Liquid Assets and Financial Fragility*

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Abstract

How does access to liquid assets affect the fragility and lending of financial intermediaries? We develop a global-game model of investor redemptions from money funds that finance corporate borrowers and hold liquid assets (assets without liquidation costs). Using the 2013 debt limit and the Federal Reserve's Overnight Reverse Repurchase (ONRRP) facility as our laboratory, we provide evidence consistent with the model. Access to liquid assets—the ONRRP—attenuates investor redemptions and allows money funds to maintain their lending to corporations. Our results suggest that the public provision of liquidity reduces intermediary fragility and increases lending to the real economy.

JEL classification: G01, G23, E58.

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1 Introduction

In the aftermath of the 2008 financial crisis, regulators worldwide required financial intermediaries to hold enough liquid assets to withstand significant outflows. Liquid assets are generally defined as assets with little credit risk that can be immediately turned into cash (liquidated at no cost), particularly during periods of stress. Requiring intermediaries to hold enough liquid assets should improve the financial stability of these intermediaries and the markets they operate in. However, liquid assets may also be a source of fragility: financial intermediaries could load up on liquid assets during periods of stress to reduce their run risk, only to curtail lending to private corporations that heavily depend on them for short-term funding. As a result, the safety of the financial intermediary may come at the expense of increased fragility for the ultimate borrowers, namely private corporations. Little is known about how the public provision of liquid assets affects the fragility of intermediaries and their lending behavior in times of stress, partly because the provision of liquid assets is not randomly assigned.

In this paper we seek to analyze these issues both theoretically and empirically. On the empirical side, we focus on a specific type of financial intermediary, namely money market mutual funds (money funds henceforth), which provide vital short-term funding to financial and non-financial corporations. To circumvent the identification problem just described, we exploit a quasi-natural experiment that occurred during the 2013 U.S. debt limit crisis, at the same time that the Federal Reserve phased in the Overnight Reserve Repurchase (ONRRP) facility to money funds. To guide the empirical analysis and clarify the main incentives at play, we build a parsimonious global-game model of investor redemptions and derive several hypotheses. We find both theoretically and empirically that access to liquid assets reduces redemption incentives among investors and allows money funds to maintain more lending to corporate borrowers in times of stress. In sum, the enhanced stability of money funds due to access to liquid assets does not increase the funding risk of private corporations.

Our global-game model of investor redemptions builds on Chen et al. (2010). Money funds hold liquid assets and make risky lending to corporate borrowers. Investors decide whether to redeem their shares based on a noisy private signal about fund performance. Liquid assets can be liquidated at no cost. One-sided strategic complementarity arises, whereby an investor's incentive to redeem *decreases* in the share of redeeming investors for low redemptions (i.e. when the available liquid assets suffices to meet redemptions). Intuitively, sharing the pie among fewer investors in the future is beneficial to investors, inducing them not to redeem. Conversely for high redemptions, costly liquidation of risky assets makes an investor's incentive to redeem increase in the share of redeeming investors, resulting in the usual complementarity.

To deal with one-sided strategic complementarity, we apply the methods in Goldstein and Pauzner (2005) to derive a unique equilibrium and obtain three testable implications. First, investors are less likely to run on money funds with access to liquid assets, reducing financial fragility. Since a liquid asset incurs no liquidation cost, a redeeming investor imposes a lower negative externality on other investors, thus reducing their redemption incentives. Second, the effect on fragility is larger when more investors are active and thus the degree of strategic complementarity is higher. Third, funds with access to a liquid asset maintain more of their lending to corporate borrowers in times of stress, due to both the lower fragility of such funds and the lower cost of liquidation.

Next, we test the three predictions of the model. Our empirical laboratory is the period surrounding a significant stress event in money markets, the 2013 U.S.

debt limit episode that, by chance, occurred right after the introduction of the Federal Reserve's Overnight Reverse Repurchase (ONRRP) facility. The ONRPP facility was introduced in September 2013 when overnight rates were at zero. The purpose of the facility was to offer safe and liquid assets (overnight reverse repos) at an administered rate so as to exert better control on short-term rates when the Federal Reserve were to lift rates from zero (FOMC 2014, Frost et al. 2015). To provide better interest rate control, a broad range of market participants, including *qualifying* money funds, were allowed to participate. ONRRPs are the safest and most liquid available asset because they are secured by the safest collateral, Treasuries, have no counterparty risk (the Federal Reserve is the borrower), and mature the next day.

There are two main identification challenges in bringing the model to the data. First, access to liquid assets (ONRRP in our case) is not random. However, we exploit the fact that around the launch of the ONRRP in September 2013, there exists a group of money funds that are technically eligible to participate, but since they did not satisfy the eligibility criteria by the last application deadline in September 2012, they do not have access to the facility a year later in September 2013. We can thus construct a control group that would have participated at the ONRRP had it been able to apply more recently.[1] We then compare the behavior of this control group to treated funds of similar size.

Second, we require an exogenous stress event that occurs after the introduction of the ONRRP but before more money funds are allowed to apply again (November 2014). The event that satisfies these conditions is the U.S. debt limit episode that unfolded in October 2013. The combination of the staggered participation at the ONRRP and the U.S. debt limit episode provide a quasi-natural experiment to study

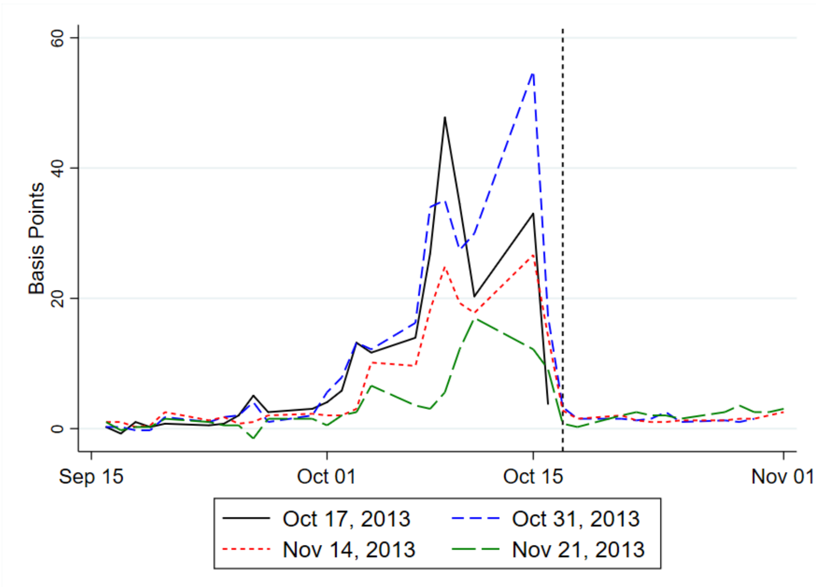
[1] Section 4 explains ONRRP eligibility and the construction of treatment and control groups.

the effect of the provision of liquid assets on the financial stability of money markets.

Using the 2013 debt limit as the stress event, we trace money funds' risk exposures to the Treasury securities affected by the debt limit. Yields on Treasury securities with payments scheduled shortly after mid-October increased markedly because of the possibility that Congress would not pass legislation to raise the debt limit in time. The market did not expect an outright default by the U.S. government. Instead, investors priced the possibility of a delay in principal and interest payments scheduled between mid-October and mid-November (see Figure 1). We call these Treasuries at risk of delayed payments "at-risk Treasuries" or "risk exposures". Treasuries are usually considered to be the most liquid assets available (e.g., Krishnamurthy and Vissing-Jorgensen 2012). However, around several debt limits, at-risk Treasuries experience a sharp drop in price (increase in yields) and may generate a capital loss if liquidated—i.e. they become less liquid. This is indeed what happened around the 2013 debt limit episode, as shown in Figure 1 by the sharp rise in yields of at-risk Treasuries. During this episode, ONRRPs are the most liquid assets available to *some* money funds.

We find evidence supportive of the model's implications. We first document that money funds with access to the ONRRP (treated funds) are less fragile than control funds. For a given risk exposure, treated funds experience fewer outflows than control funds without access to the ONRRP. This is in line with the model, where access to a liquid asset allows treated funds to accommodate redemptions by not rolling over ONRRP investments without incurring any fire-sale loss, while control funds may have to incur higher liquidation costs. As a result, treated funds experience fewer outflows than control funds in response to exposures to at-risk Treasuries during the debt limit crisis. Second, we find that the effect of access to the ONRRP is more pronounced

Figure 1: **Bill yields around the 2013 debt limit episode.** This figure shows the yield (in basis points) of some of the Treasury bills maturing around the 2013 debt limit episode. To reduce clutter, we do not display the at-risk bills maturing on Oct 24, 2013 and Nov 7, 2013, nor at-risk bonds with coupon payments due between October 17 and November 22, 2013. The vertical dashed black line represents Oct 17, 2013, the "breach date". As the maturity date of the bills moves further past the breach date, the spike in yields is reduced, indicating that markets priced the possibility of a delay in payments on Treasury securities.



for the more active institutional investors relative to retail investors (Schmidt et al. 2016). Third, treated funds maintain more of their lending to risky corporate borrowers during the stress episode than control funds, suggesting that the enhanced stability of treated funds does not come at the expense of increased fragility to private borrowers.

Identification rests on both the exogeneity of risk exposures and the lack of any systematically relevant difference between funds in the treatment and control groups. We address both endogeneity concerns by conducting several checks. Regarding the exogeneity of risk exposures, we show that neither being an ONRRP counterparty nor the general risk profile of the fund is correlated with risk exposures ex ante (before the stress event). However, it might still be the case that funds with no exposure to at-risk Treasuries possess better managerial skills and thus stay away from those securities. If so, we would expect to observe a positive and significant correlation between risk exposures during the 2011 debt limit episode and risk exposures for the 2013 episode. However, the two variables are uncorrelated, suggesting that managerial skill is unlikely to drive our results.

