Liquidity Restrictions, Runs, and Central Bank Interventions: Evidence from Money Market Funds

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Abstract

Liquidity restrictions on investors, like the redemption gates and liquidity fees introduced in the 2016 money market fund (MMF) reform, are meant to improve financial stability. However, we find evidence that such liquidity restrictions exacerbated the run on prime MMFs during the Covid-19 crisis. Our results indicate that gates and fees could generate strategic complementarities among investors in crisis times. Severe outflows from prime MMFs led the Federal Reserve to intervene with the Money Market Mutual Fund Liquidity Facility (MMLF). Using MMLF micro-data, we show how the provision of "liquidity of last resort" stabilized prime funds.

JEL classification: G23, G28, E58.

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1 Introduction

Prime money market funds (MMFs) offer cash-like shares that are redeemable on demand while investing in relatively illiquid securities, such as commercial paper (CP) and negotiable certificates of deposit (CDs). This liquidity transformation may result in run-like behaviors in crisis times. As the 2008 financial crisis revealed the fragility of prime MMFs to investor redemptions, the Securities and Exchange Commission (SEC) introduced two sets of reforms aimed at making prime MMFs capable to withstand stress without the need for emergency interventions. In particular, the reform adopted by the SEC in 2014 and implemented in 2016 allowed prime MMFs to impose redemption gates and liquidity fees on their investors once their weekly liquid assets (WLA), namely the share of assets that convert into cash within a week, fall below 30%.[1] As argued by then-SEC Chair Mary Jo White, redemption gates and liquidity fees would "mitigate [the run] risk and the potential impact for investors and markets."[2]

However, the possibility that MMFs may impose gates and fees when their WLA falls below a certain threshold could introduce additional strategic complementarities among investors, above and beyond those intrinsic to liquidity transformation. Indeed, to accommodate investor redemptions, a MMF usually draws down its WLA. As a result, the expectation that other investors will withdraw money and drive WLA below the 30% threshold may incentivize them to run *preemptively* before such liquidity restrictions are imposed. Such incentives are consistent with the global games literature on bank runs (Rochet and Vives, 2004; Goldstein and Pauzner, 2005; Schmidt, Timmermann and Wermers, 2016). Echoing this concern, SEC Commissioner Kara Stein questioned whether gates and fees were the right tool to address run risk. She noted that allowing funds to impose gates and fees "could actually increase an investor's incentive to redeem," especially in a crisis.[3]

In this paper, we study the anatomy and drivers of the run on prime MMFs during

[1]Henceforth, we refer to this reform as the 2016 MMF reform.
[2]See https://www.sec.gov/news/public-statement/2014-07-23-open-meeting-statment-mjw.
[3]See https://www.sec.gov/news/public-statement/2014-07-23-open-meeting-statement-kms.

the Covid-19 crisis to understand whether the WLA-contingent redemption gates and liquidity fees introduced by the 2016 reform may have exacerbated the run. When concerns over the coronavirus escalated in early March, MMF investors, in particular institutional ones, started to run on prime MMFs. During the two weeks from March 9 to March 20, institutional prime MMFs lost about 30% of their assets under management (AUMs), with outflows more severe among funds with lower WLAs.

Consistent with the notion that WLA-contingent gates and fees introduce additional strategic complementarities among investors, we find that the sensitivity of outflows to funds' WLAs increases substantially during the Covid-19 crisis. Relative to normal times, a one-standard-deviation decrease in WLA is associated with a one-percentage-point increase in daily outflows during the crisis (one third of average daily outflows during the crisis). In addition, outflows accelerate significantly as funds' WLAs approach the 30% regulatory threshold.

Our findings are corroborated by anecdotal evidence and industry reports. The president of Crane Data (a money fund research firm) stated that the 30% threshold has become the most important metric tracked by institutional prime investors. In a March 2020 report to clients, Blackrock called the WLA ratio an "amber flashing light" for investors. They wrote that "*the fear of the imposition of a liquidity fee or redemption gate* essentially converted the 30% WLA threshold to a new 'break the buck' triggering event for investors."[4] Fitch Ratings echoed the same sentiment, stating that investors' attention is all about funds' WLAs.[5]

Given that WLA is also a measure of fund liquidity, a possible concern is that it is asset illiquidity and not the possible imposition of gates and fees that drives our results. If that were the case, a fund's daily liquid assets (DLA), namely the share of assets that covert into cash within a day, would seem more likely to drive outflows in a crisis than WLA would, as investors might be more interested in knowing how much liquidity a

[4]See source: Lessons from COVID-19: U.S. short-term money markets.
[5]See source: Fed's money market move lifts Northern Trust fund above key threshold.

fund can raise overnight rather than later in the week.[6] However, we find no evidence that DLA drives outflows during the crisis. Since the option to impose gates and fees is only tied to WLA, our results suggest that it is the distance to the 30% cutoff on WLAs that serves as a coordination device in the Covid-19 run. Further, we find no evidence of acceleration of outflows as WLA approaches 30% during the 2008 financial crisis, when prime MMFs experienced similar outflows but were not subject to gates and fees regulations. This finding also supports the view that the fear of a possible imposition of gates and fees, rather than asset illiquidity, drives the Covid-19 run on MMFs.

We explore a number of alternative explanations for our findings. First, we study the potential impact of other regulatory changes that were introduced in the 2016 MMF reform. In particular, institutional prime funds are required to move from a stable $1 share price to a floating net asset value (NAV). To the extent that a floating NAV exposes investors to more uncertainty, this change might have also affected investor redemptions in stressed market conditions. However, we find little support for this argument, as investor outflows are not significantly related to funds' floating NAVs during the Covid-19 crisis. Second, we examine the potential impact of the riskiness of funds' portfolios on investor outflows. The emerging pandemic in March raised concerns on the credit risk of prime funds' assets, which may have affected investor decisions to redeem. Using funds' security-level holding data, we capture funds' portfolio risks by their holdings of long-term unsecured debt and long-term nonfinancial debt. Our results are robust to controlling for these portfolio risk factors. Third, we also control for the potential incremental impact of fund characteristics on flows during the crisis. Either using funds' expense ratios as a proxy for investor sophistication (Schmidt, Timmermann and Wermers, 2016) or using funds' bank affiliation as a proxy for sponsorships does not alter our results. Our results are also robust to the inclusion of fund fixed effects or using a normalized measure of WLA distance to the regulatory threshold, which captures how far a fund's WLA is from

[6] In addition to WLAs, the 2016 reform also requires MMFs to disclose their Daily Liquid Assets (DLAs). The key difference between DLA and WLA in terms of regulatory implications is that the option to impose fees and gates is only coupled with WLA.

the 30% threshold relative to the average distance in normal times.

Lastly, we employ an instrumental variable approach to directly address concerns of potential endogeneity between investor flows and funds' WLAs. We use the predetermined amount of a fund's assets that are going to mature on a given day as exogenous variation in the fund's WLA during the crisis. We find that the instrumented WLAs continue to have a significant effect on investor flows during the Covid-19 crisis. Taken together, these results reinforce the hypothesis that redemption gates and liquidity fees introduced in the 2016 MMF reform might have exacerbated the run on prime MMFs in March 2020.[7]

While the existing regulations on MMFs did not prevent the run from happening, we find that emergency interventions by the Federal Reserve were effective in boosting fund liquidity and stemming outflows. In particular, the Money Market Mutual Fund Liquidity Facility (MMLF) was launched on March 23 to allow MMFs to liquidate some of their assets to meet redemptions.[8] Using micro-level data from the MMLF, we find that securities that weigh more on MMFs' liquidity conditions (i.e., longer-term assets) are more likely to be pledged at the MMLF. In addition, funds that suffered larger declines in WLAs during the crisis relied more on the MMLF. During the two weeks following the launch of the MMLF, institutional prime funds' daily flows rebounded by about 1.5 percentage points on average. Moreover, funds with lower WLA experienced a stronger rebound in flows, suggesting that the facility was particularly beneficial to less liquid funds. To tease out the effect of the MMLF from that of other broad-based emergency facilities, we compare the flow patterns of institutional prime MMFs to those of offshore institutional USD prime MMFs. Offshore prime MMFs invest in the same

[7]It is worth noting that we focus on understanding whether the possibility of funds imposing liquidity restrictions creates incentives for investors to run ahead of other investors prior to such option becoming viable, i.e., before a fund's WLA drops below 30%. A related question is how investors and funds would respond when the 30% threshold is actually breached. Such question is challenging to analyze empirically, as only one fund (Northern Institutional Prime Obligations Portfolio) went below the 30% WLA threshold during the Covid crisis and it did not impose gates or fees. The fund continued to experience outflows and decided to close down later in July. See Online Appendix B for more details.

[8]Under the MMLF, banks could purchase high-quality CP and CDs from MMFs and pledge those assets at the MMLF as collateral for a cash loan for the whole life of the security. Economically, this is similar to banks selling the assets that they bought from MMFs to the Fed.

pool of assets (including CP and CDs) and experienced severe outflows (about 25% of AUMs) during the Covid-19 crisis, but are ineligible for the MMLF. Relative to them, domestic institutional prime MMFs had a much quicker and larger rebound in their flows following the implementation of the MMLF, suggesting that such stabilization effect can be attributed to the MMLF.

Our paper lies at the intersection of a few literatures. First, we contribute to the literature that studies runs on banks and mutual funds. On the theoretical side, Diamond and Dybvig (1983); Goldstein and Pauzner (2005); Chen, Goldstein and Jiang (2010) show how liquidity transformation creates strategic complementarities among investors, which could result in a run. On the empirical side, several papers document the run on money funds in 2008, the role of sponsor support, franchise value, and informed institutional investors (McCabe, 2010; Kacperczyk and Schnabl, 2013; Schmidt, Timmermann and Wermers, 2016), as well as how money funds depleted liquidity to accommodate redemptions (Strahan and Tanyeri, 2015).[9] The effects of the run on prime funds in 2011 are documented by Chernenko and Sunderam (2014), Ivashina, Scharfstein and Stein (2015), and Gallagher et al. (2020). Our key contribution to this strand of the literature is to identify a new run pattern driven by investors' fear of the potential imposition of gates and fees, which suggests that contingent liquidity restrictions on MMF investors can be destabilizing during a crisis.

Second, we add to the literature on the effectiveness of Federal Reserve emergency lending facilities. Several papers study the effectiveness of such facilities during the 2008 crisis (Duygan-Bump et al., 2013; Armantier et al., 2015; Acharya et al., 2017; Carlson and Macchiavelli, 2020). Most relevant for our paper, Duygan-Bump et al. (2013) study the effects of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF). Compared to Duygan-Bump et al. (2013), our analysis helps to better

[9]Relatedly, Kacperczyk and Schnabl (2010); Covitz, Liang and Suarez (2013); Pérignon, Thesmar and Vuillemey (2017); Gorton and Metrick (2012); Copeland, Martin and Walker (2014) document the funding freeze in asset-backed commercial paper (ABCP), CDs, and repurchase agreements in 2008. Also, Kruttli et al. (2021) and Jin et al. (2021) discuss redemption restrictions for hedge funds and swing pricing for corporate bond funds, respectively.

understand the mechanisms through which Fed interventions stabilize MMF flows. In particular, we identify the impact of the MMLF by comparing segments of the market that are directly targeted by the MMLF with those that are not. We also study both fund-level and security-level determinants of MMLF usage, which is useful to understand how liquidity of last resort is utilized.

Furthermore, we contribute to the discussion on the post-2008 liquidity regulations and reforms.[10] Li (2020) studies how the postcrisis liquidity regulations on MMFs and banks generate tensions and spawn reciprocal lending relationships between them. Hanson, Scharfstein and Sunderam (2015) evaluate various MMF reform proposals and recommend to require MMFs to hold capital buffers. McCabe et al. (2013) propose to require MMF investors to hold "minimum balance at risk" (MBR), a small fraction of their recent balances that could be redeemed only with a delay. Notably, McCabe et al. (2013), Cipriani et al. (2014), Hanson, Scharfstein and Sunderam (2015), and Lenkey and Song (2016) argue that redemption gates and liquidity fees could exacerbate runs on distressed MMFs (or even trigger preemptive runs). To the best of our knowledge, our paper is the first empirical study that documents the effect of the 2016 MMF reform (specifically gates and fees) on MMFs during a crisis.

