sample. Funds are classified into types based on their largest asset class holding. In addition, the weight of that asset class must be greater than or equal to 20%. Exceptions to this rule are Investment-Grade and High-Yield funds, which are classified using objective codes provided by the CRSP. Flows and changes in asset ratios are winsorized at 5% and 95% every quarter. Cash-like securities include cash, short-term treasuries, and bonds with less than 365 days to maturity.

The data in Panel A of Table 1 describe an average fund in my sample. The median fund holds around $400 million in net assets, which includes fairly large weights in corporate bonds, agency-backed bonds, and asset-backed securities, and a significant buffer of liquid assets. The volatility of its flows is 6.4%, it has been active for 11 years, and replaces nearly half of its assets every year.

Panel B details noticeable dissimilarities between funds of different types. Their holding structures differ significantly, not just by the obvious difference in classification: Municipal bond funds and funds that hold shares in other mutual funds hold nearly all their portfolios in the respective asset classes, while other fund types own more proportionately across all asset classes. Municipal bond funds also exhibit much lower liquidity ratios, flow volatilities, and turnovers compared to other fund types. They also account for over a third of all observations in my sample, which may affect the outcomes of some analyses.

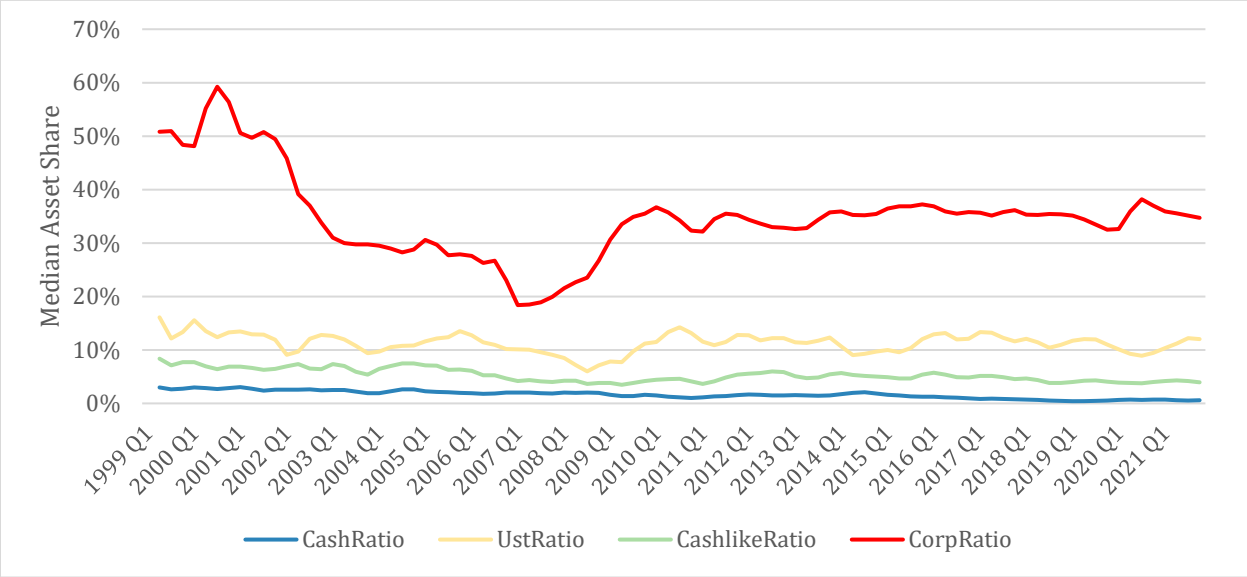

Figure 1: Median asset shares in fixed-income mutual funds between 1999 and 2021
This figure illustrates a time-series of the median asset share in four asset classes across all funds during the sample period of 1999 Q1 to 2021 Q4. All trendlines have been fitted with a 2-period moving average.

Figure 1 plots the time-series variation in median asset shares of the four asset ratios which will be used in most of the following analysis. I have chosen these asset classes in particular because most funds in the sample hold a non-trivial amount of these asset classes, whereas other asset classes, such as municipal bonds, are principally held only by funds dedicated to that asset class. The median figure would therefore be unrepresentative of the funds in the sample.

The fall in the median share of corporate bonds from its height in the turn of the century to the financial crisis of 2008 coincides (in broad terms) with the Fed's tightening interest rate policy during the same period (Fed, 2022). The subsequent rise in the share of corporate bonds after the financial crisis also coincides with the significant interest rate cut, after which it stays fairly constant. A similar increase is visible during the COVID-19 crisis in the beginning of 2020, albeit at a much smaller magnitude.