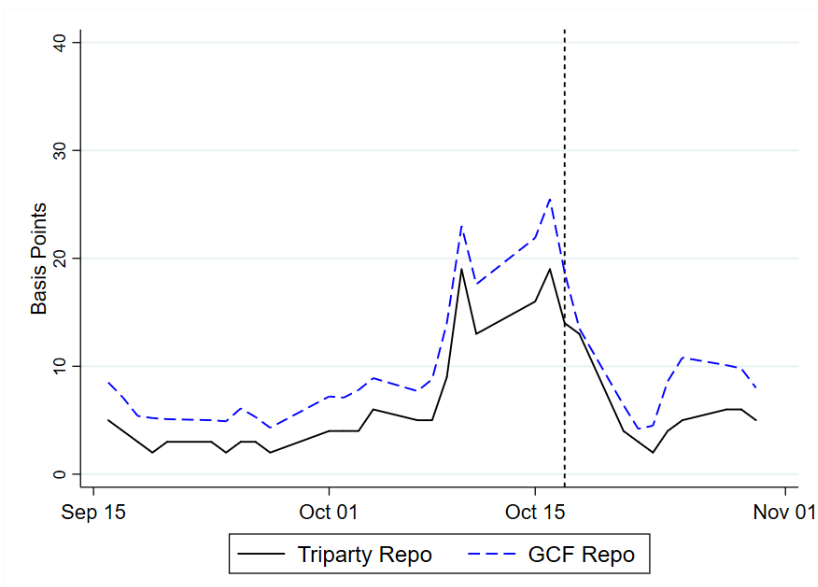
Another potential concern is that money funds that are ONRRP counterparties in 2013 are systematically less sensitive to runs than other funds for reasons unrelated to ONRRP access. To address this concern, we exploit the fact that no ONRRP facility exists during the 2011 debt limit episode. We show that funds that are ONRRP counterparties in 2013 are actually more sensitive to the 2011 debt limit episode than other funds. If anything, this finding strengthens our results. Finally, we show that the sensitivity of flows to at-risk Treasuries is not driven by overall fund liquidity, which measures how many assets can be liquidated by the fund in a short period of time. Fund liquidity is nevertheless important because our main result (the sensitivity of outflow to risk exposures) is driven by the less liquid funds. The amplification of shocks in less liquid funds is consistent with our run model and previous empirical literature on fund fragility (Goldstein et al. 2017, Fleming and Sarkar 2014).

We refer to the ONRRP offered by the Federal Reserve as liquid in order to distinguish them from the other triparty repos offered by private firms, namely broker-dealers. For a combination of collateral and counterparty risks,[2] these private triparty

[2]It is important to remember that repos backed by even the safest collateral are still subject to counterparty risk, and therefore there are various degrees of safety even for repos backed by the same Treasury collateral. Indeed, Lehman lost access even to triparty repos backed by Treasury collateral. Copeland et al. (2014) suggest two explanations for this pattern: first, upon the default of the triparty repo borrower, the money fund that lends money against general Treasury collateral may receive a Treasury security which the money fund is unable to hold because it exceeds the 13-months residual maturity limit. Second, a money fund manager may be afraid of facing investors' redemptions that could be triggered if the fund makes the headlines of a news story that associates

repos become risky during the 2013 debt limit episode: while the ONRRP facility offers an interest rate of one basis point throughout the episode, rates on triparty repos backed by Treasuries go from two basis points on September 27 to 19 basis points on October 16 at the height of the debt limit episode, before retracing to two basis points on October 23 (see Figure 2). Inter-dealer repos, where typically smaller dealers and hedge funds borrow from larger dealers, follow a similar pattern: the GCF Treasury repo rate goes from four basis points on September 27 to 25 basis points on October 16.

Figure 2: **Repo rates around the 2013 debt limit episode.** This figure shows two different repo rates around the 2013 debt limit episode. The solid black line represents the rate on triparty treasury repos with overnight tenor, and similarly the dashed blue line displays the rate on GCF treasury repos with overnight tenor. GCF repo is a blind-brokered, interdealer repo market cleared by FICC that operates on the triparty platform. The GCF repo market mainly consists of smaller dealers borrowing from the larger dealers that have a broader access to repo funding. The vertical dashed black line represents Oct 17, 2013, the "breach date", at which point Treasury was expected to run out of cash. The 2013 debt limit episode was resolved just one day prior, on Oct 16, 2013.



Literature. To the best of our knowledge, ours is the first paper to shed light on the financial intermediation and stability effects of providing liquid assets to money

it with the failing dealer (headline risk).

funds during financial stress. On the theoretical side, Chen et al. (2010) develop a model of investor redemptions from mutual funds using global-game methods of Morris and Shin (2003). They show that strategic complementarities among investors result in the fragility of mutual funds. We build on this model and allow for asset heterogeneity, whereby mutual funds hold both liquid and risky assets, and study the implications for the fragility of the fund, its ability to maintain intermediation to the real economy, and the role of investor sophistication. Since liquid assets make the redemption choices of investors one-sided strategic complements, we apply the global-game methods of Goldstein and Pauzner (2005) to derive a unique equilibrium.

On the empirical side, we contribute to the literature that studies the fragility of financial intermediaries. McCabe (2010), Kacperczyk and Schnabl (2013), Duygan-Bump et al. (2013), and Strahan and Tanyeri (2015) document the interplay of money funds' outflows and risk-taking around Lehman's collapse in 2008. Chernenko and Sunderam (2014), Ivashina et al. (2015), and Gallagher et al. (2020) study the run on prime funds during the 2011 European sovereign debt crisis. Schmidt et al. (2016) illustrate the interactions of retail and institutional investors in money funds after the bankruptcy of Lehman Brothers. Li et al. (2021) find that the option to impose gates and fees may exacerbate run risk for prime money funds. Goldstein et al. (2017) and Falato et al. (2021) show that less liquid corporate bond funds are more sensitive to shocks. We complement these studies by analyzing the effect of the public provision of a liquid asset to money funds on fragility and intermediation.

There is also a nascent literature on the effects of the ONRRP. Martin et al. (2019) provide a theory of monetary policy implementation through the ONRRP, while Anderson and Kandrac (2017) show that introducing the ONRRP facility has a pricing impact in the triparty repo market by improving the bargaining power of money funds with ONRRP access. Our focus is instead on its financial intermediation and stability implications.

2 Model and hypotheses

We develop a model to study the effect of liquid assets on redemptions from mutual funds. Specifically, we incorporate a liquid asset into the mutual fund runs model of Chen et al. (2010), resulting in one-sided strategic complementarity in redemption decisions. We use the global-game methods developed in Goldstein and Pauzner (2005) to solve for the unique equilibrium and derive three testable hypotheses.

There are two dates $t = 1, 2$, one good, and universal risk neutrality. Investors consume at either date. Prior to $t = 1$, each investor from a continuum $[0, 1]$ holds one share in a mutual fund, where the total amount of investment is normalized to 1. Prior to $t = 1$, funds invested $S \in (0, 1)$ in a liquid asset and $1 - S$ in a risky asset that we interpret as lending to riskier borrowers. In the context of money market mutual funds, these include commercial paper and certificates of deposit. Liquid assets are heterogeneous across funds: treated funds (T) are eligible to participate at the ONRRP prior to $t = 1$ and hold these as liquid assets, so their cost of liquidation is $\eta_T = 0$. Control funds are ineligible to participate at the ONRRP and hold Treasuries as liquid assets. While Treasuries are normally very safe and liquid assets, some of them become costly to liquidate during the debt limit episode. Accordingly, we interpret $t = 1$ as the beginning of the debt limit episode, so the cost of liquidation is positive at this particular time, $\eta_C > 0$. The cost of liquidation of risky assets is $\lambda > \eta_C$. Consistent with our timing interpretation, the liquidation costs $(\eta_T, \eta_C, \lambda)$ are commonly known at $t = 1$. In practice, treated funds also hold Treasuries, some of which become risky, but they are the only ones that can invest in ONRRPs, which are the safest assets available during the debt limit. Therefore, for the sake of tractability, we make the simplifying assumption that the liquid assets available to treated funds are ONRRPs while those available to control funds are Treasuries, which are generally safe other than around some debt limit episodes.

The fund generates returns at $t = 1$ and $t = 2$. The return on the liquid asset is normalized to 1 at each date. The gross return on the risky asset is R_1 at $t = 1$, which is commonly known. At $t = 1$ each investor decides whether to withdraw their money (by redeeming their share). We assume that only a fraction $\overline{N} \in \left(0, \frac{1}{1+\lambda}\right)$ of all investors make a withdrawal choice.[3] We interpret $\overline{N}$ as a measure of investor sophistication, as in Schmidt et al. (2016). Since the fund is always solvent, investors withdrawing at $t = 1$ receive the current value per share, $\pi_1 \equiv S + (1 - S)R_1$.

The fact that redemptions may impose a negative externality on the investors who stay in the fund is captured by funds having to sell assets to meet redemptions. Due to the illiquidity generated by transaction costs or asymmetric information, a fund needs to sell $1 + \lambda$ units of the risky asset to receive one unit of funds. A pecking order is optimal, whereby a fund sells liquid assets first in order to meet redemptions, because only $1 + \eta$ units of the liquid asset have to be sold to receive one unit of funds. For simplicity, we abstract from fund inflows. We also assume that redeeming investors do not bear a portion of the liquidation cost.[4]

Let $R_2(\theta)$ be the gross return on the risky asset at $t = 2$, where R_2 strictly increases in the fundamental of the fund θ realized at $t = 1$, which captures its ability

[3] This simplifying assumption ensures that the fund is always solvent, ruling out the complications arising from bankruptcy—see Goldstein and Pauzner (2005) for an analysis of this issue.

[4] Consistent with this assumption, changes to NAV rules occurred after the period of empirical investigation.

to generate high future returns. It can be related to the skill of the fund manager or the strength of the investment strategy or both. We assume a uniform distribution: $\theta \sim \mathcal{U}[-B, B]$ for some $B > 0$.

The payoffs to investors who stay in the fund at $t = 1$ depend on whether the liquid asset suffices to meet redemptions at $t = 1$. We consider each of these cases.

Case 1: few withdrawals ($N \leq \underline{N}$)**.** In this case, only liquid assets are liquidated, which is at cost $1 + \eta$ per unit, with $\eta_T = 0 < \eta_C$. Thus withdrawals worth $\frac{S}{1+\eta}$ can be met. Since withdrawing investors each receive π_1 at $t = 1$ and the fund is always solvent to meet these redemptions, we have $\underline{N} \equiv \frac{S}{(1+\eta)\pi_1}$. Since, $\eta_T < \eta_C$, a treated fund can meet more withdrawals without liquidating the risky asset than a control fund, $\underline{N}_T > \underline{N}_C$.

We turn to the payoff of investors staying in the fund at $t = 1$. The cumulative return of the risky asset, of which the funds holds $1 - S$, is $R_1 R_2(\theta)$ at $t = 2$. With few withdrawals, some liquid asset remain at $t = 2$, $S - (1 + \eta)N\pi_1$. All proceeds of the fund are shared among the remaining $1 - N$ investors. Thus, the payoff at $t = 2$ to investors staying with the fund at $t = 1$ is

$$\pi_2(\theta, N) \equiv \frac{(1 - S)R_1 R_2(\theta) + S - (1 + \eta)N\pi_1}{1 - N}. \tag{1}$$

The net payoff from not withdrawing is $v(\theta, N) \equiv \pi_2(\theta, N) - \pi_1$. The condition $\eta_C < \frac{(1-S)R_1(R_2(\theta)-1)}{\pi_1}$ suffices for the net payoff from not redeeming to *increase* in the proportion of all investors withdrawing, $\frac{dv}{dN} > 0$, for $N \leq \underline{N}$. In other words, more withdrawals are good for non-withdrawing investors as long as withdrawals are small enough (strategic substitutability). Intuitively, more withdrawals have two opposing effects. First, the funds returned at $t = 2$ are shared with fewer investors, which increases the incentives to wait. Second, more withdrawals lead to some liquidation costs (for control funds) borne by non-withdrawing investors, which increases the incentives to withdraw. For a low liquidation cost, the first effect dominates.