2 Institutional Background

In this section we briefly describe the money market fund industry and discuss the two SEC reforms of 2010 and 2016. We then review the prime MMF run and stress in related markets around the Covid-19 crisis and provide institutional background of the MMLF.

[10] Macchiavelli and Pettit (2020) and Roberts, Sarkar and Shachar (2018) study the impact of the liquidity coverage ratio (LCR) on maturity and liquidity transformation by broker-dealers and commercial banks.

2.1 Money Market Funds and the SEC reforms

Money market funds raise cash from both retail and institutional investors by issuing shares that can be redeemed on demand. Money fund managers invest the pool of cash in a set of eligible assets. Since investors can withdraw from MMFs on demand, MMFs typically hold a diversified portfolio of high-quality short-term debt instruments. There are three broad categories of MMFs, each facing some restrictions on the types of securities that they can hold. Government funds invest in government debt (Treasury and agency debt) and repos backed by government debt. Tax-exempt funds invest in municipal and state debt. Prime funds mainly invest in high-quality short-term private debt, including time deposits, CP, and CDs, as well as repos backed by government and private collateral. As of April 2020, the money fund industry managed around $5 trillion in assets.

MMFs are an important source of short-term funding for governments, corporations, and banks (Hanson, Scharfstein and Sunderam, 2015) and, as part of the shadow banking system, play a notable role in the transmission of monetary policy (Gorton and Metrick, 2010; Xiao, 2020). The resilience of the MMF industry has profound implications for the stability of the financial system. In the aftermath of the 2008 financial crisis, during which one prime fund "broke the buck" due to its exposure to Lehman Brothers and triggered the large-scale run on prime funds (McCabe, 2010; Kacperczyk and Schnabl, 2013), the SEC introduced two sets of MMF reforms. The first reform, implemented in 2010, mandated minimum requirements for MMF liquidity buffers, tightened the limitations on the maturity of their portfolios, and enhanced the public disclosure of their holdings. One of the key requirements was that MMFs must hold at least 30% of their assets in weekly liquid assets (WLA), namely cash, Treasuries, certain agency notes that mature within 60 days, and other assets that convert into cash (mature) within one week.[11]

[11] Prior to the 2010 MMF reform, there was no minimum liquidity requirement for money funds. The 2010 reform changed that, mandating that a minimum percentage of assets be highly liquid securities. Specifically, the SEC required that all prime MMFs must have at least 10 percent of assets in cash, U.S. Treasury securities, or securities that convert into cash within one day (the "daily liquidity" requirement), and at least 30 percent in weekly liquid assets. The reform also shortened the average maturity limits for MMFs. It restricted the maximum "weighted average life" (WAL) of a fund's portfolio from unlimited to 120 days and reduced the maximum weighted average maturity (WAM) of a fund's portfolio from 90

The second reform, announced in 2014 and implemented in October 2016, primarily aimed at making MMFs less prone to runs. It introduced two main changes. First, it required non-government (i.e., prime and tax-exempt) funds catering to institutional investors to transact at a floating net asset value (NAV), which means that investors withdrawing from their MMFs may not receive $1 per share, as they almost always do under a stable NAV. Instead, they would redeem their shares based on the market value of the fund portfolio. Second, the reform allowed non-government funds to impose redemption gates and liquidity fees when the fund's liquidity buffer falls below a threshold. Specifically, if a non-government MMF's WLA falls below 30 percent of its total assets, it would be allowed to suspend redemptions for up to 10 business days in any 90-day period, and/or impose a liquidity fee of up to two percent on all redemptions.

Compared to floating NAV, gates and fees were deemed more controversial. For example, SEC Commissioner Kara Stein noted in a public statement that "as the chance that a gate will be imposed increases, investors will have a strong incentive to rush to redeem ahead of others to avoid the uncertainty of losing access to their capital." She further noted that "a run in one fund could incite a system-wide run because investors in other funds likely will fear that they also will impose gates." Amid such controversy, the SEC approved the 2016 MMF reform by a small margin, as two out of the five commissioners voted against it. In Section 4 we empirically examine whether redemption gates and liquidity fees led to preemptive runs on prime MMFs during the Covid-19 crisis.

2.2 The Covid-19 Crisis and the Money Market Mutual Fund Liquidity Facility (MMLF)

In late February, 2020, with increasing Covid-19 cases in the U.S. and Europe, major capital markets started to show signs of distress (panel (a) in Figure 1). By mid-March, conditions in short-term funding markets significantly deteriorated, with yield spreads on various short-term funding securities, including CP and CDs, surging to levels last

to 60 days.

seen during the 2008 financial crisis (panel (b) in Figure 1). Amid the broad risk-off sentiment, investors started to run on prime MMFs, which are major investors in the CP and CD markets. The run was concentrated among institutional investors (panel (a) in Figure 2), as they are more risk sensitive than retail investors (Gallagher et al., 2020). Within two weeks from March 9, $96 billion (about 30% of assets under management) were withdrawn from institutional prime MMFs.

MMFs potentially have two ways to meet investor redemptions. The first option is to tap into their liquid assets that are readily convertible into cash, and the second option is to sell longer-term holdings, such as CP and CDs. Both options had severe limitations at that time. As prime MMFs are allowed to impose redemption gates and liquidity fees on investors once the funds' liquidity buffers (i.e., WLA) fall below 30% of their assets, depleting liquidity buffers may accelerate investors' runs, fearing an imminent imposition of gates and fees. At the same time, the secondary markets for CP and CDs were essentially frozen. As the flight to liquidity emerged and MMFs pulled back from new investments in CP and CDs, the market conditions deteriorated further.

To stabilize the MMF industry and hence restore functioning in short-term funding markets, the Federal Reserve announced the establishment of the Money Market Mutual Fund Liquidity Facility (MMLF) on March 18.[12] The MMLF was created under the authority granted by Section 13(3) of the Federal Reserve Act, which allows the Federal Reserve to establish facilities with broad-based eligibility to lend to any market participant in case of "unusual and exigent circumstances". Operated by the Federal Reserve Bank of Boston, the facility provided nonrecourse loans for banks to purchase certain high-quality assets from MMFs. Banks would pledge those assets as collateral for the loans. Economically, pledging assets to the MMLF is similar to selling the assets to the Federal Reserve.[13] Initially, MMLF-eligible assets included CP as well as government

[12]For a complete timeline of the Federal Reserve interventions during the Covid-19 crisis, see Online Appendix Table A.1.

[13]The principal amount of the MMLF loan is equal to the value of the collateral. The MMLF loan is made without recourse to the borrower and has the same maturity date as the collateral. In addition, on March 19, 2020, U.S. banking regulators issued a rule that effectively neutralizes the effect of asset purchases under the MMLF on banks' capital ratios.

securities. The list of eligible assets was expanded on March 20 to include short-term municipal debt, and again on March 23 to include CDs and variable-rate demand notes. The MMLF loans are priced at a fixed spread over the Primary Credit Rate (PCR, or discount rate), depending on the type of collateral. For example, loans secured by CP and CDs are priced at PCR plus 100 basis points. Immediately following the implementation of the MMLF on March 23, runs on MMFs halted, funds' liquidity further improved (Panel (a) of Figure 3), and conditions in short-term funding markets stabilized.

3 Data

Our data come from multiple sources. To study the role of WLA-contingent gates and fees in driving the run on prime MMFs during the Covid-19 crisis, we primarily use share class level MMF information from iMoneyNet. The iMoneyNet data include multiple files with various information reported at different frequencies. We obtain the following variables from the daily file: assets under management (AUM), weekly liquid assets (WLA), daily liquid assets (DLA), and floating net asset value (NAV).[14] From the weekly file, we obtain fund yields, expense ratios, as well as funds' portfolio composition. Some additional information, such as investor type (i.e., institutional or retail), fund inception date, and bank affiliation, is retrieved from the monthly file. All share class level information from iMoneyNet is aggregated to the fund level.

We obtain MMFs' security-level holdings data from their N-MFP filings to the SEC. Each MMF is required to report its portfolio holdings as of every month-end in the N-MFP Form. For each security in their portfolios, MMFs report its CUSIP, asset type, amortized cost, market value, yield, and maturity among other characteristics. We use the security-level holding data to calculate MMFs' risk exposures and to create our instrument variable for WLA during the crisis period.

In addtion, to identify the effect of the MMLF in stemming redemptions from prime

[14] WLA, DLA, NAV information is not available before 2016, and NAV information is for institutional prime MMFs only.

MMFs (relative to similar funds not eligible to the MMLF), we obtain information on offshore U.S. dollar prime MMFs from the iMoneyNet, including AUM information from the daily file and fund characteristics from the weekly file. We also manually collect investor type information from their prospectuses. Lastly, we use confidential micro level MMLF data from the Federal Reserve. For each MMLF loan, the data contain information about the borrower (bank), transaction date, loan maturity date, the CUSIP of the collateral, the amount pledged, and the MMF that sold the collateral to the borrowing bank. Such detailed information on the actual usage of the MMLF provides additional insights into the effectiveness of the MMLF in normalizing the money market fund industry.

4 Gates, Fees, and Runs

In this section we analyze whether or not redemption gates and liquidity fees (that are contingent on WLA levels) introduced in the 2016 SEC reform exacerbate the run on prime MMFs during the Covid-19 crisis. Based on existing theories, we develop and test a set of hypotheses on investors' redemption decisions in the face of potential gates and fees. We also test and rule out a number of alternative explanations for our findings.

4.1 Hypotheses Development

Several theoretical studies model how strategic complementarities among mutual fund investors affect their redemption decisions in the spirit of Diamond and Dybvig (1983) and Goldstein and Pauzner (2005).[15] Indeed, similar to banks, mutual funds hold relatively illiquid assets while offering to investors shares that are redeemable on demand. Chen, Goldstein and Jiang (2010) and Zeng (2017) emphasize how the asset illiquidity of mutual funds could create strategic complementarities in investors' redemptions. For mutual

[15] Diamond and Dybvig (1983) model how panic-based banks runs could emerge from depositors' self-fulfilling beliefs about the actions of other depositors. Goldstein and Pauzner (2005) further show that public signals could act as a coordination device for depositors in their decisions to run.

funds holding illiquid assets, flow-induced trades cannot be all conducted on the same day of redemptions. Consequently, most of the costs imposed by redemptions are not reflected in the NAV that investors receive at the time of redemption, but rather are borne by investors who remain with the fund. As a result, investors in less liquid funds face stronger strategic complementarities and thus greater incentives to run at the first sign of stress. Schmidt, Timmermann and Wermers (2016) focus on MMF investors and show that the level of investor sophistication could magnify strategic complementarities during a crisis.

We hypothesize that the WLA-contingent redemption gates and liquidity fees introduced in the 2016 MMF reform generate additional strategic complementarities among MMF investors. Most institutional investors of prime MMFs (including corporate treasurers) are very risk averse with respect to how quickly they can monetize their MMF investments. As a result, having their investments suspended (redemption gates) or having to pay up to 2% (liquidity fees) to redeem their shares is considered impermissible. When a subset of investors rushed for cash on rising concerns about the Covid-19 shock, money funds resorted to their liquid assets to meet those redemption requests, leading to rapid declines in their WLAs. This introduces strategic complementarities among investors: the expectation that other investors will withdraw money and drive down WLAs below the 30% threshold (in which case funds can impose gates and fees on the remaining investors) increases the incentives for each investor to withdraw preemptively. This leads to our first hypothesis:

Hypothesis 1 (H1): *During the Covid-19 crisis, prime MMFs with lower WLAs experience greater outflows.*

The incentives for investors to withdraw become stronger as the strategic complementarities intensify. That is, investors have a stronger incentive to preemptively run as the fund's WLA gets closer to the 30 percent threshold that may trigger gates and fees. Therefore, a related hypothesis is:

Hypothesis 2 (H2): *Outflows accelerate as funds' WLAs approach the 30% regulatory threshold.*

One potential concern with the use of WLA to test the role of potential fees and gates in driving outflows is that WLA is also a measure of fund liquidity, which could play a key role in investors' redemption decisions in itself. Chen, Goldstein and Jiang (2010) illustrate that conditional on poor past performance, funds with more illiquid assets experience greater outflows than funds with more liquid assets. Goldstein, Jiang and Ng (2017) and Falato, Goldstein and Hortaçsu (2020) find similar empirical evidence for corporate bond mutual funds. Therefore, even if we find evidence consistent with our hypotheses H1 and H2, such evidence may be driven by fund illiquidity, rather than the proximity of fund WLA to the 30% regulatory threshold.