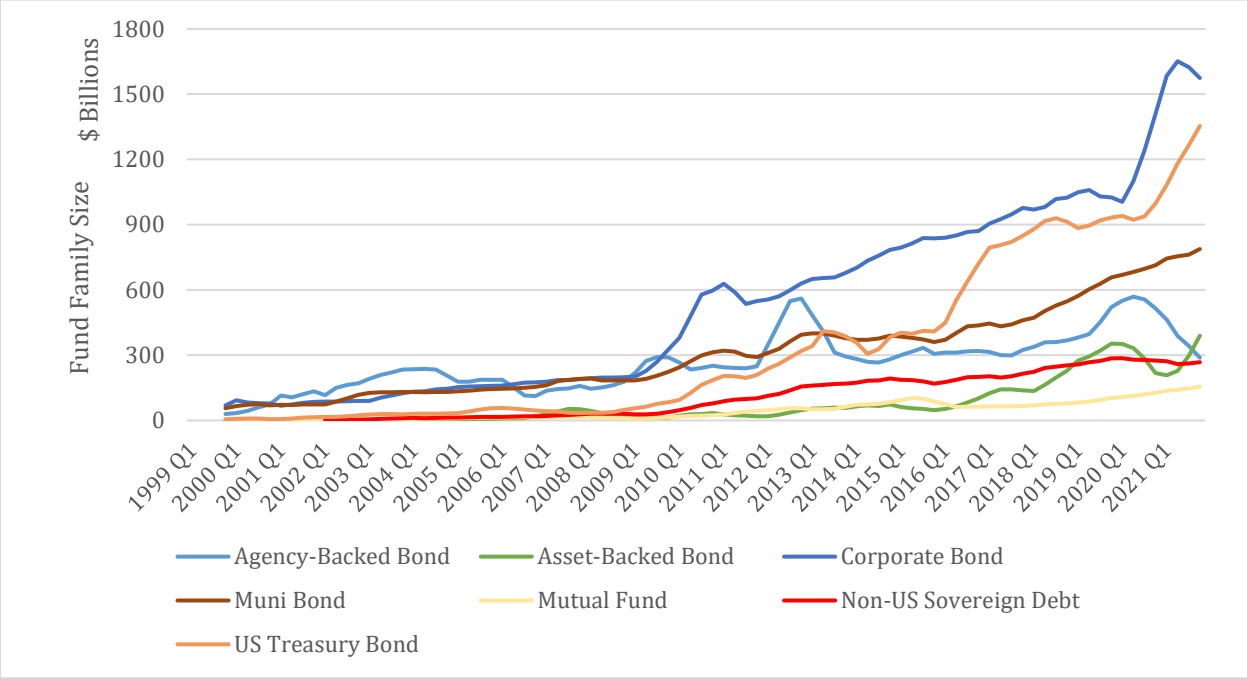

Figure 2: Fund family size development between 2000 and 2021
This figure plots a time-series of the total net assets (in $ billions) held by each fund type during the sample period. All trendlines are fitted with a one-year moving average, which is why the observations begin from 2000 Q1.

The size of corporate bond funds begins to rise alongside the increase in corporate bond issuance, which was made attractive by the low-rate environment after the financial crisis (Lo Duca et al., 2016). A similar shift is noticeable during the COVID-19 crisis of 2020. The size of US Treasury funds grows visibly as well after the financial crisis, which is presumably due to the sizeable

quantitative easing programs the Fed introduced as market stimulants after the aforementioned crises (The Economist, 5.11.2020).

The large size of corporate bond funds, U.S. Treasury funds, and municipal bonds introduce some challenges and could potentially skew some results in the analyses that will follow, especially since the funds' characteristics are so fundamentally different. For example, in a flight-to-quality scenario, high-yield corporate bond funds could experience significant outflows, while Treasury funds receive substantial inflows. In this case, the regression coefficients for outflows would mostly pick up data from high-yield corporate bond funds, which makes interpreting the results more difficult. To combat this time-varying sample bias, each sub-section below (except the first) narrows down the sample in terms of time periods or fund characteristics to isolate drivers of behavioral differences in liquidity management.

4 Results

This section pursues explanations to my hypotheses and evaluates how open-end fixed income funds manage their liquidity facing redemptions. I begin by examining how fixed-income funds manage their liquidity under normal conditions without specifying defining fund characteristics. I then consider how this behavior changes among funds with different levels of flow volatilities and holding liquidities. Next, I study the effects of aggregate uncertainty on liquidity management, and I observe how funds behave during periods of persistent outflows.

4.1 Baseline Results

The following two parts form a basis for further analysis by examining how fixed-income funds react to investor outflows without controlling for any additional factors. I find that in general, fixed-income funds accommodate redemptions by tapping into existing cash reserves.

4.1.1 Liquidity Management Facing Flows

I start by examining Hypothesis 1 from Section 2. Following Chernenko and Sunderam (2017), I estimate this relationship by regressing the change in a fund's liquid holdings over the last four quarters on the flows it received during each of those four quarters:

$$\Delta LiquidAsset_{i,t-4\rightarrow t} = \alpha_{i,t} + \sum_{k=0}^{3} \beta_k Flow_{i,t-k} + \varepsilon_{i,t}$$

I use two different types of dependent variables: In columns 1-3, the dependent variable is the change in liquid holdings as a fraction of total net assets one year ago, while columns 4-6 show

the change in a fund's liquid assets ratio during the same period. Table 2 presents the results of this regression.