Case 2: many withdrawals ($\underline{N} < N$)**.** In this case, all liquid assets are exhausted and the residual amount required to meet redemptions, $N\pi_1 - \frac{S}{1+\eta}$, triggers costly liquidation of risky assets, forgoing the return R_2. The payoff to non-withdrawing investors is

$$\pi_2(\theta, N) \equiv \frac{(1-S)R_1 R_2(\theta) - (1+\lambda)\left(N\pi_1 - \frac{S}{1+\eta}\right) R_2(\theta)}{1-N}. \tag{2}$$

Thus, there is strategic complementarity among investors once the risky asset is liquidated, $\frac{dv}{dN} < 0$, so the incentive to withdraw increases in the proportion of investors withdrawing.

Taken together, there is one-sided strategic complementarity in the withdrawal incentives of investors. If the fundamental θ were commonly known at $t = 1$, we obtain dominance bounds that solve $R_2(\underline{\theta}) = 1$ and $R_2(\overline{\theta}) = \frac{(1-\overline{N})\pi_1}{(1-S)R_1[1-(1+\lambda)\overline{N}]+S(1+\lambda)\left(\frac{1}{1+\eta}-\overline{N}\right)}$.[5] That is, an investor strictly prefers to withdraw for $\theta < \underline{\theta}$ even if no other investor withdraws, $N = 0$. Similarly, an investor prefers to stay for $\theta > \overline{\theta}$ even if all other investors withdraw, $N = \overline{N}$.

We use the global-game methods proposed by Goldstein and Pauzner (2005) to obtain a unique equilibrium. Specifically, the fundamental of the fund θ is not common knowledge at $t = 1$. Instead, each investor i receives a noisy signal

$$\theta_i = \theta + \epsilon_i, \tag{3}$$

[5] Note that $\overline{\theta} > \underline{\theta}$ is ensured by a small enough share of liquid assets, $S < \frac{1+\eta}{\lambda-\eta}\lambda\overline{N}\pi_1$, which we assume henceforth.

where $\epsilon_i \sim \mathcal{U}[-\epsilon, \epsilon]$ is an i.i.d. noise term that is also independent of θ. For example, all investors see some common information about the fund but have slightly different interpretations of it, generating different assessments captured by θ_i.

We derive the equilibrium in the Appendix and obtain the following hypotheses.

Hypothesis 1 *Funds with access to liquid assets are less fragile. As a result, treated funds experience smaller outflows in response to risk exposures during the debt limit episode than control funds.*

Intuitively, funds that have access to liquid assets do not incur the cost of liquidation during the debt limit episode. Investors who withdraw are initially served by liquidating (i.e. not renewing) ONRRP, which is costless. Thus, these investors do not impose a negative externality on investors who stay in the (treated) fund. In contrast, investors who withdraw from funds without access to a liquid asset cause some liquidation costs and thus impose a negative externality on investors who stay in the (control) fund. As a result, a fund with access to a liquid asset can meet more redemptions before having to liquidate the risky asset.

When redemptions impose a negative externality on other investors, an investor's withdrawal incentive increases in the proportion of withdrawing investors. This generates self-fulfilling redemptions. Since treated funds are less exposed to this mechanism, they are less fragile. Moreover, the expected outflows of treated money fund responds less to risk exposures during the debt limit episode than control funds, because treated funds can meet redemptions by not rolling over ONRRPs at no liquidation cost and are therefore less subject to strategic complementarities.

We next describe how the magnitude of fund fragility depends on investor sophistication.

Hypothesis 2 *Fund fragility increases in the degree of investor sophistication. Moreover, the access to a liquid asset reduces fragility by more when investor sophistication is high.*

Investor sophistication is modeled as the fraction of investors making a redemption decision $\overline{N}$ (while the remainder is passive), following Schmidt et al. (2016). Its empirical counterpart is the share of institutional investors (as opposed to retail investors). For the range of redemptions in which liquidation is costly, a larger proportion of active investors increases a given investor's concern about other investors withdrawing, causing a negative externality. This increases a given investor's incentive to redeem and, as a result, the higher degree of strategic complementarity in redemption decisions raises fund fragility. Since access to a liquid asset reduces the degree of these redemption complementarities, the impact of the liquid asset is higher for a larger share of sophisticated investors.

Finally, we turn to the expected liquidation volume of money funds.

Hypothesis 3 *Funds with access to a liquid asset liquidate less in expectation. That is, treated funds maintain more of their lending to riskier corporate borrowers during the debt limit episode than control funds.*

Intuitively, treated funds liquidate fewer of their risky assets than control funds in expectation, which is for two reasons. First, if Hypothesis 1 holds, treated funds are less fragile, so large-scale redemptions occur less often for treated funds. Second, for any given amount of redemptions, the amount liquidated is lower because the access to a liquid asset reduces the cost of liquidation. Both effects combine and result in lower average liquidations by treated funds. In other words, treated funds maintain more lending to riskier borrowers during the debt limit episode than control funds.

3 Data and Background

In this section we introduce the dataset and provide some background on the 2013 debt limit episode in the U.S. and the ONRRP facility offered by the Federal Reserve. Our dataset is the result of merging four different sources: iMoneyNet weekly data, N-MFP month-end filings, MSPD reports, and confidential daily ONRRP data.

First, iMoneyNet contains weekly data on assets under management and yields at the share-class level, and fund-level data on asset holdings and liquidity measures. Money funds offer rights (shares) on the same pool of assets to different investors (retail and institutional), with differing fee structures. At the fund level, asset holdings are broken down in several categories, including Treasuries, agency debt, repos, domestic and foreign bank obligations, first-tier and second-tier commercial paper, and asset-backed commercial paper. As a measure of fund profitability, we use the annualized gross yield. As a measure of fund liquidity, we use the percentage of assets with residual maturity of seven days or less.

Second, N-MFP month-end filings contain information on the assets held by each fund as of the last business day of the month. We use this information to compute the percentage of assets invested in at-risk Treasuries, namely the Treasury securities that are at risk of delayed payments during the 2013 debt limit episode. To identify the specific Treasury securities with principal or interest payments at risk of being delayed (October 17 to November 22), we use information from the third dataset, the monthly statement of the public debt (MSPD) available on TreasuryDirect.

Debt limit episode. The debt limit is a limit on the amount of money that the U.S. government can borrow from the public. Once reached, Congress has the option to suspend the debt limit until a later date. However, if Congress does not act in time, the Treasury can invoke a debt issuance suspension period (DISP) which makes certain extraordinary measures to borrow additional funds available (typically, withholding transfers to certain government trust funds). These extraordinary measures, together with the current cash balances are used to meet current payments. Usually, the Treasury Secretary informs Congress about the date at which the extraordinary measures are expected to run out (the "breach date").

In May 2013, after the previous debt limit suspension expires, Treasury Secretary Lew declares a DISP and starts using extraordinary measures to meet federal obligations (Cashin et al. 2017, Austin 2019). Secretary Lew indicates on August 2 that the extraordinary measures can be extended to last until October 11, in light of stronger fiscal revenues. On August 26, he updates Congress that the extraordinary measures would be exhausted in mid-October. Then, in a September 25 communication, Treasury indicates that it expects to exhaust its borrowing capacity on October 17, at which point it would have only $30 billion in cash to meet current obligations. When Congress could not pass a budget deal and on September 30, the government shuts down. This acts as a wake-up call to markets that the standoff in Congress may even delay a timely resolution of the debt limit. As a result, yields on Treasury securities with payments shortly after October 17 increase (see Figure 1). On October 16, in the third week of the shutdown, Congress passes a budget deal that includes the suspension of the debt limit, ultimately putting an end to the debt limit episode.

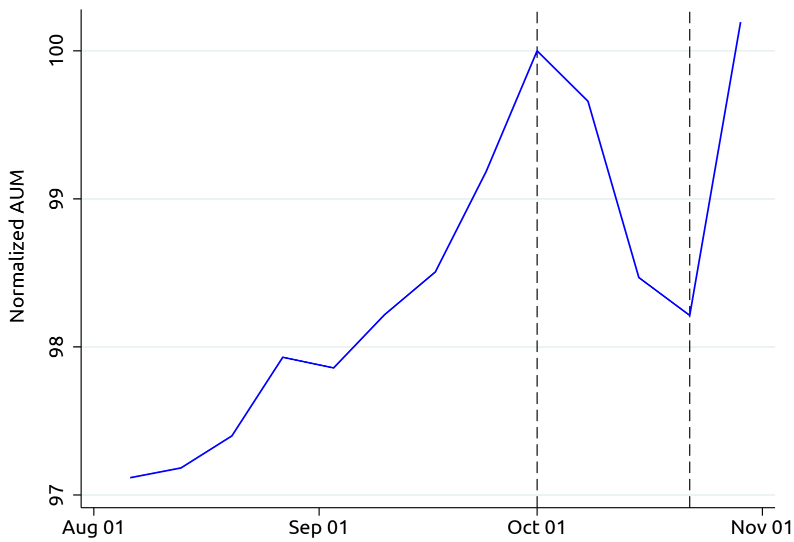
ONRRP. As the final data source, we use confidential fund-level investments (take-up) at the ONRRP facility operated by the New York Fed. At the July 2013 FOMC meeting, participants discussed the possibility of offering reverse repos to a broad set of cash investors, such as money market funds (Frost et al. 2015). With ONRRP access, a money fund can lend cash overnight to the New York Fed and obtain Treasuries as collateral. Historically, the Federal Reserve has conducted open market operations, including repos and reverse repos with Treasury and agency collateral, with the primary dealers. The purpose of enlarging the set of ONRRP counterparties from the usual set of primary dealers to include money market funds is unrelated to possible developments surrounding the 2013 debt limit. Instead, its purpose was to test the extent of interest rate control in light of a possible future tightening of monetary policy (Frost et al. 2015, Ihrig et al. 2015). Daily ONRRP operations start on September 23, 2013. Initially, the offered interest rate is one basis point and the individual cap is $500 million. The offered rate increases to two basis points on October 21, 2013 as a way of testing both the sensitivity of take-up to rate changes and the extent of interest rate control. The individual cap is raised to $1 billion on September 27, 2013 and stays at that level for the rest of our sample.

During mid-2013 the overall U.S. Money fund industry manages about $3.2 trillion, with $1.9 trillion in prime funds and $1 trillion in government (agency and Treasury) funds. In this paper, we focus solely on prime money funds due to their ability to invest in a wider range of debt instruments, which is crucial to meaningfully measure their extent of risk-taking. Government money funds, on the other hand, can only invest in government debt and repos backed by government debt. Panel A of Table 1 shows some statistics for the sample of all prime funds surrounding the 2013 debt limit episode. As also shown in Figure 3, prime funds' flows turn from mildly positive prior to October 2013 to negative during the debt limit episode. Risk exposures are mechanically smaller in the pre-stress period because at the beginning of that period some at-risk bills were not issued yet. Other variables tend to be quite stable around the debt limit episode.