To disentangle the effect of potential fees and gates on investor outflows from that of the general asset liquidity conditions of the fund, we develop two additional hypotheses. First, in addition to WLA, the 2016 MMF reform also requires MMFs to disclose their daily liquid assets (DLA). DLA measures the share of an MMF's assets that could be converted to cash overnight and hence provides an important indicator of the fund's asset liquidity conditions (Chernenko and Sunderam, 2016, 2020). However, the option to impose gates and fees is only tied to WLA. Therefore, although DLA captures the fund's asset liquidity conditions, it does not serve as a coordination device as WLA does. If MMF outflows during the Covid-19 crisis are mainly driven by funds' asset liquidity conditions, we would expect DLA to drive outflows in a similar way as WLA does, or even more so since DLA summarizes how much "cash" is available on the immediate day that the redemption decision is made instead of within a week. This leads to the following hypothesis:

Hypothesis 3 (H3): *During the Covid-19 Crisis, the sensitivity of outflows to WLA is robust to controlling for the asset liquidity channel, as captured by DLA.*

Second, if the proximity of WLA to the 30% threshold introduces strategic complementarities in investor behavior, the acceleration of outflows as WLA approaches 30% should be present only after the 2016 reform. Specifically, during the 2008 financial crisis when prime MMFs also experienced a similar magnitude of outflows within a similar time window, we should not observe a greater sensitivity of outflows to WLA as the latter gets closer to 30%. Therefore, we also test the following hypothesis:

Hypothesis 4 (H4): *The acceleration of outflows as funds' WLAs approach 30% is not present during the 2008 MMF run.*

4.2 Empirical Design and Hypotheses Testing

In this section, we empirically test the hypotheses developed above. For our empirical analysis, we define a "normal" period and a "crisis" period. The crisis period starts on March 9 when large-scale investor redemptions begin and ends on March 20, the last business day prior to the implementation of the MMLF. The normal period spans one month prior to the start of the crisis, i.e., from February 6 to March 6.

To test hypothesis H1, we analyze the effect of WLA levels on MMF flows. Specifically, we use the sample of institutional prime funds that spans both the normal and the crisis periods (i.e., February 6–March 20) and estimate the following model:

$$Flow_{i,t} = \beta_1 Crisis_t + \beta_2 WLA_{i,t-2} + \beta_3 Crisis_t \times WLA_{i,t-2} + Controls_{i,t-1} + \varepsilon_{i,t}, \quad (1)$$

where $Flow_{i,t}$ is the daily percentage change in the AUM of fund i, winsorized at the 0.5% and 99.5% levels. $WLA_{i,t-2}$ is the share of WLAs in total assets for fund i on day $t-2$, which is the most recent reading available to investors on day t. $Crisis_t$ is a dummy that equals one if day t is in the crisis period (i.e., March 9–20). We also control for a battery of lagged fund characteristics as of the most recent Tuesday. First, we include a fund's abnormal gross yield to capture the potential effect of fund performance on investor flows (La Spada, 2018), particularly as past fund performance can be used by investors to infer others' propensity to redeem, thus affecting their own redemption decisions upon a negative shock (Chen, Goldstein and Jiang, 2010). Second, following Schmidt, Timmermann and Wermers (2016), we include the fund's expense ratio to capture the effect of investor sophistication on outflows during a crisis.[16] Third, we also include the fund's safe holdings (Treasury and agency debt) and risky holdings (CP and CDs), both as a share of total assets, to control for the effect of portfolio risk on outflows. Lastly, we follow Kacperczyk and Schnabl (2013) and McCabe (2010) and control for the potential effects of age, size, and bank affiliation of a fund on its flows. Standard errors are two-way clustered at the fund and day levels.

Results in Table 1 provide strong support for our hypothesis H1. While fund flows are insensitive to WLA levels during the normal period (as represented by the insignificant coefficient of WLA), the coefficient of the interaction between $Crisis$ and WLA is positive and highly significant (Column (1)), consistent with intensified flow sensitivity to fund WLA levels during the crisis period. The increase in flow sensitivity to WLA during the crisis is also economically significant. Relative to normal times, a one-standard-deviation (6.5%) decrease in WLA is associated with an additional 0.9-percentage-point increase in daily outflows during the crisis, which is about one third of average daily outflows during that period. Our results change little when we include lagged flows ($Flow_{i,t-1}$) to control for possible serial correlation in fund flows (Column (2)). Controlling for time-varying aggregate shocks does not affect our conclusion either. Indeed, the coefficient of the interaction between $Crisis$ and WLA changes little when we include day fixed effects (Column (3)).

To address the concern that our results are driven by some pre-crisis trend on the relation between fund flows and WLA, we also check for parallel trends following Borusyak and Jaravel (2017). Specifically, we divide the normal period into four weekly sub-periods and interact the third to last ($PreCrisis(-3)$) and the second to last ($PreCrisis(-2)$) with WLA. As a result, the baseline WLA coefficient is estimated on the first and last

[16]Institutional and retail prime MMFs have been separated from each other since the 2016 reform. Our sample consists of only institutional prime MMFs. Hence using investor type (i.e., institutional vs. retail) to proxy for investor sophistication does not apply to our setting.

pre-crisis weeks. The interactions of WLA with $PreCrisis(-3)$ and $PreCrisis(-2)$ test for the possibility that the sensitivity of flows to WLA begin to change before the start of the crisis. The insignificance of the pre-crisis interactions with WLA suggest that the parallel trends assumption holds in the data (Column (4)). Our results again change little when controlling for day fixed effects (Column (5)).

If investors fear the potential imposition of gates and fees when WLA falls below the 30% regulatory threshold, we should expect the sensitivity of outflows to WLA to increase when funds move closer to that threshold (i.e., hypothesis H2). To test this hypothesis, we split the WLA variable into three segments depending on whether WLA is below 40%, between 40% and 50%, or above 50%. Panel (b) of Figure 3 shows that institutional investors run more intensely on funds with lower WLAs. Although net flows were similar across funds with different levels of WLAs before mid-March, lower-WLA funds experienced substantially larger outflows during the crisis period. To control for other potential drivers of fund outflows during the crisis period, we use the same sample of institutional prime funds over the period of February 6 to March 20 and estimate the following model:

$$\begin{aligned} Flow_{i,t} = \beta_1 Crisis_t + \beta_2 WLA(\leq 40)_{i,t-2} + \beta_3 WLA(40-50)_{i,t-2} + \beta_4 WLA(>50)_{i,t-2} \\ + \beta_5 Crisis \times WLA(\leq 40)_{i,t-2} + \beta_6 Crisis \times WLA(40-50)_{i,t-2} \\ + \beta_7 Crisis \times WLA(>50)_{i,t-2} + Controls_{i,t-1} + \varepsilon_{i,t}, \quad (2) \end{aligned}$$

where $WLA(\leq 40)$ equals WLA if the fund's WLA is below or equal to 40% and zero otherwise, and WLA(40-50) and $WLA(>50)$ are similarly defined.

Results in Table 2 support hypothesis H2 that the flow sensitivity to WLA increases as WLA gets closer to the 30% threshold. Column (1) shows that the incremental sensitivity of flows to WLA during the crisis period monotonically increases as WLA gets closer to 30%. In particular, for funds with WLA below 40%, a one-standard-deviation (6.5%) decrease in WLA is associated with additional daily outflows of about 2% in the crisis period relative to normal times, which is 33% higher than the additional outflows had the fund kept a WLA above 50%. The outflow difference between the two WLA groups is economically significant as it is equivalent to about 20% of the average daily outflow during the crisis. The bottom two rows of Table 2 show the p-values of the F-tests for the equality of the coefficients of the interaction terms between $Crisis$ and WLA variables. The flow sensitivity when WLA is below 40% is statistically different from the flow sensitivity when WLA is either between 40% and 50% or above 50%. Our results change little when controlling for day fixed effects (Column (2)) or when checking for parallel trends (Column (3)).

As a robustness check, we apply a dynamic WLA partition and split the WLA variable into two segments depending on whether WLA is below or above the weekly median. Columns (4) to (6) of Table 2 show that the flow sensitivity to WLA is significantly higher for funds with below-median WLA than for those with above-median WLA.

One potential concern with the use of WLA to test the role of potential fees and gates in driving outflows is that WLA is also a measure of fund liquidity. Thus, the sensitivity of outflows to WLA could be driven by the illiquidity of fund assets instead of the potential imposition of gates and fees. To address this concern, we conduct two additional tests to understand whether it is asset illiquidity, or the redemption gates and fees, that exacerbated the run on MMFs.

First, we use an alternative measure, daily liquid assets (DLA), to capture funds' liquidity conditions. DLA measures the share of a MMF's assets that could be converted to cash overnight and hence provides an important indicator of the fund's liquidity conditions (Chernenko and Sunderam, 2016, 2020). In addition, the SEC requires MMFs to maintain at least 10% of their assets as DLA and disclose it at the same frequency as WLA. The key difference between DLA and WLA is that the potential imposition of gates and fees is only contingent on WLA.[17] If our results are indeed driven by asset

[17]Note that WLA consists of both DLA and some less liquid assets, which we refer to as WLA–DLA and mostly include CP and CDs maturing between 2 and 5 business days for prime funds. Compared to DLA, WLA–DLA should matter less to investors who are concerned with fund asset liquidity and immediate availability of their funds, as it cannot be liquidated due to essentially fronzen secondary

illiquidity, we should find similar (if not greater) flow sensitivities to DLA.

Specifically, we re-estimate Equation 1 by replacing WLA with DLA. Column (1) of Table 3 shows that DLA does not have any significant effect on fund flows during the crisis, as represented by the insignificant coefficient on the interaction between $Crisis$ and DLA. Controlling for day fixed effects does not change our conclusion (Column (2)). We also re-estimate Equation 1 by including both DLA and WLA, as well as their interactions with $Crisis$. Columns (3) and (4) of Table 3 show that the coefficient of the interaction between DLA and $Crisis$ continues to be insignificant at any conventional level, while that of the interaction between WLA and $Crisis$ is significantly positive, with similar magnitude to that in Table 1.

We also explore potential DLA effects on outflows when DLA gets closer to the 10% regulatory minimum level. Specifically, we split the DLA variable into three segments depending on whether DLA is below 20%, between 20% and 30%, or above 30%. We then re-estimate Equation 2 by replacing the three WLA variables ($WLA(\leq 40)$, $WLA(40-50)$, and $WLA(>50)$) with the three DLA variables ($DLA(\leq 20)$, $DLA(20-30)$, and $DLA(>30)$). $DLA(\leq 20)$ equals DLA if the fund's DLA is below or equal to 20%, and $DLA(20-30)$ and $DLA(>30)$ are similarly defined. We do not find supporting evidence for acceleration in outflows when DLA gets closer to 10% (see Table 4). In particular, the flow sensitivity to DLA when DLA is below 20% is not significantly different from the flow sensitivity when DLA is either between 20% and 30% or above 30% (Column (1)). Our results change little when controlling for day fixed effects (Column (2)). In Columns (3) and (4), we augment the model by including as regressors $WLA(\leq 40)$, $WLA(40-50)$, and $WLA(>50)$, as well as their interactions with the $Crisis$ dummy. We again do not find any evidence of outflow acceleration associated with DLA. More importantly, results in Columns (3) and (4) show that even after allowing for a nonlinear effect of DLA, the acceleration effect of WLA remains robust.