Table 2: Flow management using liquid assets

Flows are winsorized at the 5th and 95th percentiles and changes in liquid assets at the 1st and 99th percentiles each quarter. All regressions include fund and quarter fixed effects, and standard errors (reported in parentheses) are clustered by quarter. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

	$\frac{\Delta Cash}{TNA}$	$\frac{\Delta UST}{TNA}$	$\frac{\Delta Cash-like}{TNA}$	$\Delta\left(\frac{Cash}{TNA}\right)$	$\Delta\left(\frac{UST}{TNA}\right)$	$\Delta\left(\frac{Cash-like}{TNA}\right)$
	(1)	(2)	(3)	(4)	(5)	(6)
$Flow_{i,t}$	0.074***	0.192***	0.187***	0.012	0.014*	0.016*
	(0.014)	(0.021)	(0.021)	(0.011)	(0.008)	(0.009)
$Flow_{i,t-1}$	0.064***	0.226***	0.207***	-0.007	0.008	0.004
	(0.015)	(0.026)	(0.026)	(0.013)	(0.009)	(0.013)
$Flow_{i,t-2}$	0.049***	0.225***	0.181***	-0.017*	0.012*	-0.002
	(0.012)	(0.035)	(0.026)	(0.007)	(0.007)	(0.008)
$Flow_{i,t-3}$	0.049***	0.169***	0.136***	-0.011	-0.002	-0.015*
	(0.011)	(0.023)	(0.019)	(0.010)	(0.006)	(0.008)
N	44,646	30,941	53,903	44,646	30,941	53,903
$Adjusted\,R^2$	0.009	0.070	0.040	0.001	0.001	0.001

In columns 1-3 of Table 2, the dependent variable is the change in liquid holdings for one year, scaled by the fund's net assets one year ago: $\Delta LiquidAsset_{i,t-4\rightarrow t} \,/\, TNA_{i,t-4}$. The coefficients in first three columns of Table 2 are all positive and highly significant, both statistically and economically. The advantage of scaling flows by the same denominator – assets one year ago – is that the coefficients can be interpreted as dollars. Therefore, $\beta_0 = 0.19$ indicates that one dollar of inflows during quarter t increases cash-like holdings by 19 cents. Conversely, this means that one dollar of redemptions is met with a reduction of 19 cents in cash-like holdings. This result provides support in favor of Hypothesis 1.

As Chernenko and Sunderam (2017) point out, a quarter is a relatively long period to observe funds' tendencies to accommodate flows with liquid assets. Despite this observation, nearly 20% of flows during a quarterly horizon are accommodated with liquid holdings. Even flows from one year before the observing period have a measurable effect on liquid holdings at time t. A higher frequency of observations should, presumably, reveal an even more important role for liquid assets in managing flows.

In columns 4-6 of Table 2, the dependent variable is the change in the fund's liquid assets ratio:

$$\Delta\left(\frac{LiquidAsset}{TNA}\right)_{i,t} = \left(\frac{LiquidAsset}{TNA}\right)_{i,t} - \left(\frac{LiquidAsset}{TNA}\right)_{i,t-4}$$

The results here are less conclusive. The coefficient $\beta_0 = 0.016$ can be interpreted as a 1.6 p.p. reduction in the liquid asset ratio for flows equal to 100% of assets. While the coefficient $\beta_0 = 0.016$ is significant at the 10% level, its economic magnitude is less so, especially since the further the flows go from the time of observation, the smaller this measure becomes. In fact, $\beta_3 = -0.015$ is already significantly negative, meaning that outflows would indicate an increase in the liquid asset ratio.

Undocumented analysis shows that results for both dependent variables are similar over a shorter period of observation as well. The significance of the findings is consistently high over the observed period especially with the first dependent variable, less so with the second specification. Chernenko and Sunderam (2017) mention that the coefficients in columns 4-6 are likely to be biased downwards due to a dynamic between the returns and flows of funds. If a fund experiences strong abnormal returns during a period, it is likely to receive inflows, but its liquid assets ratio at the end of the period will be lowered because of returns inflating asset values.

4.1.2 Outflow-induced Liquidity Management

Section 4.1.1 explains how funds use liquid assets to respond to flows at a general level. The analysis in this section makes a distinction between inflows and outflows and introduces additional control variables related to the fund's performance and its defining characteristics. It also presents the change in corporate bond holdings as a dependent variable. The dependent variable in the regressions that will follow is the change in a particular asset class's share by fund i from the end of quarter $t-1$ to the end of quarter t (Jiang et al., 2021). The variable is calculated with the following formula:

$$\Delta AssetShare_{i,t} = \frac{Asset\ weight_{i,t}}{Asset\ weight_{i,t-1}} - 1.$$

Following Jiang et al. (2021), I approximate a panel regression associating quarterly changes in asset weights to contemporaneous flows and other control variables as follows:

$$\Delta AssetShare_{i,t} = \alpha_{i,t} + \beta_0 Inflow_{i.t} + \beta_1 Outflow_{i.t} + \beta_2 Controls_{i.t-1} + \varepsilon_{i,t}.$$

The asset classes I include in my analysis are the same as in Section 4.1.1, with the addition of corporate bonds. Like in Jiang et al. (2021), $Outflow_{i.t}$ equals the flows fund i faces during quarter

t if it is negative and zero otherwise. The opposite applies for $Inflow_{i.t}$. The separation of positive and negative flows allows me to observe behaviours of different magnitudes when funds face deposits and withdrawals. Should funds use liquid assets to meet withdrawals, β_1 should be positive for liquid assets, but negative for illiquid assets, such as corporate bonds.