Table 1: **Summary statistics: pre-crisis vs crisis.** The sample is at the fund-week level. AUM is the assets under management of the fund, in $ billion. Flows is the weekly percentage change in the fund's AUM. Yield is the gross annualized yield in basis points. Mat7d is the percentage of the fund assets maturing in 7 days or less. Repo and Treasuries are the percentage of assets invested in repos and Treasuries, respectively. AtRisk is the percentage invested in at-risk Treasuries, namely those Treasuries with principal or interest payments between October 17 and November 22, 2013. Prime Risk is the percentage invested in ABCP, foreign bank obligations, and second-tier CP. Panel A includes all prime funds while Panels B and C include only the prime funds in Sample 2 (repo-capable prime funds with AUM between $4 and $8 billion); those in the treatment group are ONRRP counterparties while those in the control group are not.

	Pre-crisis (Jul 1 – Sep 30)					Crisis (Oct 1 – Oct 16)				
	Obs.	Mean	St.Dev.	p(25)	p(75)	Obs.	Mean	St.Dev.	p(25)	p(75)
Panel A: All Prime Funds										
AUM	2046	7.93	18.71	0.34	6.52	462	8.19	19.36	0.37	6.92
Flows	2046	0.05	4.40	-0.95	0.89	462	-0.21	3.96	-1.13	0.85
Yield	2045	18.78	5.28	16	23	462	18.60	5.22	15	22
Mat7d	2025	42.09	16.68	33	47	458	41.40	15.62	33	46
Repo	2046	12.93	12.60	4	18	462	13.64	12.92	4	19
Treasuries	2046	4.78	6.75	0	8	462	4.88	7.49	0	7
AtRisk	2037	0.87	1.65	0	1.34	462	1.79	5.08	0	2
PrimeRisk	2046	25.07	15.20	13	36	462	24.62	14.62	15	35
Panel B: Treatment Group, Sample 2 (12 funds)										
AUM	130	5.45	1.67	3.71	6.59	36	5.22	2.22	3.37	6.86
Flows	130	-0.15	2.90	-1.06	0.51	36	-0.53	3.92	-1.75	0.74
Yield	130	19.95	3.95	17	22	36	19.67	3.30	17	22
Mat7d	130	35.2	12.98	30	42	36	36.31	10.32	32	44
Repo	130	13.07	10.63	6	21	36	13.72	9.70	7.5	18
Treasuries	130	5.76	4.43	0	10	36	5.89	4.23	1.5	9.5
AtRisk	130	1.20	1.42	0	2.71	36	1.21	1.31	0	2.43
PrimeRisk	130	29.92	10.65	26	37	36	30.58	9.85	28	36
Panel C: Control Group, Sample 2 (8 funds)										
AUM	112	5.53	1.36	4.17	6.75	24	5.80	1.37	4.83	6.96
Flows	112	1.18	6.05	-1.03	2.85	24	-1.34	3.58	-2.29	0.43
Yield	112	22.23	3.04	20	24	24	22.38	3.44	19	25
Mat7d	112	40.58	9.41	33	44	24	40.42	9.12	32	45.5
Repo	112	7.36	6.01	0	11	24	6.21	5.60	0	11
Treasuries	112	2.05	2.65	0	4	24	3.67	5.39	0	4
AtRisk	112	0.39	0.73	0	0.54	24	0.5	0.77	0	1.04
PrimeRisk	112	33.84	17.31	24	47	24	33.75	16.59	27	46.5

Figure 3: **Prime funds' assets around the 2013 debt limit episode.** This figure shows the evolution of prime funds' assets under management (AUMs) around the 2013 debt limit episode. Prime AUMs in blue are normalized to equal 100 on Oct 01, 2013, the beginning of the debt limit episode period. The first and second vertical dashed lines represent the beginning of the debt limit episode (Oct 01, 2013) and the first day in the post-debt limit episode period (Oct 22, 2013), respectively.



3.1 From the Theory to the Data

A necessary ingredient for run risk in our theoretical framework is the presence of illiquid assets, namely assets that incur a liquidation cost if sold before maturity. On the other hand, if held to maturity, these assets would return principal and interest. This is exactly what happened to at-risk Treasury bills during the 2013 debt limit episode. Treasury bills are issued at a discount from par and return the par value at maturity. In 2013, short-term rates were close to zero and consequently T-bills were trading close to par. During the 2013 debt limit crisis, markets priced in the possibility that some T-bills could experience delays in the repayment of principal and interest. As a result, their prices dropped and their yields spiked, as shown in Figure 1. If prime funds had to raise significant amounts of cash at short notice to accommodate large redemptions, they may have needed to sell at-risk Treasuries at a loss, potentially breaking the buck. This is the equivalent of the potential liquidation cost in the theoretical model.

The concept of liquidation cost is broader than that of secondary market liquidity. This is because money funds break the buck if the market value of their assets falls below $0.995 per share. Thus, when liquidating an asset, the money fund only cares about the price it gets relative to the purchase price, not whether a low price is due to increased credit risk or lower secondary market liquidity (higher bid-ask spread).

To elucidate the point, take for example a money fund investing all its money in a 4-week T-bill. T-bills are issued at a discount from par and return the par value at maturity. Assume that the money fund issued 9.9 million shares, each at $1 a share and invested the $9.9 million solely in 4-week T-bills that return $10 million in 4 weeks. If all goes well, the money fund will return $0.1 million as dividends in 4 weeks to investors so as to maintain its $1 per share value throughout the period. However, if investors redeem money at the second week mark, the money fund has to sell its T-bills on the secondary market. Under normal circumstances and with stable short term rates, the 4-week bills with 2 weeks to maturity would sell for $9.95 million, allowing the money fund to return $1 per share and total dividends of $0.05 million. Alternatively, suppose that we are in the middle of a debt limit crisis and that 4-week bills are trading at significant discount from par. Now the money fund can only get $9.7 million by selling its bills, resulting in its shares being valued at $0.98 a share. The fund broke the buck.

From this example we can see that all that the money fund manager cares about is the price at which she can sell the bills back to dealers in the secondary market. It does not matter whether the bid and ask are \$100 and \$97 (no credit risk and wide bid-ask spread) or \$97.2 and \$97 (significant credit risk and narrow bid-ask spread). In either cases, the money fund manager sells the bills at \$97 and is able to recover the same \$9.7 million. During the 2013 debt limit episode, secondary market liquidity in T-bills remained elevated (bid-ask spreads obtained from CRSP stayed narrow), while at-risk bills trade at a significant discount, as shown in Figure 1 by the sharp increase in yields. We define liquidity as the ease of immediately turning an asset into cash at no liquidation cost. In that sense, at-risk bills became illiquid during the debt limit episode.

4 Identification and Results

We start by describing the construction of the main variables as well as the control and treatment groups. On October 1, 2013, a week after the ONRRP facility started its daily operations, the U.S. federal government shutdown begins and Treasury reaffirms that extraordinary measures would be exhausted no later than October 17, the breach date. At that point, with no additional borrowing capacity, Treasury would only have about \$30 billion to meet current payments. The shutdown serves as a wake-up call to markets that Treasury securities with principal or interest payments due soon after October 17, 2013 could enter a technical default due to a delay in payments until new legislation would suspend the debt limit. The Treasury securities that display spikes in yields following October 1, 2013 are those with either principal or interest payments due between October 17 and November 22, 2013, as shown in Figure 1. We refer to these Treasuries as at-risk Treasuries. While they are fully fungible with other Treasury bills prior to October 1, they become a source of risk for money funds at the onset of the debt limit episode (as they sell at a discount).

We first analyze at the fund level how the sensitivity of outflows to at-risk Treasuries depends on whether or not a fund has access to the ONRRP facility. Since ONRRP counterparties are different from other funds, we restrict our sample to funds that are essentially identical other than for the fact that some are ONRRP counterparties while others are not.

Even though daily ONRRP operations start on September 23, 2013, the New York Fed had previously conducted a few test operations with some eligible money funds. From February 1, 2011 onwards, the most stringent initial eligibility criteria are as follows: a fund needs to have assets under management (AUM) of no less than $5 billion for the most recent six months (measured at each month-end) and it has to be a consistent investor in the triparty repo market. The last date prior to October 2013 in which money funds could apply to become counterparties is in September 2012.[6] We then restrict our sample of ONRRP counterparties, the treatment group, to prime money funds with AUM between $5 and $10 billion as of September 30, 2013. On the other hand, our control group consists of prime money funds that did not satisfy the two above-mentioned requirements in 2012 but do so in September 2013 and, at the same time, report AUM between $5 and $10 billion as of September 30, 2013. Funds belonging to the control group would have applied to become ONRRP counterparties in 2013 had they been allowed to do so. Indeed, virtually all of these funds become counterparties later on once applications are allowed again in November 2014.[7]

The sample of funds in the treatment and control groups that satisfy these

[6] Information on ONRRP eligibility criteria, application deadlines, and the list of eligible funds is obtained from https://www.newyorkfed.org/markets/rrp_announcements.

[7] There is only one fund in the control group that is not a counterparty in 2014. This is because the fund's AUM declines to just below the minimum AUM requirement sometime between October 2013 and November 2014 and therefore loses its eligibility.

requirements we call "Sample 1". For robustness, we use two additional samples with different AUM windows: "Sample 2" keeps funds capable of triparty repo transactions and AUM between \$4 and \$8 billion; "Sample 3" keeps funds capable of triparty repo transactions and AUM between \$5 and \$8 billion. Therefore, money funds in both treatment and control groups have similar size as of September 2013 and are both able to operate on the triparty repo platform. This last feature is important because some prime money funds purposefully decide not to invest in triparty repos as they seek exposures to maturity and counterparty risk to boost yields, and repos limit such exposures. As a result, requiring the control group to consist of money funds that additionally invest in triparty repos implies that we are comparing money funds with similar risk profiles. As a precaution, we still control for lagged yield and size.

Panels B and C of Table 1 provide summary statistics for the treatment and control groups in Sample 2. Relative to funds in the control group, those in the treatment group have 2 basis points lower yields in part due to their greater allocations to repos (13% instead of 7%) and slightly lower allocations to riskier assets (30% average PrimeRisk for the treated funds istead of 34% for the control funds). Treated funds have higher average exposures to at-risk Treasuries relative to control funds, which, if any, works against our finding that treated funds are less sensitive to risk exposures. Using public N-MFP data, we estimate that the average allocation to ONRRP of all the ONRRP-eligible prime funds is 3.2% of assets, while the average allocation for the treated funds in Sample 2 is 4.7%, out of a total allocation to repo of 13%. Due to the well documented month-end deveraging in Treasury repos by foreign dealers (Anbil and Senyuz 2018, Munyan 2017), the month-end allocations to ONRRP by money funds overestimate the average allocations throughout the month.