Altogether, the results in Tables 3 and 4 support hypothesis H3 and highlight the

markets for CP and CDs during a crisis (as was the case during the Covid-19 crisis).

role played by the potential imposition of gates and fees (rather than asset illiquidity) in exacerbating runs during the Covid-19 crisis. In addition to allowing prime MMFs to impose gates and fees when WLAs fall below 30%, the 2016 reform also requires MMFs to disclose their liquidity conditions, both DLA and WLA, on a daily basis. Therefore, our finding that investor flows respond only to WLA and not to DLA suggests that enhanced transparency on funds' liquidity is not a sufficient condition to induce runs. Nevertheless, it is still possible that the public and timely disclosure of WLA may have magnified the preemptive run incentives generated by the option to impose gates and fees. This would be consistent with the global games literature (Morris and Shin, 2004; Rochet and Vives, 2004) which shows that more precise public signals may intensify strategic complementarities in investor redemptions.

To further address the concern that fund liquidity conditions rather than gates and fees drive our results, we study the run on MMFs during the 2008 financial crisis, when MMF investors were not subject to contingent gates and fees. As before, we focus on institutional prime funds.[18] Panel (b) of Figure 2 shows that the patterns of MMF outflows during both crises are fairly similar. Despite different triggers, both runs spanned a period of about two weeks before the Fed's intervention, over which institutional prime MMFs experienced an outflow of about 30% of AUMs. They also occurred amid extremely strained conditions in the short-term funding markets. In addition, both episodes can be characterized as a flight to safety, with investors withdrawing money from prime funds and depositing them at government funds, which saw very large inflows during the same period in both crises.

As in our previous analysis, for the 2008 run we define a two-week "crisis" period from September 10 to September 19 and a "normal" period that covers the four weeks prior to the beginning of the crisis. Table 5 presents summary statistics for institutional prime MMFs around the 2008 and 2020 MMF runs. In normal times, fund size is comparable between the two episodes, with about $9 billion of AUMs for the average fund.

[18]For funds with both institutional and retail share classes, which were more common in 2008, we remove their retail share classes.

Funds displayed little pre-crisis fluctuations in their AUMs, but experienced significant redemptions during both crises. Compared to the 2008 episode, in 2020 funds have lower expense ratios, lower gross yields, and slightly higher WLAs.[19] Meanwhile, funds hold comparable shares of risky assets and have similar levels of affiliations with banks between the two episodes.

We use a sample that includes all institutional prime funds and spans both normal and crisis periods in 2008 and re-estimate Equations 1 and 2. Consistent with hypothesis H4, investor flows exhibit very low sensitivity to fund liquidity prior to the introduction of gates and fees (Table 6) in 2016. The coefficient of the interaction between WLA and $Crisis$ is 0.02 in the 2008 run (Column (1)), substantially smaller than the 0.14 coefficient estimate in 2020. Controlling for day fixed effects does not change the results (Column (2)). More importantly, investor flows do not exhibit stronger sensitivity to WLA for funds with lower WLA. (Columns (3) to (6)). The lack of acceleration in the sensitivity of outflows to WLAs during the 2008 run suggests that investors only speed up their redemptions if lower WLA are associated with a higher chance of gates and fees being imposed on investors.

Taken together, our results suggest that it is the fear of gates and fees, rather than concerns about asset illiquidity, that has exacerbated the run on MMFs during the Covid-19 crisis.

4.3 Testing for Alternative Channels

Next, we test the robustness of our results and explore a number of factors that could also potentially drive our results.

First, we consider another regulatory change that could have also affected investor redemption decisions in stressed market conditions. Specifically, in addition to the op-

[19]Note that neither the official concept of WLA nor the minimum requirement existed in 2008. We calculate the WLA for our 2008 analyses as the sum of assets maturing in seven days, Treasury securities, and government agency debt, which is the closest estimate based on the definition of WLA. Such proxy for WLA is calculated at the weekly frequency based on data availability.

tion to impose gates and fees, the 2016 MMF reform also introduced the obligation for institutional prime funds to transact at floating net asset value (NAV), with the implication that investors may not be able redeem their shares at $1 per share. As floating NAVs expose investors to more uncertainty under stressed conditions, they might have also contributed to investor outflows during the Covid-19 crisis. To address this concern, we estimate the effect of WLA on fund outflows during the crisis while controlling for floating NAV.

Specifically, we re-estimate Equation 1 by including both the fund's floating NAV and its interaction with the $Crisis$ dummy as additional explanatory variables. Column (1) of Table 7 shows that the coefficient of the interaction between NAV (measured in basis points) and $Crisis$ is not significant at any conventional level, suggesting that little role is played by floating NAV in driving outflows during the Covid-19 crisis.[20] Meanwhile, the coefficient of the interaction between WLA and $Crisis$ changes little and remains positive and highly significant (Column (1)). These results are robust to controlling for day fixed effects (Column (2)). To the extent that a fund's NAV also proxies for its performance, this analysis allows us to capture the effect of WLA on fund flows after controlling for the differential effect of performance during the crisis.

Second, we consider the potential impact of the riskiness of fund portfolios on investor redemptions. The emerging pandemic could raise concerns over the credit quality of certain assets held by money funds and lead some investors to withdraw their money. Several papers link investor redemptions to money funds' exposure to various sources of risk. For example, during the 2008 MMF run, outflows were found to be larger for funds that had exhibited greater portfolio risk (McCabe, 2010) and those with larger holdings of asset-backed commercial paper (ABCP) (Duygan-Bump et al., 2013). Gallagher et al. (2020) and Chernenko and Sunderam (2014) document stronger outflows from money

[20] One possible reason for this finding is that MMFs' NAV did not decline much during the Covid-19 crisis, while WLA for some funds fell close to or even below 30%. Indeed, among all institutional prime MMFs, the lowest NAV that a fund ever reached during the Covid-19 crisis was $0.998, while the lowest WLA was 27%. (See Online Appendix B for the case study on the fund breaching the WLA regulatory threshold.) Note that before the 2016 reform, NAV falling below $0.995 is considered as "breaking the buck" for MMFs, the occurrence of which triggered the 2008 run on prime MMFs.

funds with larger European exposures during the 2011–2012 Eurozone crisis.

To account for the potential impact of portfolio risk on investor outflows, we construct two measures of fund portfolio risk using money funds' security-level holdings data: namely, long-term unsecured debt and long-term nonfinancial debt. Long-term unsecured debt is defined as the percentage of MMF assets invested in unsecured CP and CD with remaining maturity over 30 days as of the end of February 2020. These instruments were under severe market stress (essentially frozen markets) at height of the crisis. Long-term nonfinancial debt is defined as the percentage of MMF assets invested in nonfinancial firms with remaining maturity over 30 days as of the end of February 2020. Since industries hit most severely by the pandemic are all nonfinancial ones (Falato, Goldstein and Hortaçsu, 2020), this measure is a proxy for funds' fundamental exposures to the pandemic. We re-estimate Equation 1 by including a portfolio risk measure and its interaction with $Crisis$ as additional explanatory variables. Columns (3) and (5) of Table 7 show that neither portfolio risk measure has any significant incremental effect on investor redemptions during the crisis, while WLA continues to play an important role in driving crisis outflows. Our results again change little with the inclusion of day fixed effects (Columns (4) and (6)).

Third, Schmidt, Timmermann and Wermers (2016) show that investor sophistication (as measured by the expense ratio) is a significant driver of fund flows during the 2008 run. In our baseline model we use the fund's expense ratio (averaged across share classes) to control for the overall effect of investor sophistication on investor flows. Since this effect tends to be amplified during the crisis, we re-estimate Equation 1 by including the interaction between the fund's expense ratio and the $Crisis$ dummy. Consistent with Schmidt, Timmermann and Wermers (2016), funds with more sophisticated investors (i.e., lower expense ratio) experience larger outflows during the crisis period. More importantly, the coefficient of the interaction between WLA and $Crisis$ remains positive and significant (Columns (7) and (8) of Table 7).

Fourth, Kacperczyk and Schnabl (2013) show that MMFs' sponsorship could affect funds' risk taking behaviors and hence run patterns during a crisis. To control for the effect of this channel, we use funds' bank affiliation as a proxy for the strength of their sponsor support, and re-estimate Equation 1 by including the interaction between the fund's bank affiliation dummy and the *Crisis* dummy. Columns (9) and (10) of Table 7 show that funds affiliated with banks experience larger outflows during the crisis period. More importantly, the coefficient of the interaction between WLA and $Crisis$ remains positive and significant.

Some unobservable fund characteristics, such as investors' risk tolerance, concentration of large investors, and pre-existing relationships between fund managers and investors, could potentially play a role in driving redemptions during the crisis. We conduct a number of tests to address this concern. To begin with, we re-estimate Equation 1 and Equation 2 by further controlling for fund fixed effects. Table 8 shows that our results are robust to the inclusion of fund fixed effects.

To more directly address the possibility that investors in different funds may have different run thresholds, we normalize the distance of a fund's WLA to the 30% threshold by its average distance to the threshold in normal times. Intuitively, investors that in normal times have a preference for larger WLA buffers in excess of 30% may be less tolerant of WLA deteriorations in crisis times.

Specifically, the normalized WLA measure is defined as:

$$NormDistance_{i,t} = (WLA_{i,t} - 30)/(PreWLA_i - 30), \tag{3}$$

where $PreWLA_i$ is the average WLA of fund i over the period from January 5 to February 5, 2020 (i.e., the one month before the beginning of our pre-crisis period). This measure allows us to capture how far a fund's WLA is from the 30% threshold relative to where it usually is in normal times.[21] We then test the sensitivity of fund flows to this normalized

[21]Intuitively, we can view $PreWLA$ as a fund-specific "comfortable" level of WLA in normal times, possibly reflecting a balanced outcome of the fund investors' risk tolerance, sophistication, and investment preferences. Thus, investors that prefer a larger WLA buffer in excess of 30% in normal times may be more inclined to withdraw their money in the face of a deteriorating WLA relative to investors who do

WLA measure by re-estimating Equation 1 with day fixed effects while replacing WLA with $NormDistance$.

Column (1) of Table 9 shows that outflows exhibit significant sensitivity to this normalized distance measure during the crisis. The coefficient of the interaction between $Crisis$ and $NormDistance$ suggests that relative to normal times, a one-standard-deviation (0.33) decrease in $NormDistance$ is associated with an 1-percentage-point increase in daily outflows during the crisis, which is about 37% of average daily outflows during that period. Our results are robust to controlling for fund fixed effects (Column (2)) and the parallel trends assumption is satisfied in the data (Column (3)).

We also explore whether outflow accelerates when $NormDistance$ gets smaller. Specifically, we split $NormDistance$ into two segments depending on whether it is above or below the sample median. We then estimate the following model:

$$\begin{aligned} Flow_{i,t} = {} & \beta_1 NormDistance(Low)_{i,t-2} + \beta_2 NormDistance(High)_{i,t-2} \\ & + \beta_3 Crisis \times NormDistance(Low)_{i,t-2} + \beta_4 Crisis \times NormDistance(High)_{i,t-2} \\ & + Controls_{i,t-1} + \mu_t + \varepsilon_{i,t}, \quad (4) \end{aligned}$$

where $NormDistance(Low)$ ($NormDistance(High)$) equals $NormDistance$ if the fund's $NormDistance$ is below (above) the median, and zero otherwise. Column (4) of Table 9 shows that outflows exhibit stronger sensitivity to the $NormDistance$ measure if $NormDistance$ is below the sample median, and the difference in flow sensitivity is significant. Specifically, in the crisis period, for funds with low $NormDistance$, a one-standard-deviation decrease in $NormDistance$ is associated with additional daily outflows of 1.64%, which is 27% higher than the additional outflows from funds with high $NormDistance$. The result becomes even stronger when controlling for fund fixed effects (Column (5)). In Column (6) we verify that the parallel trends assumption is satisfied in the data.

not mind a lower WLA buffer in the first place. This new normalized measure takes into consideration such potential heterogeneity across funds.