The control variables include the following: log of fund assets and log of fund family size, past returns, expense and turnover ratios, a dummy variable indicating availability to retail investors, and log of fund age. Table 3 presents the results of these regressions.

Table 3: Changes in Asset Allocations in Response to Withdrawals
Flows and asset shares are winsorized at the 5th and 95th percentiles each quarter. All regressions include fund and quarter fixed effects, and standard errors (reported in parentheses) are clustered by fund. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

	$\Delta Cash$	ΔUST	$\Delta Cash-like$	$\Delta Corporate\ Bonds$
	(1)	(2)	(3)	(4)
$Inflow$	0.332**	0.175***	0.264***	0.074*
	(0.143)	(0.049)	(0.075)	(0.042)
$Outflow$	0.223	0.2842***	0.449***	-0.195**
	(0.297)	(0.104)	(0.149)	(0.077)
$Log(TNA)_{t-1}$	-0.001	-0.001	-0.012	-0.005
	(0.019)	(0.006)	(0.008)	(0.006)
$Log(FamilySize)_{t-1}$	-0.055***	0.014**	-0.023**	0.004
	(0.018)	(0.006)	(0.010)	(0.005)
$Return_{t-1}$	0.738	0.419*	0.480*	0.751***
	(0.579)	(0.249)	(0.276)	(0.129)
$ExpenseRatio_{t-1}$	-24.85**	-5.371	-15.75**	19.37**
	(12.52)	(4.288)	(6.443)	(8.483)
$TurnoverRatio_{t-1}$	0.007	0.002	0.001	0.010***
	(0.005)	(0.003)	(0.002)	(0.004)
$RetailDummy_{t-1}$	0.187**	0.037**	0.080**	-0.033*
	(0.080)	(0.018)	(0.038)	(0.018)
$Log(Age)_{t-1}$	0.005	-0.007	0.019	-0.076***
	(0.026)	(0.009)	(0.012)	(0.017)
N	42,184	27,999	49,732	37,570
$Adjusted\ R^2$	0.001	0.002	0.001	0.001

Table 3 shows that the coefficient for outflow is positive among liquid asset classes but negative for corporate bonds. This means that when funds face redemptions, they decrease their allocations of liquid assets and tilt their portfolios towards more illiquid asset classes. A one standard deviation increase in outflows results in a $0.449 \times 11.6\% = 5.2\%$ decrease in the weight

of cash-like securities, and a $0.195 \times 11.6\% = 2.3\%$ increase in the weight of corporate bonds. Additional undocumented analysis with variables lagged further into the past confirms that β_1 stays positive for liquid assets and negative for corporate bonds. These findings lend further support to Hypothesis 1.

Table 3 also shows that inflows tend to increase the weights of all asset classes, albeit at a smaller magnitude and significance. Some characteristics that appear to have some explanatory power in the way funds manage flows are the fund's family size, returns of the previous period, and whether the fund is available to retail investors or not. For example, a fund that accepts retail investors holds on average more liquid assets and fewer illiquid assets than one that doesn't.

4.2 Heterogeneity Across Funds

The following two parts examine how funds with relatively high flow volatilities and illiquid portfolios react to investor outflows. I find that funds with more illiquid portfolios are more likely to scale down their portfolios proportionally and avoid relying solely on liquid assets to meet outflows. However, the results for funds with volatile flows partly contradict the hypothesis. Despite using less liquid assets than their less-volatile counterparts, their exposure to illiquid assets rises at the same time.

4.2.1 Liquidity Management in Funds with Volatile Flows

The willingness of funds to use liquid assets to meet redemptions may depend on fund characteristics. In particular, funds with more volatile flows face higher funding insecurity. This insecurity may lead to intensified concerns about mass withdrawals, thus leading fund managers to prioritize liquidity in their portfolios. To do so, they would need to meet outflows by simultaneously scaling down illiquid assets to maintain healthy liquidity. Following Jiang et al. (2021), I examine this behavior by conducting the following panel regression:

$$\begin{aligned}\Delta AssetShare_{i,t} = \alpha_{i,t} &+ \beta_0 Inflow_{i.t} \times LowVol_{i,t} + \beta_1 Inflow_{i.t} \times HighVol_{i,t} \\ &+ \beta_2 Outflow_{i.t} \times LowVol_{i,t} + \beta_3 Outflow_{i.t} \times HighVol_{i,t} + \beta_4 Controls_{i.t-1} + \varepsilon_{i,t}\end{aligned}$$

where $LowVol$ and $HighVol$ are dummy variables that indicate whether the flows of fund i during quarter t are less volatile or more volatile than the median during the same quarter. The dummy variables capture the variation across each fund and time period in flow volatilities. The results of these regressions are reported in Table 4. For brevity, I only report results from the variables of interest.

Table 4: Changes in asset allocations in funds with different flow volatilities

Flows and asset shares are winsorized at the 5th and 95th percentiles each quarter. All regressions include fund and quarter fixed effects, and standard errors (reported in parentheses) are clustered by fund. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively. All control variables from Section 4.1.2 are included as well.