We acknowledge that in our setting, as in many other studies, there is a tradeoff between identification and sample size. In our case, we prefer to have a cleaner identification that relies on funds in the control group being virtually ONRRP-eligible had there been an application window in 2013. Since this requires picking funds around or just above the $5 billion eligibility threshold, the cleaner identification comes at the cost of a relatively small sample size.

4.1 Fund fragility and run-risk

Under **Hypothesis 1**, funds with access to a liquid asset are less sensitive to risk exposures. To assess whether the ONRRP facility reduces the sensitivity of flows to risk exposures, we run the following panel regression at the fund level:

$$\begin{aligned} Flow_{i,t} = {} & \beta_1 AtRisk_{i,t-1} + \beta_2 Treat \cdot AtRisk_{i,t-1} + \beta_3 Crisis \cdot AtRisk_{i,t-1} \\ & + \beta_4 Treat \cdot Crisis \cdot AtRisk_{i,t-1} + \gamma X_{i,t-1} + \mu_i + \mu_t + \varepsilon_{i,t} \end{aligned} \tag{4}$$

where $Flow_{i,t}$ is the weekly percentage change in AUM at the fund level, $AtRisk_{i,t-1}$ is the percentage of the fund's assets invested in Treasury securities with either principal or interest payments scheduled between October 17 and November 22, 2013.[8] $Treat$ equals one for prime funds in the treatment group, while the omitted group consists of prime funds in the control group (both described above). $Crisis$ equals one during the 2013 debt limit episode (October 1 to October 16, 2013). $X_{i,t-1}$ is a set of lagged controls that include gross simple yields (Yield), the logarithm of the fund's AUM

[8] Data regarding the fund-specific exposure to at-risk Treasuries comes from end-of-month N-MFP reports. For each fund, $AtRisk_{i,t-1}$ is constant within the month. We use its lag so as to incorporate information that pertains to the month that just ended. N-MPF reports are published with some delay. However, investors can inquire with a money fund whether they have exposures to at-risk Treasuries. In addition, money funds hold their assets to maturity for the most part. As a result, investors can infer the September holdings of at risk Treasuries by looking at the August or July holdings (since most Treasury bills have maturities greater than one or two months) .

(Size), the fund's weighted average maturity of assets (WAM), and the share of assets invested in Treasuries.

We control for yields to allow for a well-documented flow-performance feedback, whereby past performance influences current flows (Ippolito 1992, Sirri and Tufano 1998, Del Guercio and Tkac 2002, Chen et al. 2010, Goldstein et al. 2017). We also allow for size effects, even if our treatment and control groups are already of similar size by construction. Next, we control for the fund's WAM since it is a proxy for the maturity risk taken by the fund. One may argue that funds with higher risk exposures are those that generally hold more Treasury securities. To account for the heterogeneity in Treasury holdings so that our results come from the actual Treasuries at risk of delayed payments and not the overall investments in Treasuries, we control for the share of assets invested in Treasuries. Finally, μ_i and μ_t are a set of fund and week fixed effects that control for unobserved fund characteristics and aggregate shocks, respectively. Errors are clustered at the fund family level. If risk exposures drive outflows during the debt limit episode, we expect $\beta_3 < 0$. In addition, if access to the ONRRP facility insulates flows from risk exposures we expect $\beta_4 > 0$.

Consistent with **Hypothesis 1**, the provision of liquid assets reduces the sensitivity of outflows to risk exposures. Indeed, Table 2 shows that during the debt limit episode, funds with access to the ONRRP facility are significantly less sensitive to risk exposures than similar funds without such access. For instance, in column (4) the additional sensitivity of outflows to risk exposures during the crisis is -1.7 for the control group, while it equals 0.3 $(2 - 1.7)$ for the treatment group. Both the sensitivity of the control group and the incremental sensitivity of the treatment group are statistically significant at the 5% level.

In terms of economic magnitude, an interquartile range increase in risk exposures

Table 2: **Flows sensitivity around the 2013 debt limit.** The sample contains information on prime funds at the fund-week level and goes from July 1 to October 16, 2013. Sample 1 keeps funds capable of repo transactions, with AUM between $ 5 and $ 10 billion as of September 30, 2013; Sample 2 keeps repo-capable funds with AUM between $ 4 and $ 8 billion as of September 30, 2013; finally, Sample 3 keeps repo-capable funds with AUM between $ 5 and $ 8 billion as of September 30, 2013. The dependent variable, Flows, is the weekly percentage change in the AUM of a fund. Crisis equals one from October 1, 2013 to October 16, 2013. Treat equals one if a fund is an ONRRP counterparty. AtRisk is the lagged percentage of assets invested in at-risk Treasuries. Controls is a set of lagged controls, including gross yields, log of AUM, WAM, and the share of assets invested in Treasuries. Fund and week fixed effects are included in all regressions. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Sample 1		Sample 2		Sample 3	
	Dependent variable: Flows					
Crisis · AtRisk	-3.074***	-1.317*	-2.286***	-1.724**	-3.142***	-1.603**
	(0.290)	(0.669)	(0.518)	(0.773)	(0.351)	(0.733)
Crisis · Treat · AtRisk	3.091***	1.620**	2.269***	2.035***	3.043***	1.821**
	(0.321)	(0.627)	(0.469)	(0.689)	(0.356)	(0.650)
N	331	331	302	302	246	246
R^2	0.102	0.136	0.115	0.152	0.139	0.168
Controls	No	Yes	No	Yes	No	Yes

during the debt limit crisis leads to additional outflows by 1.7 percentage points in the control group ($-1.7 \cdot 1$), which is equivalent to 60% of the interquartile range of outflows for the control group (2.7). On the other hand, the same increase in risk exposures leads to an insignificant and small increase in flows for the treatment group (10% of the interquartile range of flows for the treatment group). The estimated elasticities vary somewhat across samples and specifications, but in all of them the additional elasticity of the treatment group fully offsets the negative sensitivity of the control group. In other words, having access to liquid assets isolates fund flows from risk exposures, reducing fund fragility.

Each money fund can manage its assets on behalf of both retail and institutional investors, the latter being more active and risk sensitive (Schmidt et al. 2016) in their decisions to allocate cash to money funds. We account for this heterogeneity in investor behavior in Table 3, by splitting money fund flows between retail and in-

Table 3: **Flows sensitivity: institutional vs retail.** The sample contains information on prime funds at the share-class-week level and goes from July 1 to October 16, 2013. Samples 1, 2 and 3 are defined as in Table 2. The dependent variable, Share-Class Flows, is the weekly percentage change in the AUM of a fund's share class (retail or institutional). Retail and Instit identify retail and institutional share-classes, respectively. Crisis equals one from October 1, 2013 to October 16, 2013. Treat equals one if a fund is an ONRRP counterparty. AtRisk is the lagged percentage of assets invested in at-risk Treasuries. Controls is a set of lagged controls, including gross yields, log of AUM, WAM, the share of assets invested in Treasuries. Fund, institutional, and week fixed effects are included in all regressions. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Sample 1		Sample 2		Sample 3	
	Dependent variable: Share-Class Flows					
Retail · Crisis · AtRisk	-2.464***	-2.563**	-0.754*	-0.529	-2.192***	-1.497
	(0.441)	(1.118)	(0.388)	(0.713)	(0.412)	(0.916)
Retail · Crisis · Treat · AtRisk	2.718***	2.834***	1.070***	0.879	2.588***	1.956**
	(0.290)	(0.944)	(0.299)	(0.630)	(0.366)	(0.865)
Instit · Crisis · AtRisk	-5.395***	-5.846***	-2.204**	-2.766***	-4.914***	-4.975***
	(0.595)	(1.001)	(0.881)	(0.772)	(0.448)	(0.396)
Instit · Crisis · Treat · AtRisk	6.086***	7.186***	2.590**	3.635***	5.537***	6.260***
	(0.560)	(0.930)	(0.934)	(0.991)	(0.384)	(0.610)
N	966	966	834	834	658	658
R^2	0.032	0.038	0.038	0.046	0.044	0.056
Controls	No	Yes	No	Yes	No	Yes

stitutional share-classes. Consistent with **Hypothesis 2**, the results of Table 3 show that the sensitivities of outflows to risk exposures are two to three times larger for institutional investors relative to retail ones. Moreover, the reduced sensitivity to risk exposures in the treatment group is more pronounced for the more sophisticated institutional investors. These results are consistent with the model's mechanism, whereby a larger share of active investors increases the degree of strategic complementarity in investor redemption choices, while access to a liquid asset reduces it.

4.2 Intermediation to risky borrowers

We next ask how access to a liquid asset affects the degree of intermediation to risky corporate borrowers during stress episodes. As before, we focus on prime funds since, differently from government funds, they invest in a wide range of instruments with various risk profiles. Prime funds indeed provide both secured and unsecured funding to banks, dealers, and non-financial corporations.

We build a weekly prime-fund-specific measure of risk-taking, called $PrimeRisk$, by adding up the portfolio shares of asset-backed commercial paper (ABCP), second-tier commercial paper (A2/P2), and foreign bank obligations (FBO). The latter are unsecured certificates of deposit issued by foreign banks. These three investment classes are considered the riskiest and least liquid investments available to prime funds.[9] To estimate the differential effect of exposure to at-risk Treasuries on risk-taking for treated and control funds, we run the following regression:

$$\begin{aligned} PrimeRisk_{i,t} = {} & \beta_1 AtRisk_{i,t-1} + \beta_2 Treat \cdot AtRisk_{i,t-1} + \beta_3 Crisis \cdot AtRisk_{i,t-1} \\ & + \beta_4 Treat \cdot Crisis \cdot AtRisk_{i,t-1} + \gamma X_{i,t-1} + \mu_i + \mu_t + \varepsilon_{i,t} \end{aligned} \tag{5}$$

where all variables other than $PrimeRisk$ are defined in Section 4.1. As before, errors are clustered at the fund family level. **Hypothesis 3** predicts that funds exposed to at-risk Treasuries would reduce lending to risky borrowers by less if they have access to the ONRRP facility ($\beta_3 < 0$, $\beta_4 > 0$), i.e. maintaining more lending to the real economy.

Table 4 shows that larger risk exposures are associated with significantly more intermediation to risky borrowers for ONRRP counterparties relative to the funds in the control group ($\hat{\beta}_3 < 0$, $\hat{\beta}_4 > 0$). The estimated elasticities in Samples 1 and 3 are of similar magnitudes, while those pertaining to Sample 2 are significantly lower

[9] See Covitz et al. (2013), and Kacperczyk and Schnabl (2013) regarding the riskiness of ABCP, and Chernenko and Sunderam (2014) regarding the run on Eurozone banks, a very large part of the foreign banks issuing FBOs. Second-tier commercial paper is the lowest quality of commercial paper that money funds can invest in by SEC rules.