Lastly, one might argue that the sensitivity of outflows to WLA could be due to reverse causality. Even if we use the lagged value of WLA and control for lagged flows to absorb any serial correlation in flows, our results may still suffer from endogeneity. To address this concern more directly, we employ an instrumental variable approach whereby we exploit exogenous changes to the WLA of a fund during the crisis. To do so, we use the predetermined amount of assets that are going to mature during the crisis period. Using the end of February N-MFP report on funds' security-level holdings, we have a pre-crisis reading of the amount of assets that will mature on any day during the crisis. As these assets mature, they convert back into cash which boosts the liquidity of the fund. As more and more assets mature, funds have the opportunity to keep more and more cash as liquidity buffers. Therefore, we use $Maturing$ as an instrument for WLA during the crisis, where $Maturing$ is equal to the cumulative share of assets maturing up to day t from the start of the crisis. Since in normal times maturing assets are reinvested in long-term securities to maintain stable WLAs and profitability, $Maturing$ would be a weak instrument in normal times. On the other hand, maturing assets were not reinvested in long-term securities during the crisis, but kept instead as liquidity buffers. Therefore, the instrumental variable regressions span the crisis period only.

As shown in the first-stage results in Table 10, maturing assets are indeed contributing to higher WLAs during the crisis. The first-stage coefficient is around 0.6 and statistically significant, which suggests that on average, for a dollar of maturing assets, WLA increases by 60 cents. It is likely that the remaining 40 cents are used to meet redemptions. Comparisons between the ordinary least squares (OLS) estimates (Columns (1) and (2)) and the instrumental variable ones (Column (3) and (4)) suggest that, during the crisis, funds attempt to keep greater liquidity buffers when faced with redemptions. The first-stage F statistics are all above the conventional critical value of 10, indicating that our instrument is not weak. Importantly, the second-stage results confirm that WLA continues to have a significant effect on investor flows during the crisis period.

5 The Stabilizing Effects of the MMLF

Policymakers have a set of tools to prevent runs, including ex-ante regulations and ex-post emergency interventions (Rochet and Vives, 2004). Given that liquidity restrictions in the form of gates and fees did not prevent the run and likely exacerbated it, the Federal Reserve intervened by introducing the MMLF in the second half of March 2020. By allowing prime funds to liquidiate their assets to meet redemptions, the MMLF aimed to boost fund liquidity buffers and eliminate investors' incentives to run. In this section, we study the micro-level MMLF data to understand how prime funds, particularly those that experience larger decline in WLAs during the crisis, benefit from the liquidity of last resort provided by the MMLF. In addition, we conduct a number of tests to evaluate the effectiveness of the MMLF in stemming outflows from prime MMFs, especially those with lower WLA.

5.1 Actual Usage of the MMLF and Fund Liquidity

MMLF usage by MMFs was substantial and concentrated in the first two weeks of its operations, which account for about 95% of its total usage. Within the first seven business days of MMLF operations, MMFs were able to offload about $53 billion worth of assets to the facility, representing 8% of all prime fund assets. We start by analyzing whether securities that weigh more on MMFs' liquidity conditions are more likely to be pledged at the MMLF. Using the N-MFP data, we build a fund-CUSIP level dataset of securities in prime funds' portfolios at the end of February. We keep only securities that mature at least one week after the launch of the MMLF on March 23. For each fund-CUSIP pair, we use the micro-level MMLF data to calculate the share of each security that is pledged to the MMLF. We focus on CP (including ABCP) and CDs as they are the only types of assets pledged to the MMLF by prime funds. Finally, we merge fund-level information from iMoneyNet to the fund-CUSIP dataset.

We then estimate the following regression on the sample of all prime MMFs:

$$SharePledged_{i,j} = \beta_1 Log(Time\ to\ Maturity_j) + \beta_2 Institutional_i + \beta_3 \mathbb{1}(Type)_j + Controls_j + \varepsilon_{i,j}, \quad (5)$$

where $SharePledged_{i,j}$ is the percentage of fund i's holding of security j at the end of February that was pledged at the MMLF during its first two weeks of operation. $Log(Time\ to\ Maturity_j)$ is the logarithm of the residual days to maturity of the security as of the end of February. $Institutional_i$ is a dummy variable that takes the value of one if the prime MMF is an institutional fund. Security-level controls, $Controls_j$, include security yield and share of the security in the fund's AUM as of the end of February. $\mathbb{1}(Type)_j$ represents security type (nonfinancial CP, financial CP, ABCP, and CDs) fixed effects. Standard errors are two-way clustered at the fund and security level.

Estimation results for Equation (5) are reported in Column (1) of Table 11. Securities with longer maturities were much more likely to be pledged to the MMLF, suggesting that funds prioritized to offload more illiquid assets to the MMLF. In addition, institutional funds sold significantly more securities to the MMLF than retail funds.

We focus on institutional prime MMFs in subsequent tests. As shown in the previous section, fund outflows during the crisis were sensitive to the deterioration in funds' WLA. To test whether MMLF usage relates to changes in WLA, we augment Equation (5) as follows:

$$SharePledged_{i,j} = \beta_1 Log(Time\ to\ Maturity)_j + \beta_2 Crisis\ \Delta WLA_i + \beta_3 \mathbb{1}(Type)_j + Controls_j + Controls_i + \varepsilon_{i,j}, \quad (6)$$

where $Crisis\ \Delta WLA_i$ is the net change in fund i's WLA during the crisis period (from March 9 to March 20). Fund-level controls, $Controls_i$, include abnormal yield, safe holdings, risky holdings, the logarithm of fund size, expense ratio, bank affiliation dummy, and fund age, as of the most recent Tuesday before the launch of the MMLF. Other variables are defined as in Equation (5) and standard errors are two-way clustered at the fund and security level.

Column (2) of Table 11 shows that funds that experienced larger declines in WLA, and therefore in more urgent need to restore liquidity buffers, sold more securities to the MMLF. This result echoes our earlier finding of a stronger MMLF effect for lower-WLA funds. In Column (3) we include $CrisisFlow_i$ (representing fund i's cumulative percentage flow during the crisis period) as an additional explanatory variable. $Crisis\ \Delta WLA_i$ remains highly significant while $CrisisFlow_i$ is insignificant. This result highlights the importance of fund WLA in explaining the usage and effects of the MMLF. In Column (4), we control for fund fixed effects and continue to find that longer-tenor securities were more likely to be sold to the MMLF.

Overall, these results highlight the role of the MMLF as the liquidity provider of last resort. By allowing funds to turn illiquid assets into cash, the MMLF reassured investors that prime funds could build back a large enough buffer in excess of the 30% regulatory threshold. As a result, prime funds could accomodate redemptions without necessarily eroding their WLA buffers, in turn reducing the very same incentives for investors to pre-emptively run. Next, we evaluate the effectivess of the MMLF in stemming prime MMF outflows.

5.2 The Effect of the MMLF on Prime MMF Flows

To evaluate the effect of the MMLF on fund flows, we compare fund flows during the crisis period to the "MMLF" period, which is defined as the two weeks immediately following the MMLF implementation (i.e., March 23–April 3). We choose to use the implementation date, rather than the announcement date, to evaluate the MMLF effect because several important changes to the MMLF were announced between those two dates. In particular, CDs were excluded from the list of MMLF-eligible assets until the MMLF implementation date. Perhaps reflecting some uncertainty around the breadth of asset eligibility to the MMLF, investors continued to redeem shares and institutional prime MMFs lost an additional 11% of AUMs to redemptions during the three business days between the announcement and the implementation of the MMLF (i.e., March 18–23).

We start with a sample including both retail and institutional prime funds for the four weeks around the launch of the MMLF (i.e., March 9–April 3) and estimate the following model:

$$Flow_{i,t} = \beta_1 MMLF_t + Controls_{i,t-1} + \varepsilon_{i,t}, \tag{7}$$

where $Flow_{i,t}$ is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. $MMLF_t$ is a dummy that takes the value of one during the post-MMLF period. $Controls_{i,t-1}$ includes the lagged dependent variable ($Flow_{i,t-1}$), lagged WLA ($WLA_{i,t-2}$), as well as other lagged fund characteristics in Equation 1. Standard errors are two-way clustered at the fund and day levels.

Column (1) of Table 12 shows that, after controlling for fund characteristics, prime funds' daily flows on average rebounded by about 0.9 percentage points in the post-MMLF period. The rebound in fund flows was concentrated among institutional funds. To show that, we create a dummy, *Institutional*, that takes the value of one for prime institutional funds, and add *Institutional* and its interaction with $MMLF$ to Equation 7. Column (2) of Table 12 shows that daily flows from retail MMFs did not experience significant changes from the crisis period to the MMLF period. Relative to retail funds, institutional funds saw their daily flows rebound by 1.6 percentage points more after the launch of the MMLF. Our results are little changed when we also control for day fixed effects (Column (3)). When we focus on institutional prime MMFs only, we confirm that institutional MMFs' daily flows rebounded by about 1.5 percentage points after the launch of the MMLF (Column (4)).

In Section 4 we documented that institutional prime MMFs with lower WLA experienced larger outflows during the crisis period. If the MMLF provided liquidity backstop to MMFs, we expect its impact to be stronger for funds with lower WLA. To test this prediction, we include the interaction of $MMLF$ and WLA as additional explanatory variable and re-estimate Equation 7 for institutional prime funds. Consistent with our expectation, the coefficient of the interaction term is negative and highly significant (Column (5)). This finding suggests that the MMLF significantly attenuated the sensitivity of flows to WLA, which characterized the crisis dynamics. Indeed, the ability for a fund to access the MMLF made its current liquidity level less of a concern given the availability of plentiful "liquidity of last resort" from the MMLF.

One potential concern about the previous finding is that it might be driven by policy actions other than the MMLF. Around the same time that the MMLF was announced, a number of liquidity and credit facilities were created by the Federal Reserve and the stance of monetary policy eased significantly (see Online Appendix Table A.1). One could argue that the stabilization of prime funds might be attributed to the improvements in CP and CD market conditions brought by the announcement of the Commercial Paper Funding Facility (CPFF) on March 17 or the launch of the Primary Dealer Credit Facility (PDCF) on March 20.[22] One could also argue that the rebound in prime fund flows might simply reflect a boost in risk sentiment brought by other policy actions, such as the resumption of asset purchases by the Federal Reserve.

To address these concerns, we design additional tests to identify an MMLF-specific effect. If the stabilization of institutional prime fund flows during the post-MMLF period was mainly due to improvements in the liquidity conditions in the CP and CD markets, we should observe a similar rebound in fund flows for offshore USD prime MMFs, which invest in essentially the same pool of assets including CP and CDs, are subject to similar regulations, and experienced comparable outflows prior to the launch of the MMLF (see Panel (a) of Figure 2).[23] Since offshore USD prime funds are not eligible to participate in

[22]The CPFF allows top-rated CP issuers to obtain CP funding directly from the Federal Reserve, and the PDCF allows primary dealers to obtain repo funding from the Federal Reserve against eligible collateral, including CP and CDs.

[23]Offshore USD prime funds share many similar features with institutional prime funds. In addition

the MMLF, they serve as a control group to test whether the broad-based improvements in short-term funding market conditions, rather than the MMLF, led to the stabilization of (domestic) prime fund flows.

Specifically, we use a sample that includes both domestic institutional prime funds and offshore institutional USD prime funds and covers the four weeks around the launch of the MMLF. We estimate the following model:

$$Flow_{i,t} = \beta_1 Domestic_i + \beta_2 MMLF_t + \beta_3 Domestic_i \times MMLF_t + \varepsilon_{i,t}, \tag{8}$$

where $Domestic_i$ is a dummy that equals one for domestic institutional prime funds. All other variables are defined as in Equation 7, and standard errors are two-way clustered at the fund and day levels.

Column (1) of Table 13 suggests that broad-based improvements in short-term funding market conditions cannot fully explain the rebound in domestic prime fund flows. During the two weeks following the MMLF, fund flows rebounded significantly more for domestic funds relative to their offshore counterparts. Although offshore USD prime funds also experienced a rebound in flows, its magnitude is much smaller and not statistically significant.