	$\Delta Cash$	ΔUST	$\Delta Cash - like$	$\Delta Corporate\ Bonds$
	(1)	(2)	(3)	(4)
Panel A*: *Full Sample				
$Outflow \times LowVol$	0.615	0.258	0.664**	-0.027
	(0.577)	(0.179)	(0.299)	(0.187)
$Outflow \times HighVol$	0.138	0.250	0.332**	-0.269***
	(0.319)	(0.121)	(0.163)	(0.079)
N	40,091	26,459	47,197	35,442
$Adjusted\ R^2$	0.001	0.002	0.001	0.002
Panel B*: *Corporate Bond Funds				
$Outflow \times LowVol$	0.229	0.683**	1.130***	-0.120
	(0.731)	(0.275)	(0.363)	(0.075)
$Outflow \times HighVol$	-0.385	0.601***	0.186	-0.172***
	(0.504)	(0.208)	(0.297)	(0.066)
N	13,518	10,715	16,056	18,305
$Adjusted\ R^2$	0.002	0.004	0.003	0.006

In column 3 of Panel A, the coefficient for $Outflow$ interacted with a high fund flow volatility dummy variable is 0.332, which is only half of $Outflow$ interacted with a low fund flow volatility dummy variable, 0.664. These results support Hypothesis 2, because funds with more volatile flows were expected to use less liquid assets to meet withdrawals. However, column 4 tells a different story: funds with volatile flows were more likely to *increase* their exposure to illiquid assets. This result contradicts with Jiang et al. (2021), who find no significant changes in asset ratios for funds with volatile flows. A possible reason behind my results could be that funds with volatile flows have a harder time predicting large-scale redemptions, having to forcefully deplete liquid reserves and simultaneously increase the weight in illiquid assets.

The structure of my sample could partly explain this phenomenon as well, since funds that exclusively trade in municipal bonds would be more likely to experience less volatile flows than funds who primarily own asset-backed securities, for example. Facing redemptions, the fund manager might choose to liquidate more liquid asset classes first, leading to an inflation in the weight of the most illiquid corporate bonds. In a case like this, the portfolio adjustment would

occur in asset classes other than corporate bonds, which is the only illiquid asset class documented here.

Panel B narrows down the sample to corporate bond funds only, like in Jiang et al. (2021). Despite making this sample restriction, the same trend persists. Corporate bond funds with volatile flows tend to use less cash-like assets to meet withdrawals compared to funds with more stable flows, but their ratio of corporate bonds increases simultaneously. An explanation could be found by inspecting column 2, where a significant decrease in Treasury assets could be enough to increase the weight of all other asset classes, including corporate bonds.

4.2.2 Liquidity Management in Funds with Illiquid Portfolios

To examine differences in behavior caused by portfolio illiquidity, I conduct the same regression analysis, this time with funds that principally invest in high-yield and investment-grade corporate bonds. To make this distinction, I use objective codes provided by the CRSP. Specifically, to be classified as a high-yield fund, a fund must possess any of the following: a Lipper objective code in the set ('BBB', 'GHY', 'HY', 'SHY'), 'ICQY' as its CRSP objective code or 'CHY' as its Strategic Insight or Wiesenberger objective code. Investment-grade funds must have had any of the following: a Lipper objective code in the set ('A', 'IID', 'SID', 'SII'), a CRSP objective code in the set ('ICQH', 'ICQM'), a Strategic Insight code in the set ('CHQ', 'CQM') or 'CBD' as its Wiesenberger objective code. The distinction results in 14,142 fund-quarter observations of 758 unique high-yield bond funds and 15,429 fund-quarter observations of 878 unique investment-grade bond funds.

As high-yield bonds are generally more illiquid than investment-grade bonds, funds that invest in high-yield bonds should be particularly wary of mass withdrawal risk and therefore more inclined to scale down their portfolios rather than using only liquid reserves to meet redemptions. To test this phenomenon, I conduct the same regression analysis as in section 4.1.1, using the sample restrictions mentioned above. Panel A of Table 5 reports the results for investment-grade funds, while Panel B reports results for high-yield funds.

Table 5 reveals a noticeable difference in behavior between investment-grade and high-yield bond funds. Examining columns 3 and 4 in Panel A shows that investment-grade funds meet redemptions with liquid assets, selling treasuries, and a moderate downscaling of illiquid assets. Columns 5 and 6 show, however, that they experience a slight tilt towards illiquid assets during periods of outflows, with outflows of 1% of the fund's assets resulting in a 3-bps increase in illiquid assets, and a 4-bps decrease in liquid assets.