Table 4: **Risk taking around the 2013 debt limit.** The sample contains information on prime funds at the fund-week level and goes from July 1 to October 16, 2013. Samples 1, 2 and 3 are defined as in Table 2. The dependent variable, Prime Risk, is the percentage of assets invested in ABCP, foreign bank obligations, and second-tier CP. Crisis equals one from October 1, 2013 to October 16, 2013. Treat equals one if a fund is an ONRRP counterparty. AtRisk is the lagged percentage of assets invested in at-risk Treasuries. Controls is a set of lagged controls, including gross yields, log of AUM, WAM, and the share of assets invested in Treasuries. Fund and week fixed effects are included in all regressions. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Sample 1		Sample 2		Sample 3	
	Dependent variable: Prime Risk					
Crisis · AtRisk	-4.932***	-5.228***	-1.471	-1.275	-5.158***	-6.266***
	(0.338)	(0.850)	(0.990)	(1.066)	(0.378)	(0.721)
Crisis · Treat · AtRisk	5.170***	5.408***	1.637*	1.519*	5.154***	6.172***
	(0.187)	(0.678)	(0.830)	(0.770)	(0.217)	(0.525)
N	331	331	302	302	246	246
R^2	0.962	0.962	0.963	0.963	0.970	0.971
Controls	No	Yes	No	Yes	No	Yes

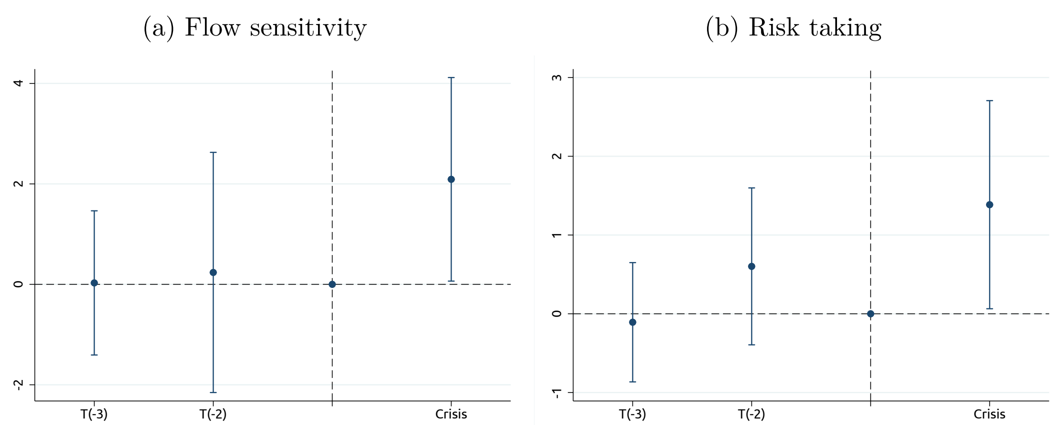
in absolute value. Nevertheless, the relevant finding is that, across all specifications, the additional coefficient for the treatment group during the crisis ($\hat{\beta}_4$) fully offsets the negative effect of risk exposures on risk-taking for the control group ($\hat{\beta}_3$).

Economically, the intermediate estimates of Sample 1 (column (2)) suggest that an interquartile range increase in risk exposures (1.6 for Sample 1) during the debt limit episode leads to a decline in $PrimeRisk$ by 8 percentage points ($1.6 \cdot 5.2$), which is equivalent to 40% of the interquartile range of $PrimeRisk$ for the control group (20 for Sample 1). On the other hand, the same increase in risk exposures leads to a negligible and statistically insignificant increase in $PrimeRisk$ for the treatment group (3% of the interquartile range of $PrimeRisk$ for the Sample 1 treatment group). This suggests that the ONRRP facility enables its money funds counterparties to continue intermediating liquidity even to the riskier borrowers during periods of stress, especially when such stress is not due to an impairment in these borrowers' creditworthiness. Recall that the shock is to the safety of Treasuries instead, resulting in liquidation cost in the stress episode. In sum, the ONRRP facility supports lending to risky borrowers during a stress episode, consistent with the model's prediction.

4.3 Robustness checks

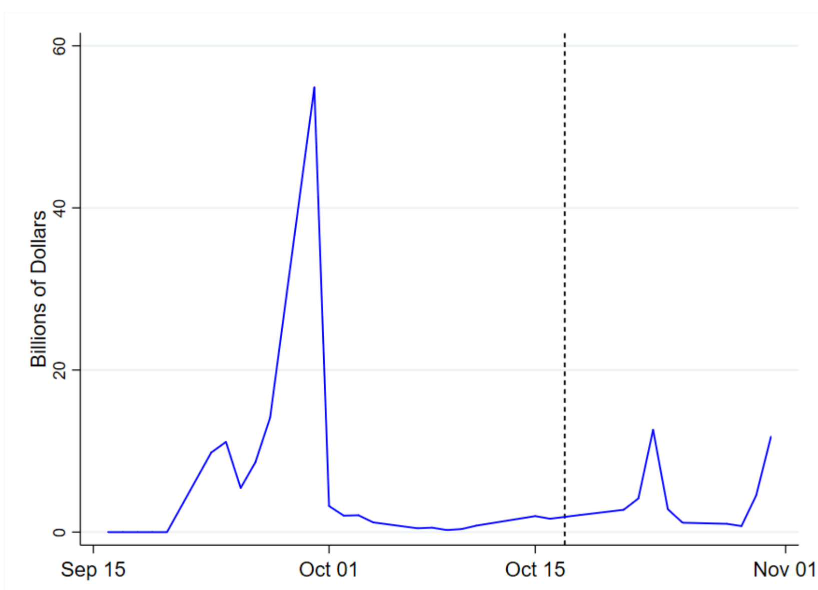
In this section we seek to alleviate concerns that our findings may be driven by alternative channels. Specifically, we check for parallel trends; provide more evidence for the lack of a flight to ONRRPs during the 2013 debt limit episode; mitigate concerns regarding the endogeneity of risk exposures; conduct some placebo tests exploiting the 2011 debt limit episode which occurred pre-ONRRP; and finally show that the sensitivity to flows to at-risk Treasuries is not solely driven by fund illiquidity.

Figure 4: **Flow sensitivity and risk taking, parallel trends.** This figure shows selected coefficients from the estimation of Equation (4), with the additional variables $T(-3) \times AtRisk$, $T(-2) \times AtRisk$, $T(-3) \times Treat \times AtRisk$, and $T(-2) \times Treat \times AtRisk$. By dividing the eight pre-crisis weeks in four subperiods, $T(-2)$ and $T(-3)$ are indicator variables for the two intermediate pre-crisis subperiods (Borusyak and Jaravel 2017). The dependent variables are Flows in panel (a) and Prime Risk in panel (b). In each panel, the first two coefficients represent the additional sensitivity of flows to risk exposures for treated funds in the two intermediate subperiods of the pre-crisis period, $T(-3) \times Treat \times AtRisk$ and $T(-2) \times Treat \times AtRisk$. The omitted groups in the pre-crisis period, represented by the vertical dashed line, are the first two and the last two weeks pre-crisis. The additional flow sensitivity for the treated funds during the crisis, $Crisis \times Treat \times AtRisk$, is represented by the last coefficient. The insignificance of the first two coefficients suggests a lack of pre-trends in the sensitivity of flows to risk exposures.



Our results are not driven by pre-existing trends that continued over the debt limit episode. Indeed, following Borusyak and Jaravel (2017), Figure 4 shows that the parallel trends assumption seems to hold in the data. Specifically, in panel (a) the sensitivity of flows to at-risk Treasuries is not significantly different between treated and control funds before the 2013 debt limit episode unfolds (the vertical dashed line). Notice that the at-risk Treasuries are not risky before the start of the debt limit episode, as shown in Figure 1. Similarly, in panel (b) the significantly greater lending to riskier counterparts in response to risk exposures for funds in the treated group only materializes at the onset of the debt limit episode.

Figure 5: **ONRRP Take-up around the 2013 debt limit.** This figure shows the total ONRRP take-up by money funds (both government and prime) around the 2013 debt limit episode. The vertical dashed line represents Oct 17, 2013, the "breach date". ONRRP take-up remains low during the debt limit episode. The spike in take-up on September 30 is completely unrelated to the debt limit episode. On the contrary, it is explained by the window dressing behavior of foreign dealers (Anbil and Senyuz 2018, Munyan 2017). Some foreign implementations of the Basel III supplementary leverage ratio are computed using only quarter-end snapshots, and some foreign dealers deleverage on those reporting dates by reducing their triparty treasury repo borrowings. Money funds respond to the lack of demand by foreign dealers at quarter-end by increasing investments at the ONRRP. As foreign dealers return to the repo market the following day, ONRRP take-up declines accordingly.



The fact that treated funds maintained lending to riskier borrowers during the debt limit episode is also evident from the dynamics of aggregate ONRRP take-up shown in Figure 5. Apart from the quarter-end spike in take-up that is solely due to foreign dealers' window dressing behavior (Anbil and Senyuz 2018, Munyan 2017) which forces money funds to place additional cash at the ONRRP, take-up remains low and flat during the debt limit episode.[10]

Moreover, in Table 5 we show the results of regressing the share of assets invested in ONRRPs on at-risk Treasuries and other controls, for the subset of prime money funds with access to the facility. Before the debt limit episode, at-risk Treasuries, which at that point are not risky yet, are not significantly associated with ONRRP take-up. During the episode, funds with more risky exposures display higher ONRRP take-up, even though the additional effect is not statisitically significant. This suggests that indeed there was no clear flight to the ONRRP facility during the debt limit episode.

The 2013 debt limit episode unfolded during the early stages of the ONRRP facility and, at that time, funds faced an individual ONRRP cap of $1 billion, significantly smaller than the more recent $30 billion individual cap. However, for the prime funds in our treatment groups (with assets between $4 and $10 billion), the cap is actually a sizable fraction of assets, and none of these funds ever reaches the cap during the debt limit episode.

Next, Tables 6 and 7 mitigate additional concerns regarding the selection of at-risk Treasuries by riskier funds or less sophisticated funds. Table 6 shows that

[10]Foreign dealers subject to Supplementary Leverage Ratio (SLR) implementations that require reporting of quarter-end balance sheet snapshots drop their treasury repo borrowings at quarter-ends in order to display less leverage. As they deleverage, they demand less repo funding from money funds, which in turn place the surplus cash at the ONRRP facility (Anbil and Senyuz 2018).