We also explore potential differences in the speed of recovery between the two types of funds after the launch of the MMLF. To do so, we divide the post-MMLF period into the first week of operations ($MMLF\_WeekOne$) and the second week ($MMLF\_WeekTwo$). Column (2) of Table 13 shows that, relative to the pre-MMLF period, offshore funds actually experienced very little inflows (also statistically insignificant) during the first week after the launch of the MMLF, while flows of the domestic funds recovered by an additional 1.3 percentage points. Only during the second week of the MMLF period did offshore funds experience a significant rebound in flows similar to domestic funds,

to holding similar types of assets, they are subject to similar regulations, including redemption gates and liquidity fees. Furthermore, it is common for large fund families to have both U.S. prime funds and offshore USD prime funds under their management. During the crisis period, assets in offshore USD prime funds dropped by about 25%.

as shown by the positive and highly significant coefficient of $MMLF\_WeekTwo_t$ and the insignificant coefficient of its interaction with $Domestic_i$. Controlling for lagged fund characteristics and day fixed effects leads to similar results (Column (3) and (4)). In sum, the rebound in domestic relative to offshore fund flows immediately after the introduction of the MMLF indicates a significant stabilization effect of the MMLF. The subsequent improvements among both domestic and offshore funds is consistent with the fact that the broader stabilization of funding markets ultimately benefited also offshore funds.

6 Conclusion

Liquidity restrictions on investors, like the redemption gates and liquidity fees introduced in the 2016 MMF reform, are meant to reduce the incentives to run on MMFs during crises. However, in this paper we find evidence that the WLA-contingent gates and fees might have exacerbated the run on prime MMFs during the Covid-19 crisis.

The fear of having gates and fees imposed on them generates strong strategic complementarities among MMF investors, leading to large-scale preemptive redemptions that cannot be explained by other known factors that could potentially drive investor flows, including asset illiquidity, risk exposures, floating NAV (fund performance), and investor sophistication. By allowing prime funds to turn their illiquid assets into cash and build back a large enough buffer in excess of the 30% regulatory threshold, the MMLF was effective in reducing investors' incentive to run pre-emptively and stemming outflows.

The short-term funding markets are a crucial component of modern financial systems. As we have witnessed twice in the last two decades, stress among MMFs can threaten the stability of these markets, leading up to systemic financial crises. Since the 2008 crisis, two sets of reforms had been implemented by the SEC to address the structural vulnerabilities of MMFs. Unfortunately, those reforms did not prevent a repeat of the run on MMFs during the Covid-19 crisis. Some feature of the 2016 MMF reform, gates and fees, might have even intensified the run in 2020.

Both the 2008 and 2020 runs on MMFs were stopped by decisive central bank interventions, and conditions in the short-term funding markets stabilized after those interventions. While central banks seem to be able to serve as a backstop during a crisis, it is never an optimal strategy to rely on direct interventions of central banks to address the financial stability risk of an industry. Policymakers have indicated that further MMF reforms will be needed to address the structural vulnerabilities exposed in the Covid-19 crisis. Given the notable role of MMFs in the short-term funding markets, more research and collaborative regulatory efforts are warranted to enhance the stability of the industry.

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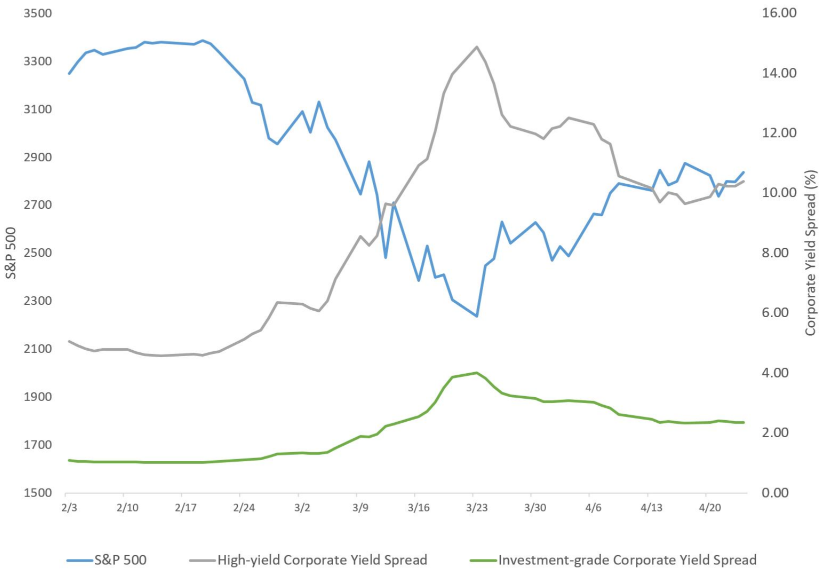
Figure 1: **Distress in funding markets during the Covid-19 crisis**

Panel (a) shows the evolution of the S&P 500 index and the yield spreads of investment-grade and high-yield corporate bonds during the Covid-19 crisis. Panel (b) plots the evolution of the yield spreads to OIS of selected short-term securities: 1-month AA nonfinancial commercial paper (CP), asset-backed commercial paper (ABCP), and negotiable certificates of deposit (CDs).

(a) Equity prices and bond yield spreads



(b) Yield spreads on 1-month CP & CD (in basis points)

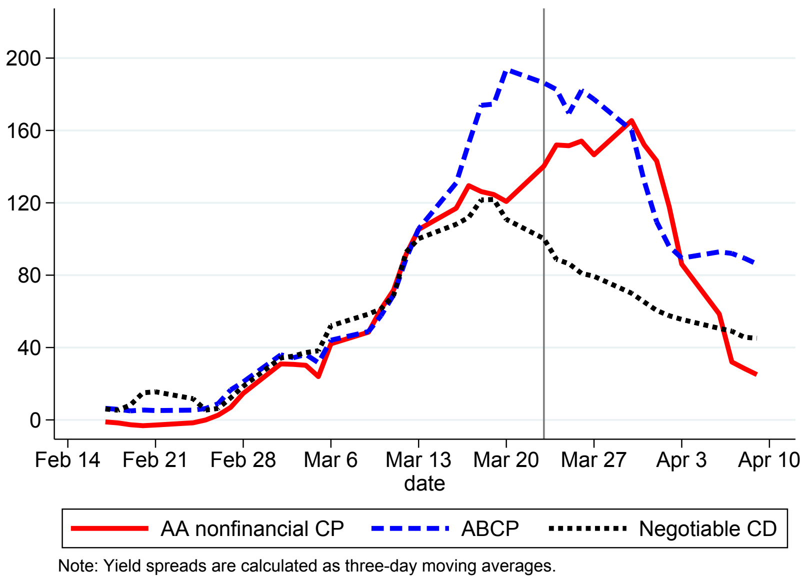
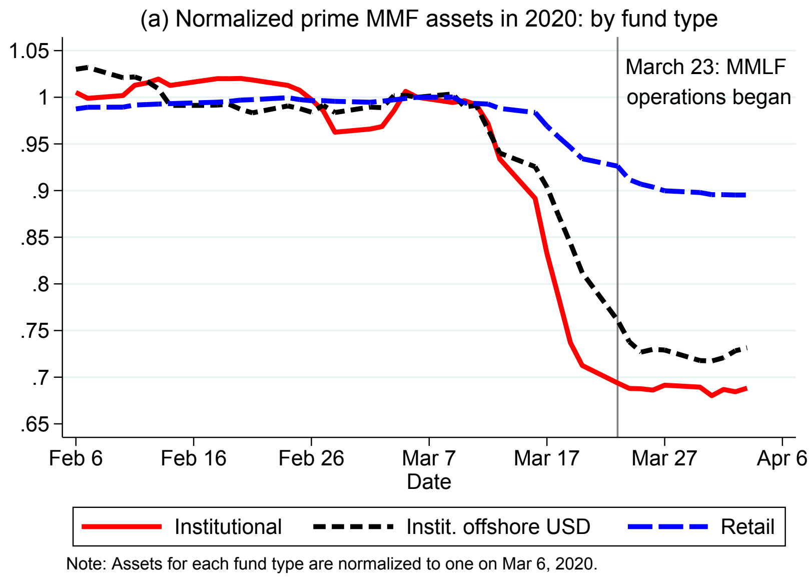


Figure 2: **Runs on MMFs**

Panel (a) plots the total assets under management (AUMs) of institutional and retail prime MMFs, as well as institutional offshore USD prime funds during the Covid-19 crisis, all normalized to one on March 6, 2020. Panel (b) compares two prominent runs on institutional prime MMFs: the 2008 financial crisis run starting on September 10, 2008, and the 2020 Covid-19 crisis run starting on March 9, 2020. Total assets of institutional prime MMFs for each crisis are normalized to one on the business day right before the crisis.



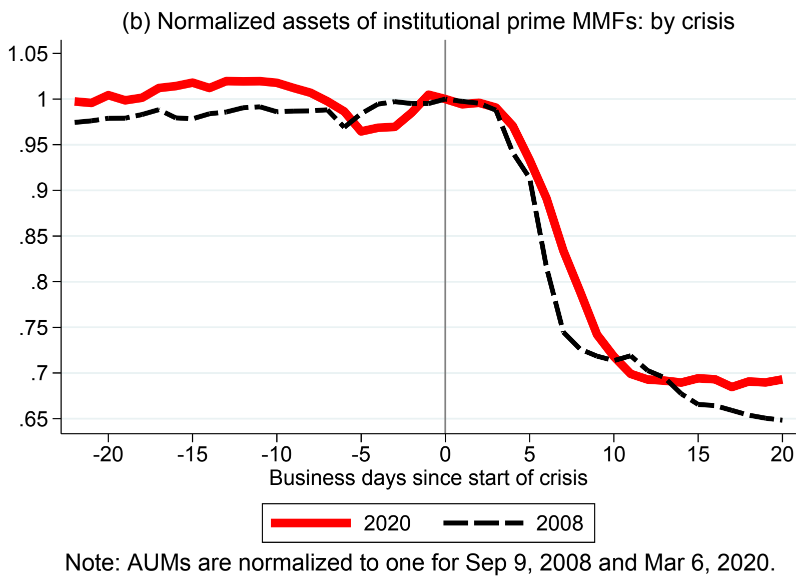
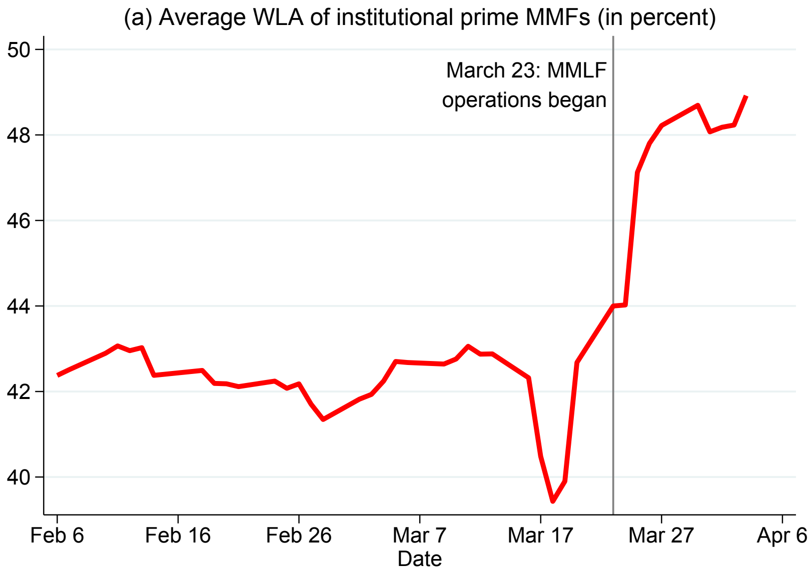


Figure 3: **WLA levels and prime MMF runs**

Panel (a) plots the average weekly liquid asset (WLA) for institutional prime MMFs (in percent). Panel (b) plots the assets of institutional prime MMFs in three portfolios based on their two-day lagged WLA levels (with WLA≤40, WLA between 40 and 50, and WLA>50), rebalanced daily. Assets of each WLA group are normalized to one on March 6, 2020.