Table 5: Outflow-induced portfolio changes in investment-grade and high-yield bond funds
Flows and asset shares are winsorized at the 5th and 95th percentiles each quarter. All regressions include fund and quarter fixed effects, and standard errors (reported in parentheses) are clustered by fund. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

	$\frac{\Delta Cash}{TNA}$	$\frac{\Delta UST}{TNA}$	$\frac{\Delta Cash-like}{TNA}$	$\frac{\Delta Corp}{TNA}$	$\Delta\left(\frac{Cash-like}{TNA}\right)$	$\Delta\left(\frac{Corp}{TNA}\right)$
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A*: *Investment − Grade funds						
$Flow_t$	0.051*	0.151***	0.180***	0.254***	0.040**	-0.030***
	(0.028)	(0.021)	(0.025)	(0.047)	(0.018)	(0.010)
$Flow_{t-1}$	0.013	0.156***	0.164***	0.365***	-0.003	-0.015
	(0.032)	(0.021)	(0.032)	(0.049)	(0.024)	(0.010)
$Flow_{t-2}$	0.007	0.170***	0.147***	0.401***	-0.010	-0.003
	(0.026)	(0.036)	(0.040)	(0.071)	(0.020)	(0.008)
$Flow_{t-3}$	0.008	0.116***	0.088***	0.368***	-0.033**	0.013*
	(0.019)	(0.026)	(0.102)	(0.037)	(0.014)	(0.007)
N	9,160	11,549	12,835	12,809	12,835	12,809
$Adjusted\ R^2$	0.001	0.051	0.025	0.125	0.001	0.002
Panel B*: *High − Yield funds						
$Flow_t$	0.060***	0.056	0.105***	0.827***	0.024	-0.020
	(0.022)	(0.049)	(0.038)	(0.089)	(0.017)	(0.013)
$Flow_{t-1}$	0.077***	0.065	0.129***	0.904***	0.026	0.002
	(0.026)	(0.040)	(0.039)	(0.074)	(0.017)	(0.012)
$Flow_{t-2}$	0.076***	0.078*	0.107***	0.946***	0.009	0.016
	(0.021)	(0.041)	(0.025)	(0.084)	(0.016)	(0.011)
$Flow_{t-3}$	0.052**	0.081*	0.058*	0.886***	-0.005	0.025**
	(0.021)	(0.044)	(0.031)	(0.078)	(0.015)	(0.012)
N	8,879	4,792	10,090	10,926	10,090	10,926
$Adjusted\ R^2$	0.013	0.007	0.009	0.222	0.001	0.002

In contrast, high-yield funds accommodate redemptions with much fewer liquid assets, and a significantly larger impact on illiquid holdings. One dollar of outflows is met with 83 cents worth of illiquid assets and only 11 cents of liquid assets. This observation is in line with Hypothesis 2, which implicitly assumes that funds with higher flow volatilities and more illiquid assets scale down their assets proportionally. This phenomenon is documented in columns 5 and 6 of Panel B, where the changes in ratios are both small and statistically insignificant, suggesting high-yield bond funds respond to redemptions by selling illiquid assets. Another noticeable difference is that

high-yield funds hold considerably less Treasuries, instead choosing to accommodate redemptions with cash.

4.3 Liquidity Management in Volatile Market Conditions

Funds' propensity to use liquid assets to meet withdrawals may also depend on aggregate uncertainty (Morris et al., 2017). Increased concern about future outflows might induce more funds to sell assets across the board to protect themselves from the worst-case scenario, fire sales associated with mass redemptions. Following Jiang et al. (2021), I modify the equation from Section 4.2.1, this time interacting flows with a market volatility dummy:

$$\Delta AssetShare_{i,t} = \alpha_{i,t} + \beta_0 Inflow_{i.t} \times LowVIX3M_t + \beta_1 Inflow_{i.t} \times HighVIX3M_t + \beta_2 Outflow_{i.t} \times LowVIX3M_t + \beta_3 Outflow_{i.t} \times HighVIX3M_t + \beta_4 Controls_{i.t-1} + \varepsilon_{i,t}$$

where $LowVIX3M$ ($HighVIX3M$) gets a value of 1 if market volatility is below (above) its historical sample median over the past two years, and 0 otherwise. The proxy I use for market volatility is the CBOE S&P 500 3-month Volatility Index, which measures aggregate uncertainty in the U.S. market. This tracker was first introduced in December 2007, which also restricts the available sample to the period after 2007 Q4. The results of these regressions are reported in Table 6.

Table 6: Effects of aggregate uncertainty on liquidity management

Flows and asset shares are winsorized at the 5th and 95th percentiles each quarter. All regressions include fund and quarter fixed effects, and standard errors (reported in parentheses) are clustered by fund. The full suite of control variables mentioned in Section 4.1.2 are included in the regressions as well. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

	$\Delta Cash$	ΔUST	$\Delta Cash-like$	$\Delta Corporate\ Bonds$
	(1)	(2)	(3)	(4)
$Inflow$	0.292	-0.001	0.147	-0.024
$\times LowVIX3M$	(0.180)	(0.068)	(0.090)	(0.015)
$Inflow$	0.462*	0.488***	0.494***	-0.063***
$\times HighVIX3M$	(0.246)	(0.103)	(0.123)	(0.021)
$Outflow$	0.063	0.492***	0.556***	-0.161***
$\times LowVIX3M$	(0.342)	(0.109)	(0.167)	(0.029)
$Outflow$	-0.621	-0.014	0.106	-0.092**
$\times HighVIX3M$	(0.569)	(0.218)	(0.274)	(0.039)
N	31,458	21,645	37,398	28,544
$Adjusted\ R^2$	0.003	0.014	0.002	0.010

Table 6 reveals the time-varying behavior in which funds adjust asset allocation when facing redemptions. My main emphasis is in the differences between coefficients β_2 and β_3. During times of comparatively low aggregate uncertainty, fund managers were more likely to accommodate withdrawals using liquid assets, and tilting the portfolio toward illiquid assets: a one standard deviation increase in redemptions is associated with a decline in the relative weight in government securities and liquid assets of $11.6\% \times 0.492 = 5.7\%$ and $11.6\% \times 0.556 = 6.5\%$, respectively, and a relative increase of $11.6\% \times 0.161 = 1.9\%$ in corporate bonds. However, during times of relatively high aggregate uncertainty, the interaction terms were much less significant and smaller in magnitude, consistent with Hypothesis 3.