Table 5: **Determinants of ONRRP take-up.** The daily sample contains information on the prime funds that are Fed counterparties at the fund-day level and goes from September 23 (beginning of ONRRP) to October 16, 2013. Crisis goes from October 1, 2013 to October 16, 2013. The weekly sample uses weekly averages of the variables used in the daily sample. The dependent variable, ONRRP/AUM, is the share of fund's assets invested in ONRRP. Crisis equals one from October 1, 2013 to October 16, 2013. AtRisk is the lagged percentage of assets invested in at-risk Treasuries. Time FE refers to daily dummies for the daily sample and weekly dummies for the weekly sample. Controls is a set of lagged controls, including gross yields, log of AUM, WAM, and the share of assets invested in Treasuries. Fund and time fixed effects are included in all regressions. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Dep. var.: ONRRP/AUM			
Crisis · AtRisk	0.842	0.791	0.522	0.516
	(0.529)	(0.588)	(0.316)	(0.397)
N	646	646	190	190
R^2	0.168	0.190	0.254	0.297
Controls	No	Yes	No	Yes
Sample	Daily		Weekly	

Table 6: **Persistence of risk exposures across episodes.** The sample is a cross-section of all prime funds. We regress the share of at-risk Treasuries each fund held prior to the 2013 debt limit episode on the share of at-risk securities it held during the 2011 episode. Specifically, the dependent variables are the share of securities at risk during the 2013 episode held in July 2013 (columns (1) and (2)), August 2013 (columns (3) and (4)), and September 2013 (columns (5) and (6)). Columns (1), (3), and (5) employ OLS estimators while columns (2), (4), and (6) use a Tobit model, with the dependent variable left-censored at zero. The marginal effects of the Tobit models are displayed in the bottom two rows of the table. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	(OLS)	(Tobit)	(OLS)	(Tobit)	(OLS)	(Tobit)
Dep. var.:	$\text{AtRisk}_{jul'13}$		$\text{AtRisk}_{aug'13}$		$\text{AtRisk}_{sep'13}$	
$\text{AtRisk}_{jul'11}$	0.094	0.148	0.103	0.203	0.005	0.186
	(0.081)	(0.170)	(0.090)	(0.210)	(0.104)	(0.359)
N	156	156	156	156	156	156
	Tobit: marginal effects					
$dP(y>0)/dx$		0.017		0.019		0.008
		(0.018)		(0.020)		(0.016)
$dE(y \mid y>0)/dx$		0.045		0.062		0.055
		(0.051)		(0.063)		(0.105)

the probability of holding at-risk Treasuries during the 2013 debt limit episode is uncorrelated with how many at-risk Treasuries a fund held during the 2011 debt limit episode.[11] The zero correlation between risk exposures in the two debt limit episodes

[11]The main timeline of the 2011 debt limit episode is as follows: the debt limit episode starts on July 14, 2011 when Moody's puts the U.S. government on review for a downgrade, at which point

Table 7: **Determinants of 2013 risk exposures.** The sample is a cross-section of prime funds: in columns (1) and (2) we keep all prime funds while in columns (3) and (4) we keep prime funds with AUM greater than $5 billion. We regress the share of at-risk Treasuries each fund held at the end of September 2013 on several lagged regressors: Treasuries is the percentage of assets invested in Treasuries; FED CP is a dummy equal to one if a fund is an ONRRP counterparty; Yield is the gross yield in basis points; Flows is the weekly percentage change in the fund's AUM; Prime Risk is the percentage invested in ABCP, foreign bank obligations and second-tier CP; finally, WAM is the fund's weighted average maturity of its assets. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Dependent variable: AtRisk			
Treasuries_{t-1}	0.313***	0.263***	0.208***	0.183***
	(0.102)	(0.079)	(0.021)	(0.024)
FED CP	-0.728	-0.544	0.055	0.131
	(0.476)	(0.468)	(0.293)	(0.303)
Yield_{t-1}		-8.754*		-3.111
		(5.047)		(2.986)
Flows_{t-1}		0.026		0.043
		(0.048)		(0.034)
PrimeRisk_{t-1}		-0.017		-0.015
		(0.026)		(0.012)
WAM_{t-1}		0.050*		0.010
		(0.028)		(0.011)
N	156	156	47	47
R^2	0.198	0.214	0.658	0.691
Sample	All Prime		Prime, AUM> 5 bln	

mitigates the concern that our results could be driven by selection bias, whereby funds with better managerial skills consistently stay away from at-risk Treasuries– which would imply a positive correlation. The zero correlation is also inconsistent with the possibility that funds with higher 2011 exposures subsequently reduce their 2013 exposures, as this learning would lead to a negative correlation.

Next, Table 7 documents that the only fund-level characteristic that is significantly correlated with at-risk Treasury holdings is the overall amount of Treasuries held: the coefficients show that on average around 20% of Treasury holdings are made

yields on at-risk Treasuries start to increase. The date on which Treasury's borrowing capacity would be exhausted (the breach date) is August 2, 2011. Exactly on that date, the debt limit is resolved with a budget resolution that increases the debt limit. The Treasuries whose pricing is affected by the 2011 debt limit are those with either principal or interest payments between the August 2 breach date and the expected resolution date of September 9. Those are the at-risk Treasuries for the 2011 debt limit episode.

up of at-risk Treasuries. This is not surprising and is consistent with the fact that an ex-ante random portion of a money fund's Treasury holdings becomes risky during the debt limit episode. In addition, liquidating such risky Treasuries would not have been worthwhile as they were trading at fire-sale prices that might have caused significant losses if sold (see Figure 1). Notice that we control for the lagged share of Treasury holdings in our main findings of Tables 2, 3, and 4. Importantly, Table 7 also shows that risk exposures are not correlated with the status of being an ONRRP counterparty, nor with our measure of risk-taking by prime money funds, $PrimeRisk$.

The lower flow sensitivity of ONRRP counterparties previously documented in Tables 2 and 3 could be due not just to the provision of liquid assets by the ONRRP facility, but also to an "imprimatur" or certification effect. That is, the perception that ONRRP counterparties could be safer than other funds just because the Federal Reserve has approved them as trading counterparties. In order to disentangle the two effects, we exploit the 2011 debt limit episode and compare the flow sensitivity of funds that were ONRRP counterparties in 2011 with that of other funds. Notice that in 2011 the Federal Reserve did not conduct daily ONRRP operations, but only infrequent test operations with some eligible money funds. These 2011 counterparties were therefore approved by the Federal Reserve, but they did not have access to ONRRP investments during the 2011 debt limit episode, making this the ideal laboratory to test for an imprimatur effect. Specifically, the imprimatur hypothesis predicts that the flow sensitivity to risk exposures is lower for ONRRP counterparties than for other funds, even if the former cannot take advantage of ONRRP investments. The 2011 debt limit unfolded in a similar fashion as the 2013 episode (see footnote 11). On July 14, 2011 Moody's puts the U.S. government on a downward review and yields on Treasuries with payments between the August 2 breach date and September 9 are

Table 8: **Imprimatur Effect (?) and Placebo (2011).** The sample includes information on all prime funds at the fund-week level and goes from May 3 to August 2, 2011. The dependent variable, Flows, is the percentage change in a fund's AUM. During the 2011 episode considered in this table, Crisis goes from July 14, 2011 to August 2, 2011. Treat '11 identifies funds that belong to the New York Fed reverse repo counterparty list as of May 2011 (the same prime funds appear in the July 2011 list). Similarly, Treat '13 identifies funds that are ONRRP counterparties around the 2013 debt limit episode. AtRisk is the percentage of assets invested in Treasuries with principal or interest payments at risk of being delayed (between August 2 and September 9, 2011). Controls is a set of lagged controls, including gross yields, log of AUM, WAM, and the share of assets invested in Treasuries. Fund and week fixed effects are included in all regressions. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Dependent variable: Flows			
Crisis · AtRisk	0.172*	0.175*	0.0761	0.0566
	(0.093)	(0.097)	(0.199)	(0.212)
Crisis · Treat '11 · AtRisk	-0.381***	-0.304***		
	(0.111)	(0.111)		
Crisis · Treat '13 · AtRisk			-0.642*	-0.442
			(0.331)	(0.315)
N	2548	2545	2548	2545
R^2	0.078	0.083	0.081	0.089
Controls	No	Yes	No	Yes

affected. These are the at-risk Treasuries for the 2011 episode. The debt limit episode that started on July 14 is then resolved by Congress exactly on the breach date.

In Table 8, columns (1) and (2) show that the sensitivity of outflows to risk exposures is higher for the 2011 ONRRP counterparties than for other funds. Thus, we find evidence against the imprimatur effect. The main results of Tables 2 and 3 are then likely driven by the availability of a liquid asset to ONRRP counterparties. Finally, the placebo regressions in columns (3) and (4) dismiss any additional concern that the results in Table 2 are due to the fact that those funds that in 2013 are ONRRP counterparties intrinsically have flows that are less sensitive to risk exposures. Indeed, columns (3) and (4) show that, if any, the funds that in 2013 are ONRRP counterparties are more sensitive to risk exposures during the 2011 debt limit episode.

Several studies have shown that the illiquidity of fund assets may drive outflows or amplify the effect of shock on outflows during a crisis (Chen et al. 2010, Goldstein et al. 2017, Falato et al. 2021). A clarification is in order. While we refer to the liquidity of an asset as the property of returning cash at short notice without incurring significant liquidation costs, the overall liquidity of a money fund refers to its ability to convert assets into cash in a short period of time. To account for the possibility that the overall liquidity of the fund may have an outsized effect during the debt limit crisis, we additionally control for the crisis-specific effect of the share invested in liquid assets, namely assets that can be readily converted into cash at little to no discount.

We use three different measures of fund liquidity. First, we use the share of assets invested in Treasuries (Tsy), since these assets have by far the most liquid secondary markets among the assets available to prime money funds. Notice that by including both the share assets invested in at-risk Treasuries ($AtRisk$) and the share of assets invested in all Treasuries (Tsy), the latter captures the share of Treasuries that are not at risk of delayed payments and thus did not trade at a large discount. Second, we control for the share of assets maturing within seven days ($Mat7d$).[12] Third, we control for the weighted average maturity of the fund (WAM), which measures how quickly on average the fund assets turn into cash. By controlling for both fund liquidity and its interaction with the crisis indicator, in Table 9 we show that our results are not driven by the overall liquidity of the fund.

In unreported results, we show that the pre-crisis liquidity of a fund is not by itself driving outflows during the debt limit crisis and that the main result, namely

[12]This is not exactly the same as the share invested in weekly liquid assets as defined by the SEC, which is only available after the 2014 money market reform (Li et al. 2021). The latter is defined as the share of assets that mature within 7 days, as well as Treasury securities and selected agency debt maturing within 60 days.

the differential sensitivity of outflows to at-risk Treasuries, is driven by funds with a below-the-median pre-crisis share of assets maturing within 7 days (less liquid funds). These findings indicate that fund liquidity is not by itself the trigger of outflows, but instead it may amplify the effect of shocks on fund flows, which is consistent with some of the literature. For instance, Goldstein et al. (2017) estimate that the response of corporate bond fund flows to bad performance if amplified in less liquid funds. Generally, the actual trigger of outflows is the fund exposure to a crisis-specific risk, such as exposures to at-risk Treasuries in the current context, ABCP in the 2008 financial crisis (Duygan-Bump et al. 2013) and European bank obligations in the 2011 Eurozone crisis (Chernenko and Sunderam 2014, Gallagher et al. 2020).