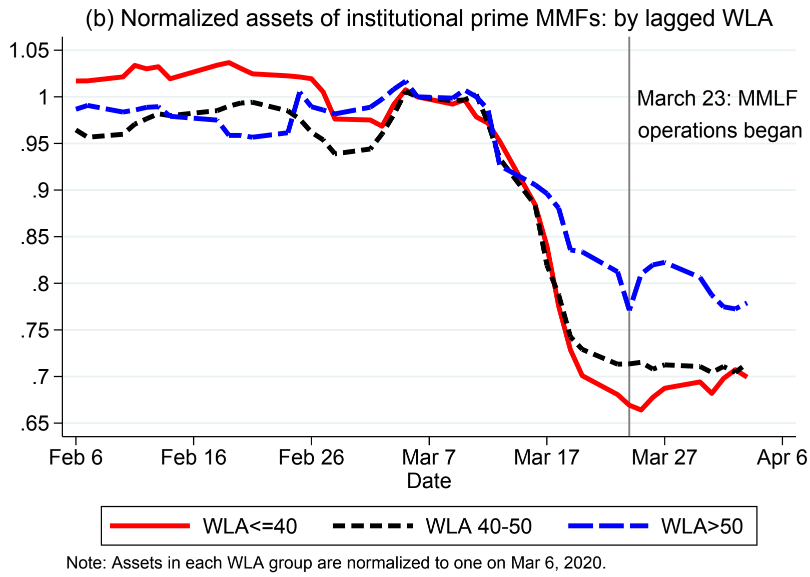


Table 1: **Fund WLA levels and crisis outflows**

The sample includes only institutional prime MMFs. The sample spans from February 6, 2020 to March 20, 2020, with $Crisis$ equal to one from March 9 to March 20. For the pre-crisis period from February 6 to March 6, we divide them into four weeks, with $PreCrisis(-3)$ equal to one for the third to last week before crisis, and $PreCrisis(-2)$ equal to one for the second to last week before crisis. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. WLA is the share of weekly liquid assets in total assets (in percent), as of day $t-2$. $Flow_{t-1}$ is the one-day lag of the dependent variable. Other controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), the logarithm of fund size, expense ratio, bank affiliation dummy, and fund age. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow					
	(1)	(2)	(3)	(4)	(5)
Flow_{t-1}		0.184**	0.083	0.174**	0.083
		(0.067)	(0.057)	(0.068)	(0.057)
PreCrisis(-3)				-0.726	
				(1.561)	
PreCrisis(-2)				-2.545	
				(1.573)	
Crisis	-8.639***	-7.034***		-7.964***	
	(2.532)	(2.123)		(2.362)	
WLA	-0.009	-0.008	-0.013	-0.019	-0.023
	(0.033)	(0.028)	(0.030)	(0.040)	(0.042)
WLA × PreCrisis(-3)				0.008	0.012
				(0.036)	(0.037)
WLA × PreCrisis(-2)				0.031	0.030
				(0.032)	(0.035)
WLA × Crisis	0.139***	0.112**	0.123***	0.124**	0.133**
	(0.050)	(0.043)	(0.044)	(0.047)	(0.048)
Adj. R^2	0.147	0.174	0.253	0.184	0.252
Obs.	1018	1018	1018	1018	1018
Controls	Yes	Yes	Yes	Yes	Yes
Day FE			Yes		Yes

Table 2: **Acceleration of redemptions when WLA is closer to 30%**

The sample includes only institutional prime MMFs. The sample spans from February 6, 2020 to March 20, 2020, with $Crisis$ equal to one from March 9 to March 20. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. WLA is the share of weekly liquid assets in total assets (in percent), as of day $t-2$. $WLA(\leq 40)$ equals WLA if the fund's WLA is below or equal to 40% and zero otherwise. WLA(40-50) and $WLA(> 50)$ are similarly defined. $WLA(Low)$ ($WLA(High)$) equals WLA if the fund's WLA is below (above) the weekly median and zero otherwise. Columns (1)–(3) control for $Crisis$ dummy, $WLA(\leq 40)$, WLA(40-50), and $WLA(> 50)$. Columns (4)–(6) control for $Crisis$ dummy, $WLA(Low)$, and $WLA(High)$. Other fund controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), the logarithm of fund size, expense ratio, bank affiliation dummy, and fund age. The bottom two rows show the p-values of the F-tests for the equality of the coefficients of the interaction terms between $Crisis$ and WLA variables, where L stands for $WLA(\leq 40)$ or $WLA(Low)$, M stands for WLA(40-50), and H stands for $WLA(> 50)$ or $WLA(High)$. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow						
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis × WLA(≤40)	0.308***	0.297***	0.290***			
	(0.084)	(0.089)	(0.086)			
Crisis × WLA(40-50)	0.265***	0.258***	0.254***			
	(0.085)	(0.083)	(0.082)			
Crisis × WLA(>50)	0.230***	0.228***	0.229***			
	(0.061)	(0.063)	(0.067)			
Crisis × WLA(Low)				0.206***	0.218***	0.220***
				(0.031)	(0.041)	(0.049)
Crisis × WLA(High)				0.175***	0.188***	0.192***
				(0.032)	(0.037)	(0.044)
Adj. R^2	0.177	0.256	0.254	0.178	0.256	0.253
Obs.	1018	1018	1018	1018	1018	1018
Lagged dependent variable	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Day FE		Yes	Yes		Yes	Yes
Parallel trends check			Yes			Yes
p-value: Crisis×L = Crisis×M	0.00	0.03	0.05	N/A	N/A	N/A
p-value: Crisis×L = Crisis×H	0.00	0.02	0.02	0.00	0.03	0.06

Table 3: **Are redemptions driven by asset illiquidity? DLA vs. WLA**

The sample includes only institutional prime MMFs. The sample spans from February 6, 2020 to March 20, 2020, with *Crisis* equal to one from March 9 to March 20. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. DLA is the share of daily liquid assets in total assets (in percent), as of day $t-2$. WLA is the share of weekly liquid assets in total assets (in percent), as of day $t-2$. Controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), and logarithms of fund size. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow				
	(1)	(2)	(3)	(4)
Crisis	-3.495***		-6.982***	
	(1.266)		(2.087)	
DLA	-0.004	-0.006	0.004	0.003
	(0.015)	(0.018)	(0.013)	(0.016)
Crisis × DLA	0.038	0.062	-0.020	0.007
	(0.039)	(0.043)	(0.047)	(0.055)
WLA			-0.012	-0.014
			(0.026)	(0.027)
Crisis × WLA			0.125**	0.118*
			(0.058)	(0.065)
Adj. R^2	0.163	0.243	0.173	0.252
Obs.	1020	1020	1018	1018
Lagged dependent variable	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Day FE		Yes		Yes

Table 4: **Do redemptions accelerate when DLA is closer to 10%?**

The sample includes only institutional prime MMFs. The sample spans from February 6, 2020 to March 20, 2020, with $Crisis$ equal to one from March 9 to March 20. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. DLA is the share of daily liquid assets in total assets (in percent), as of day $t-2$. WLA is the share of weekly liquid assets in total assets (in percent), as of day $t-2$. $DLA(\leq 20)$ equals DLA if the fund's DLA is below or equal to 20% and zero otherwise; DLA(20-30) and $DLA(> 30)$ are similarly defined. $WLA(\leq 40)$ equals WLA if the fund's WLA is below or equal to 40% and zero otherwise; WLA(40-50) and $WLA(> 50)$ are similarly defined. Columns (1)–(2) control for $Crisis$, $DLA(\leq 20)$, DLA(20-30), and $DLA(> 30)$. Columns (3)–(4) further control for $WLA(\leq 40)$, WLA(40-50), and $WLA(> 50)$. Other fund controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), the logarithm of fund size, expense ratio, bank affiliation dummy, and fund age. The bottom four rows show the p-values of the F-tests for the equality of the coefficients of the interaction terms between $Crisis$ and DLA (WLA) variables, where L stands for $DLA(\leq 20)$ or $WLA(\leq 40)$, M stands for DLA(20-30) or WLA(40-50), and H stands for $DLA(> 30)$ or $WLA(> 50)$. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow				
	(1)	(2)	(3)	(4)
Crisis × DLA(≤20)	0.203	0.242	0.0810	0.135
	(0.140)	(0.147)	(0.158)	(0.158)
Crisis × DLA(20-30)	0.177*	0.206*	0.0752	0.118
	(0.0984)	(0.103)	(0.125)	(0.122)
Crisis × DLA(>30)	0.123*	0.150**	0.0444	0.0829
	(0.0672)	(0.0716)	(0.0880)	(0.0909)
Crisis × WLA(≤40)			0.294**	0.259**
			(0.111)	(0.119)
Crisis × WLA(40-50)			0.254**	0.222*
			(0.112)	(0.115)
Crisis × WLA(>50)			0.221**	0.196**
			(0.0875)	(0.0937)
Adj. R^2	0.168	0.248	0.175	0.254
Obs.	1,018	1,018	1,018	1,018
Lagged dependent variable	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Day FEs		Yes		Yes
p-value: Crisis×L = Crisis×M (DLA)	0.70	0.62	0.94	0.82
p-value: Crisis×L = Crisis×H (DLA)	0.36	0.31	0.69	0.56
p-value: Crisis×L = Crisis×M (WLA)	N/A	N/A	0.01	0.05
p-value: Crisis×L = Crisis×H (WLA)	N/A	N/A	0.02	0.05

Table 5: **Summary statistics for the 2020 and 2008 MMF runs**

This table reports summary statistics for institutional prime MMFs in the 2020 and 2008 run samples. The crisis time is defined as the period from March 9 to March 20, 2020 for the 2020 run and September 10 to September 19, 2008 for the 2008 run. The normal time is defined as the one-month period before the beginning of the crisis (i.e., February 6 to March 6, 2020, and August 10 to September 9, 2008). Fund AUM is a fund's assets under management in millions. Daily percentage flow is the daily percentage change in fund AUM, winsorized at the 0.5% and 99.5% levels. WLA is the share of weekly liquid assets in total assets (in percent), including cash, direct obligations of the US government, certain securities issued by US government instrumentalities with a remaining maturity date of 60 days or less, and securities that mature or are subject to a demand feature exercisable and payable within five business days. For the 2008 sample, WLA is estimated as the sum of assets maturing in seven days, Treasury, and agency debt. DLA is the share of daily liquid assets in total assets (in percent), including cash, direct obligations of the U.S. government, securities that will mature or are subject to a demand feature that is exercisable and payable within one business day. NAV is the floating net asset value. Gross yield is a fund's gross yield (i.e., before fees) in percentage points. Safe holdings include Treasury and agency debt, measured as share of fund AUM. Risky holdings include unsecured CP, ABCP, and CDs, measured as share of fund AUM. Expense ratio is a fund's expense ratio in percentage points. Bank affiliated is a dummy variable equal to one if the fund is affiliated with a bank. Age is a fund's age in years.