4.4 Liquidity Restoration After Periods of Persistent Outflows

If a fund encounters unexpected outflows which force them to deviate from their preferred asset allocations, they may need to restore liquid assets back to their pre-redemption levels. To test whether outflows during quarter $t-1$ are associated with adjustments in liquid asset holdings during quarter t, I calculate the following regressions, following Jiang et al. (2021):

$$\begin{aligned}\Delta AssetShare_{i,t} = \alpha_{i,t} &+ \beta_0 Inflow_{i.t} + \beta_1 Outflow_{i.t} + \beta_2 Inflow_{i.t-1} + \beta_3 Outflow_{i.t-1} \\ &+ \beta_4 Controls_{i.t-1} + \varepsilon_{i,t}\end{aligned}$$

The results of these regressions are detailed in Panel A of Table 7. Panel B adds volatility interaction terms to the equation, examining the difference in behavior across different levels of aggregate uncertainty.

$$\begin{aligned}\Delta AssetShare_{i,t} = \alpha_{i,t} &+ \beta_0 Inflow_{i.t} \times LowVIX3M_t + \beta_1 Inflow_{i.t} \times HighVIX3M_t \\ &+ \beta_2 Outflow_{i.t} \times LowVIX3M_t + \beta_3 Outflow_{i.t} \times HighVIX3M_t \\ &+ \beta_4 Inflow_{i.t-1} \times LowVIX3M_t + \beta_5 Inflow_{i.t-1} \times HighVIX3M_t \\ &+ \beta_6 Outflow_{i.t-1} \times LowVIX3M_t + \beta_7 Outflow_{i.t-1} \times HighVIX3M_t \\ &+ \beta_8 Controls_{i.t-1} + \varepsilon_{i,t}\end{aligned}$$

The estimated β_1 coefficients in Panel A of Table 7 follow the pattern predicted in Hypothesis 1: in general, funds prefer to meet outflows with liquid assets. The estimates on β_3 show, however, that if funds face two subsequent quarters of net outflows, they are likely to respond by increasing liquid assets to maintain an adequate level of liquidity. Simultaneously, there is a significant reduction in Treasury assets, and the portfolio is slightly more tilted toward illiquid assets. This finding introduces a new dimension to the results in Section 4.1.2 and forms a solid basis for

Hypothesis 4. The pace at which the fund must rebalance its portfolio may, however, require a higher degree of urgency during concerns of macroeconomic uncertainty. Panel B estimates this phenomenon.

Table 7: Liquidity restoration in different macroeconomic environments

Flows and asset shares are winsorized at the 5th and 95th percentiles each quarter. All regressions include fund and quarter fixed effects, and standard errors (reported in parentheses) are clustered by fund. The full suite of control variables mentioned in Section 4.1.2 are included in the regressions as well. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

	$\Delta Cash$	ΔUST	$\Delta Cash-like$	$\Delta Corporate\ Bonds$
	(1)	(2)	(3)	(4)
Panel A*: *Baseline				
$Outflow_t$	0.330	0.298***	0.546***	-0.187***
	(0.306)	(0.107)	(0.156)	(0.082)
$Outflow_{t-1}$	-0.790**	-0.055	-0.673***	-0.051
	(0.332)	(0.109)	(0.173)	(0.056)
Panel B*: *Aggregate Uncertainty				
$Outflow_t \times LowVIX3M_t$	-0.143	0.393***	0.471**	-0.142***
	(0.375)	(0.114)	(0.185)	(0.031)
$Outflow_t \times HighVIX3M_t$	0.267	0.266	0.395	-0.065
	(0.658)	(0.264)	(0.330)	(0.048)
$Outflow_{t-1} \times LowVIX3M_t$	-0.880***	-0.073	-0.472**	-0.019
	(0.377)	(0.130)	(0.194)	(0.031)
$Outflow_{t-1} \times HighVIX3M_t$	0.629	0.009	0.109	-0.055
	(0.627)	(0.230)	(0.346)	(0.050)

During times of low aggregate uncertainty, the estimates in Panel B are very similar to those in Panel A: Cash's share of the portfolio increases considerably, while the level of cash-like securities stays fairly constant, and the weight of corporate bonds increases significantly. This indicates that during low uncertainty, fixed income funds are comfortable with using liquid assets to meet redemptions, even when they face two subsequent quarters of net outflows. In contrast, the coefficients for high aggregate uncertainty are all insignificant and smaller in magnitude than their low-uncertainty counterparts, suggesting that no significant changes are being made to portfolio weights during those periods. During two successive quarters of outflows and high uncertainty, funds are more likely to engage in a downscaling of their portfolios, rather than using liquid assets to meet redemptions.