4.4 External Validity

The reader may wonder whether our findings still apply to money funds after they underwent a series of reforms or whether they are general enough to apply to different types of shocks. Irrespective of the regulatory stance, it seems that all the recent runs on prime money funds share a similar characteristic (Bouveret et al. 2022): once the market identifies a certain risk, investors run more strongly on the funds with higher risk exposures.[13] While each crisis has different risk factors, the run mechanics are the same. Investors want their money back to avoid being the last investor holding their cash in a fund that is incurring losses.

Regulations have attempted to stop runs on money funds but to no avail (Li et

[13]In 2008, investors ran more strongly on funds with larger exposures to Lehman Brothers' commercial paper and asset-backed commercial paper (McCabe 2010, Kacperczyk and Schnabl 2013, Duygan-Bump et al. 2013); in 2012, during the European sovereign debt crisis, the risk came from exposures to European banks' short-term debt (Chernenko and Sunderam 2014, Ivashina et al. 2015, Gallagher et al. 2020); and finally in 2020, during the Covid-19 liquidity crisis, the risk originated from the possibility that money funds could impose gates and fees on investor redemptions (Li et al. 2021).

Table 9: **Flow sensitivity: risk exposures or liquidity.** The sample contains information on prime funds at the fund-week level and goes from July 1 to October 16, 2013. Sample 1 keeps funds capable of repo transactions, with AUM between $ 5 and $ 10 billion as of September 30, 2013; Sample 2 keeps repo-capable funds with AUM between $ 4 and $ 8 billion as of September 30, 2013; finally, Sample 3 keeps repo-capable funds with AUM between $ 5 and $ 8 billion as of September 30, 2013. The dependent variable is Flows, the weekly percentage change in the AUM of a fund. Crisis equals one from October 1, 2013 to October 16, 2013. Treat equals one if a fund is an ONRRP counterparty. AtRisk is the lagged percentage of assets invested in at-risk Treasuries. In columns (1), (4), and (7) we control for lagged Tsy, the share of assets invested in all Treasuries, and its interaction with Crisis; in columns (2), (5), and (8) we control for lagged Mat7d, the share of assets maturing within a week, and its interaction with Crisis; and in columns (3), (6), and (9) we control for lagged WAM, the weighted average maturity of assets, and its interaction with Crisis. Fund and week fixed effects are included in all regressions. Standard errors clustered at the family level in parentheses; ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Sample 1			Sample 2			Sample 3	
	Dependent variable: Flows								
Crisis·AtRisk	-1.795***	-2.572***	-2.817***	-2.802***	-2.236***	-2.484***	-2.860***	-2.812***	-3.267***
	(0.451)	(0.388)	(0.713)	(0.483)	(0.429)	(0.661)	(0.889)	(0.481)	(0.398)
Crisis·Treat·AtRisk	2.478***	2.712***	3.257***	2.843***	2.377***	2.629***	3.059***	2.793***	3.218***
	(0.417)	(0.642)	(0.292)	(0.481)	(0.445)	(0.420)	(0.522)	(0.690)	(0.268)
Crisis·Tsy	-0.210***			-0.000			-0.072		
	(0.068)			(0.130)			(0.150)		
Crisis·Mat7d		-0.016			-0.007			-0.013	
		(0.058)			(0.059)			(0.058)	
Crisis·WAM			-0.060			0.019			0.034
			(0.165)			(0.104)			(0.125)
N	331	331	331	302	302	302	246	246	246
R^2	0.106	0.115	0.122	0.118	0.126	0.131	0.145	0.147	0.152

al. 2021). Short of requiring money funds to invest only in ONRRPs or introducing an insurance scheme, it seems impossible to entirely prevent runs (Bouveret et al. 2022). Money fund investors want immediate access to their cash and do not tolerate the chance of incurring losses. The 2014 SEC reform that allowed prime funds to impose gates and fees on redemptions backfired and actually exacerbated the 2020 run on prime funds (Li et al. 2021). The newly proposed rule by the SEC posits that swing pricing will deter investors from running. However, swing pricing acts just like a contingent fee, and investors are going to try to preempt it, just as they preempted gates and fees during the 2020 Covid-19 crisis. In sum, the run incentives identified in our paper are likely to be still relevant for money markets, despite recent regulations.

5 Conclusion

We study how access to liquid assets affects the fragility and lending behavior of financial intermediaries. We first develop a global-game model of investor redemptions from money market mutual funds that hold publicly provided liquid assets and lend to risky corporate borrowers. Since the liquid asset can be liquidated at no cost, access to it reduces the fragility of the fund and allows it to maintain more lending to the real economy. The model highlights a mechanism whereby liquid asset reduce the redemption incentives of investors because of a lower negative externality imposed on other investors and, thus, a lesser concern about the redemptions of other investors.

Next, we turn to the data and find evidence in support of the model's implications. We use the staggered introduction of the Federal Reserve's ONRRP facility and the 2013 U.S. debt limit episode as our empirical laboratory. This timing allows us to compare similar money funds that only differ in their access to a liquid asset (the ONRRP), while there is a shock to the liquidation costs of some Treasury securities. In sum, access to the ONRRP reduces the run-risk of money funds in response their exposure to at-risk Treasuries and allows these funds to keep funding more risky corporate borrowers during this stress event. Access to liquid assets by financial intermediaries does not come at the cost of increased funding risk for the ultimate borrowers.

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A.1 Equilibrium and deriving the hypotheses

There is a unique equilibrium characterized by a threshold θ^*, whereby each investor withdraws if and only if $\theta_i < \theta^*$ (threshold strategy). Since we heavily rely on Goldstein and Pauzner (2005), we only sketch the proof here, going through a few key steps. Let $\alpha \in [0, 1]$ be the proportion of investors withdrawing (out of $\overline{N}$): $N \equiv \overline{N}\alpha$. First, given the realized θ and the threshold θ^* (to be determined), we have

$$N(\theta, \theta^*) = \overline{N} \begin{cases} 1 & \theta \leq \theta^* - \epsilon \\ \frac{1}{2} + \frac{\theta^* - \theta}{2\epsilon} & \text{if} \quad \theta^* - \epsilon \leq \theta \leq \theta^* + \epsilon \\ 0 & \theta \geq \theta^* + \epsilon \end{cases} \tag{6}$$

by a law of large numbers. Also note that $2\epsilon d\alpha = -d\theta$, which we will use later.

Second, the payoff difference is $v(\theta, N) = \pi_2 - \pi_1$ for each of the two cases, where v is continuous at $\underline{N}$. The posterior is $\theta|\theta_i \sim \mathcal{U}[\theta_i - \epsilon, \theta_i + \epsilon]$, so the expected payoff difference is

$$\Delta(\theta_i, \theta^*) \equiv \int_{\theta_i - \epsilon}^{\theta_i + \epsilon} v(\theta, N(\theta, \theta^*)) \frac{d\theta}{2\epsilon}. \tag{7}$$

The threshold equilibrium implies that $\Delta(\theta^*, \theta^*) = 0$. Changing the variable of integration from θ to α, using $2\epsilon d\alpha = -d\theta$, and taking the limit of $\epsilon \to 0$ (that we impose henceforth) yields the run threshold θ^* implicitly defined by $f(\theta^*) = 0$, where

$$\begin{aligned} 0 = f(\theta^*) &= \int_0^{\underline{N}/\overline{N}} \frac{(1-S)R_1(R_2(\theta^*) - 1) - \eta\pi_1\alpha\overline{N}}{1 - \alpha\overline{N}} d\alpha + \cdots \\ &\cdots + \int_{\underline{N}/\overline{N}}^1 \left(\frac{R_2(\theta^*)}{1 - \alpha\overline{N}} \left[(1-S)R_1 + S\frac{1+\lambda}{1+\eta} - (1+\lambda)\alpha\overline{N} \right] - \pi_1 \right) d\alpha \end{aligned} \tag{8}$$

$$\begin{aligned} \frac{df(\theta^*)}{d\theta^*} &= \int_0^{\underline{N}/\overline{N}} \frac{(1-S)R_1R_2'}{1 - \alpha\overline{N}} d\alpha + \int_{\underline{N}/\overline{N}}^1 \left(\frac{R_2'}{1 - \alpha\overline{N}} \left[(1-S)R_1 + S\frac{1+\lambda}{1+\eta} - (1+\lambda)\alpha\overline{N} \right] \right) d\alpha > 0 \\ \frac{df(\theta^*)}{d\eta} &= -\int_0^{\underline{N}/\overline{N}} \frac{\pi_1\alpha\overline{N}}{1 - \alpha\overline{N}} d\alpha - \int_{\underline{N}/\overline{N}}^1 \frac{R_2(\theta^*)}{1 - \alpha\overline{N}} S \frac{1+\lambda}{(1+\eta)^2} d\alpha < 0. \end{aligned} \tag{9}$$

The implicit function theorem yields $\frac{d\theta^*}{d\eta} > 0$ and is the basis for our first hypothesis.

Specifically, $\eta_T < \eta_C$ implies

$$\theta_T^* < \theta_C^*. \tag{10}$$

In words, treated funds (T) are less fragile than control funds (C), which is the first part of Hypothesis 1. The model also has implications for how the expected outflows, EO, respond to the higher liquidation cost of at-risk Treasuries, namely η, during the debt limit crisis. The probability of a run is $\Pr\{\theta < \theta^*\} = \frac{\theta^*+B}{2B}$ and the proportion of investors withdrawing (for $\epsilon \to 0$) is $N(\theta, \theta^*) = \overline{N}\,\mathbf{1}_{\{\theta<\theta^*\}}$. Expected outflows are then $EO \equiv \overline{N}\Pr\{\theta < \theta^*\} = \overline{N}\frac{\theta^*+B}{2B}$. Thus, $\frac{dEO}{d\eta} > 0$ whenever $\frac{d\theta^*}{d\eta} > 0$, which always holds. This yields the second part of Hypothesis 1.

Moreover, $R_1 < 1 + \lambda$ (to ensure strategic complementarity) suffices for $\frac{d\theta^*}{d\overline{N}} > 0$ at $S = 0$. Therefore, under the additional condition described below, we obtain

$$\frac{d\theta^*}{d\overline{N}} > 0, \tag{11}$$

which is the basis of our second hypothesis. This condition is a small enough S. The latter is consistent with our weekly sample from June 2013 to January 2014: the liquid asset share is 16% (median) with a standard deviation of 13%, where this share is Treasuries and repos as a fraction of AUM.

Finally, we calculate the expected liquidation volume at $t = 1$. Using the results above, the amount liquidated for $\theta < \theta^*$ is $(1 + \lambda)\left(\overline{N}\pi_1 - \frac{S}{1+\eta}\right)$. Taken together, the expected liquidation volume is $ELV \equiv \frac{\theta^*+B}{2B}(1 + \lambda)\left(\overline{N}\pi_1 - \frac{S}{1+\eta}\right)$, which is lower for treated funds and is the basis of our third hypothesis.

$$ELV_T < ELV_C. \tag{12}$$