5 Discussion and Conclusions

In this thesis, I investigated the liquidity management practices of U.S. fixed-income mutual funds between 1999 and 2022. This behavior has been examined before by several researchers (e.g., Jiang et al., 2021; Chernenko and Sunderam, 2017; Morris et al., 2017), although a majority of the literature has focused on corporate bond mutual funds. Despite not making this distinction, my results document very similar phenomena as the earlier research, albeit at slightly different magnitudes. While this thesis is only a brief excursion into the field of liquidity management by fixed-income mutual funds, it provides some promising preliminary results for further assessment.

First, I find that, all else equal, fixed-income mutual funds prefer to accommodate outflows with existing liquid holdings (as in Chernenko & Sunderam, 2017), which slightly tilts the funds' portfolios toward more illiquid assets, consistent with Jiang et al. (2021). In terms of magnitudes, a one standard deviation increase in flows results in a 5.2% decrease in the weight of cash-like securities, and a 2.3% increase in the weight of corporate bonds. This preference stems from a trade-off between short-term performance considerations and long-term illiquidity-induced mass redemption risk aversion.

Second, the data suggest that bond funds with more illiquid portfolios were more averse to mass redemption risk, choosing to liquidate holdings proportionally across the entire portfolio rather than relying only on liquid assets. Investment-grade bond funds were much more likely to experience significant portfolio tilts during outflows than high-yield bond funds, whose portfolio weights stayed relatively constant because of more active rebalancing. This result is in line with Goldstein et al. (2017), who find that funds with more illiquid assets react more sensitively to outflows, and Morris et al. (2017), who find that the most illiquid bond funds tend to hoard cash by selling assets in response to withdrawals. This result is also in line with Jiang et al. (2021) and Ma et al. (2022), who further propose that funds adjust their portfolios consistent with a "liquidity pecking order", selling more liquid corporate bonds before illiquid ones to reduce transaction costs. Additionally, Choi et al. (2020) propose that corporate bond funds engage in momentum trading by choosing to sell securities they expect to perform poorly in the future.

The results were much less convincing for funds with highly volatile flows, who indeed were much less likely to use only cash-like assets to meet withdrawals, but nevertheless saw a statistically significant increase in the weight of illiquid assets. The results persist when limiting the sample to corporate bond funds, although the magnitudes of the effects became slightly more in line with

Jiang et al. (2021). Compared to the existing literature studying the same phenomenon in corporate bond mutual funds, the difference in sample construction is the most noticeable here.

Third, I go by Jiang et al. (2021) and find that fixed-income funds are comfortable using liquid assets to meet withdrawals during periods of low aggregate uncertainty but become more anxious of illiquidity risk during periods of high uncertainty, tending to sell illiquid holdings more aggressively. This result is consistent with the findings of Vayanos (2004), who notes that fund managers' preference for liquid assets rises during economic uncertainty, leading them to shy away from more illiquid portfolios, especially since liquidity premia have historically been higher at the same time. Furthermore, Goldstein et al. (2017) find that during periods of low market liquidity, funds that hold illiquid assets perform more poorly than more liquid funds, giving rational investors an incentive for further withdrawals. This, in turn, should make fund managers more cautious with higher liquidity reserves.

Finally, I find that fixed-income funds will restore their liquidity buffers after subsequent periods of redemptions. They will do so especially conscientiously when aggregate uncertainty is high, which confirms the results of Jiang et al. (2021).

While this thesis provides a window into the intricacies of liquidity management by fixed-income mutual funds, there are many factors that haven't been considered in detail. For example, many earlier papers (e.g., Goldstein et al., 2017; Jiang et al., 2021) have examined fund liquidity by approximating the liquidity of the underlying bonds, whereas I have only proxied it with considering the difference between high-yield and investment-grade corporate bond funds. Having a more precise measure for liquidity could justify a stronger association between the data and the behavioral patterns to be inferred from it. One could also consider the behavioral differences stemming from the fund manager's personality traits; however, Chernenko and Sunderam (2017) find little to no impact on liquidity management here.

The liquidity management practices of fixed-income funds affect the bonds they hold as well. While Coval and Stafford (2007) and Chernenko and Sunderam (2020) find that suboptimal liquidity management causes fire sales that depress asset values and fund NAVs in equity funds, Choi et al. (2020) find no such evidence for corporate bond funds due to the liquidity buffers they hold. In contrast, Jiang et al. (2021) find that individual corporate bond funds selling assets in large quantities can exert pressure sufficient to raise concerns about financial stability.

Since the size of the fixed-income market has grown substantially over the past two decades, its efficient operation is necessary for macroeconomic stability. As Choi et al. (2022) point out, the

market for fixed-income securities is much more illiquid than the equity market, which leads to the stale pricing of bonds and, consequently, the funds that hold the bonds. Stale pricing makes funds more fragile to large-scale outflows, which in aggregate endangers all market participants.

The liquidity management practices of open-end fixed-income mutual funds therefore affects performance and behavior at the fund-level and ensures the smooth operation of the economy. As the market for fixed-income securities continues to grow, understanding how its components act becomes increasingly important as well.

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