	2020 Run (No. of funds: 34)				**2008 Run (No. of funds: 135)**			
	Normal Time		**Crisis Time**		**Normal Time**		**Crisis Time**	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
AUM (mn $)	9030.0	13862.0	7975.1	12776.6	9468.0	15766.6	8458.4	14342.4
Daily pct. flow	-0.04	2.56	-2.68	4.54	0.06	3.13	-1.63	5.64
WLA (%)	42.3	5.2	41.9	6.5	40.9	23.2	40.6	22.7
Gross yield (%)	1.82	0.04	1.58	0.14	2.65	0.18	2.69	0.18
Safe holdings	0.02	0.05	0.03	0.04	0.09	0.14	0.09	0.15
Risky holdings	0.53	0.17	0.53	0.16	0.59	0.22	0.60	0.21
Expense ratio	0.18	0.08	0.18	0.08	0.29	0.18	0.30	0.18
Bank affiliated	0.47	0.50	0.47	0.50	0.49	0.50	0.49	0.50
Fund age	18.66	11.78	18.68	11.77	12.00	7.22	12.28	7.32
DLA (%)	30.6	6.5	32.3	7.5				
NAV	1.0005	0.0003	1.0000	0.0007				

Table 6: **Fund WLA levels and outflows during the 2008 MMF run**

The sample includes only institutional prime MMFs. The sample spans from August 10 to September 19, 2008, with $Crisis$ equal to one from September 10 to September 19. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. WLA is a proxy for share of weekly liquid assets (calculated as the sum of assets maturing in seven days, Treasury, and agency debt, in percent), as of the most recent Tuesday. $WLA(\leq 40)$ equals WLA if the fund's WLA is below or equal to 40 and zero otherwise. WLA(40-50) and $WLA(> 50)$ are similarly defined. $WLA(Low)$ ($WLA(High)$) equals WLA if the fund's WLA is below (above) the weekly median and zero otherwise. Columns (1)–(2) control for WLA. Columns (3)–(4) control for $WLA(\leq 40)$, WLA(40-50), and $WLA(> 50)$. Columns (5)–(6) control for $WLA(Low)$ and $WLA(High)$. Other fund controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), logarithms of fund size, expense ratio, bank affiliation dummy, and fund age. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow						
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis × WLA	0.023**	0.022**				
	(0.010)	(0.010)				
Crisis × WLA(≤40)			-0.006	-0.027		
			(0.024)	(0.022)		
Crisis × WLA(40-50)			0.033*	0.019		
			(0.019)	(0.016)		
Crisis × WLA(>50)			0.015	0.008		
			(0.012)	(0.011)		
Crisis × WLA(Low)					0.014	-0.001
					(0.021)	(0.019)
Crisis × WLA(High)					0.021*	0.016
					(0.012)	(0.011)
Adj. R^2	0.053	0.096	0.055	0.098	0.053	0.096
Obs.	3925	3925	3925	3925	3925	3925
Lagged dependent variable	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Day FE		Yes		Yes		Yes

Table 7: **Crisis outflows, WLA, and alternative channels**

The sample includes only institutional prime MMFs. The sample spans from February 6, 2020 to March 20, 2020, with $Crisis$ equal to one from March 9 to March 20. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels.NAV is floating net asset value (in basis points), as of day $t-2$. $LT\ unsecured$ is the share of fund assets in unsecured CP/CDs with maturity over 30 days (as of the end of February), in percent. $LT\ nonfinancial$ is the share of fund assets in nonfinancial CP with maturity over 30 days (as of the end of February), in percent. $Expense\ ratio$ is the expense ratio. $Bank\ affiliation$ is a dummy variable equal to one if the fund is affiliated with a bank and zero otherwise. WLA is the share of weekly liquid assets in total assets (in percent), as of day $t-2$. The lagged dependent variable, $Flow_{t-1}$, is the one-day lag of the dependent variable. Other controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), logarithms of fund size, expense ratio, bank affiliation dummy, and fund age. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow										
Alternative Channel:	**NAV**		**LT unsecured**		**LT nonfinancial**		**Expense ratio**		**Bank affiliation**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Crisis	-303.149		-4.625		-9.100***		-9.694***		-5.688**	
	(968.120)		(3.734)		(2.568)		(2.349)		(2.071)	
Alt Channel	0.060	-0.018	0.017	0.019	-0.010	-0.026	-1.664	-1.786	0.161	0.184
	(0.044)	(0.044)	(0.016)	(0.018)	(0.031)	(0.041)	(1.100)	(1.280)	(0.248)	(0.270)
Crisis × Alt Channel	0.030	-0.091	-0.064	-0.077	0.152	0.178	9.447***	10.512***	-0.876*	-1.021*
	(0.097)	(0.109)	(0.049)	(0.052)	(0.098)	(0.108)	(2.364)	(2.533)	(0.507)	(0.590)
WLA	-0.011	-0.009	-0.017	-0.025	-0.038	-0.050	-0.022	-0.029	-0.001	-0.004
	(0.033)	(0.033)	(0.041)	(0.042)	(0.032)	(0.033)	(0.027)	(0.028)	(0.030)	(0.031)
Crisis × WLA	0.098**	0.124***	0.105*	0.104*	0.147***	0.156***	0.135***	0.148***	0.090*	0.096**
	(0.044)	(0.041)	(0.055)	(0.057)	(0.046)	(0.050)	(0.039)	(0.038)	(0.044)	(0.045)
Adj. R^2	0.175	0.251	0.182	0.280	0.181	0.277	0.182	0.264	0.176	0.257
Obs.	989	989	773	773	773	773	1018	1018	1018	1018
Lagged dependent variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day FE		Yes		Yes		Yes		Yes		Yes

Table 8: **Fund WLA levels and crisis outflows: robustness**

The sample includes only institutional prime MMFs. The sample spans from February 6, 2020 to March 20, 2020, with $Crisis$ equal to one from March 9 to March 20. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. WLA is the share of weekly liquid assets in total assets (in percent), as of day $t-2$. $WLA(\leq 40)$ equals WLA if the fund's WLA is below (or equal to) 40 and zero otherwise. WLA(40-50) and $WLA(> 50)$ are similarly defined. $WLA(Low)$ ($WLA(High)$) equals WLA if the fund's WLA is below (above) the weekly median and zero otherwise. Columns (1)–(2) control for WLA. Columns (3)–(4) control for $WLA(\leq 40)$, WLA(40-50), and $WLA(> 50)$. Columns (5)–(6) control for $WLA(Low)$ and $WLA(High)$. Other fund controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), and logarithms of fund size. The bottom two rows show the p-values of the F-tests for the equality of the coefficients of the interaction terms between $Crisis$ and WLA variables, where L stands for $WLA(\leq 40)$ or $WLA(Low)$, M stands for WLA(40-50), and H stands for $WLA(> 50)$ or $WLA(High)$. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow						
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis × WLA	0.187***	0.193***				
	(0.054)	(0.056)				
Crisis × WLA(≤40)			0.398***	0.399***		
			(0.131)	(0.123)		
Crisis × WLA(40-50)			0.356***	0.357***		
			(0.123)	(0.116)		
Crisis × WLA(>50)			0.312***	0.315***		
			(0.093)	(0.092)		
Crisis × WLA(Low)					0.266***	0.269***
					(0.051)	(0.053)
Crisis × WLA(High)					0.239***	0.243***
					(0.047)	(0.049)
Adj. R^2	0.259	0.257	0.263	0.260	0.260	0.257
Obs.	1018	1018	1018	1018	1018	1018
Lagged dependent variable	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes
Parallel trend check		Yes		Yes		Yes
p-value: Crisis×L = Crisis×M	N/A	N/A	0.02	0.03	N/A	N/A
p-value: Crisis×L = Crisis×H	N/A	N/A	0.04	0.02	0.08	0.10

Table 9: **Normalized distance of WLA to 30% and crisis outflows**

The sample includes only institutional prime MMFs. The sample spans from February 6, 2020 to March 20, 2020, with $Crisis$ equal to one from March 9 to March 20. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. $NormDistance$ is the normalized distance of WLA to the 30% threshold. Specifically, $NormDistance = (WLA - 30)/(PreWLA - 30)$, where WLA is the share of weekly liquid assets in total assets (in percent) as of day $t-2$, and $PreWLA$ is the average WLA of the same fund calculated over the period from January 5 to February 5 (i.e., one month before the sample window). $NormDistance(Low)$ equals $NormDistance$ if the fund's $NormDistance$ is below sample median and zero otherwise. $NormDistance(High)$ is similarly defined. Columns (1)–(3) control for $NormDistance$. Columns (4)–(6) control for $NormDistance(Low)$, and $NormDistance(High)$. Other fund controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), logarithms of fund size, expense ratio, bank affiliation dummy, and fund age. The last row show the p-values of the F-tests for the equality of the coefficients of the interaction terms between $Crisis$ and $NormDistance$ variables, where L stands for $NormDistance(Low)$ and H stands for $NormDistance(High)$. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow						
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis × NormDistance	2.973**	2.950**	3.265**			
	(1.421)	(1.267)	(1.444)			
Crisis × NormDistance (Low)				4.964***	5.358***	5.674***
				(1.640)	(1.599)	(1.538)
Crisis × NormDistance (High)				3.910**	4.068***	4.343***
				(1.470)	(1.353)	(1.396)
Adj. R^2	0.252	0.250	0.250	0.253	0.252	0.251
Obs.	1,018	1,018	1,018	1,018	1,018	1,018
Lagged dependent variable	Yes	Yes	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	Yes	Yes	Yes	Yes
Day FEs	Yes	Yes	Yes	Yes	Yes	Yes
Fund FEs		Yes	Yes		Yes	Yes
Parallel trend check			Yes			Yes
p-value: Crisis×L = Crisis×H	N/A	N/A	N/A	0.08	0.02	0.02

Table 10: **Crisis outflows and WLA, instrumental variable approach**

The sample includes only institutional prime MMFs The sample spans the crisis period only (March 9 to March 20). The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. WLA is the share of weekly liquid assets in total assets (in percent), as of day $t-2$. In Columns (3) to (4), WLA is instrumented for by $Maturing$, which equals the cumulative share of assets maturing up to day t from the start of the crisis (using information from the February N-MFP reports). $Flow_{t-1}$ is the one-day lag of the dependent variable. Other controls are as of the most recent Tuesday, including abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), the logarithm of fund size, expense ratio, bank affiliation dummy, and fund age. Standard errors (in parentheses) are clustered at the day level.

Estimator:	**OLS**		**IV**	
			First Stage	
			Dep. var.: WLA	
	(1)	(2)	(3)	(4)
Maturing			0.573***	0.571***
			(0.090)	(0.081)
			Second Stage	
Dependent variable: daily fund percentage flow				
WLA	0.105**	0.094*	0.377**	0.315*
	(0.046)	(0.045)	(0.152)	(0.166)
Log(AUM)	-0.388	-0.354	-0.374	-0.347
	(0.218)	(0.213)	(0.211)	(0.207)
Abnormal Yield	1.046	1.684	14.457	12.446
	(5.793)	(5.613)	(9.794)	(10.323)
Risk	-0.067	-0.059	2.198	1.773
	(1.766)	(1.863)	(2.312)	(2.345)
Safe	-4.751	-4.815	-4.776	-4.826
	(9.326)	(9.705)	(9.344)	(9.609)
Bank affiliation	-0.607	-0.450	0.331	0.286
	(0.405)	(0.431)	(0.517)	(0.556)
Expense ratio	7.277***	6.113***	8.921***	7.612***
	(1.418)	(1.350)	(2.090)	(2.060)
Fund age	-0.037*	-0.032	-0.018	-0.017
	(0.020)	(0.019)	(0.025)	(0.022)
$Flow_{t-1}$		0.160**		0.137*
		(0.056)		(0.064)
Adj. R^2	0.269	0.287	0.013	0.066
Obs.	327	327	327	327
First-stage F statistic			40	50
Day FE	Yes	Yes	Yes	Yes

Table 11: **Prime MMFs' WLA deterioration and usage of the MMLF**

The sample is at the fund-CUSIP level and includes CP (including ABCP) and CDs held by prime MMFs at the end of February with maturity beyond March 31 (i.e., one week after the launch date of the MMLF). The dependent variable is the percentage of a security holding by a fund that is pledged at the MMLF during its first two weeks of operations, ranging between 0 and 100. $Log(Time\ to\ Maturity)$ is the logarithm of the residual days to maturity of the security as of the end of February. $Crisis\ \Delta WLA$ is the net change in the fund's WLA during the crisis period. $Crisis\ fund\ flow$ is the fund's cumulative percentage flow during the crisis period from March 9 to March 20. *Institutional* is a dummy variable equal to one if the prime MMF is an institutional fund. Security-level controls include security yield and share of the security in the fund's AUM at the end of February. All securities are categorized into four types: nonfinancial CP, financial CP, ABCP, and CDs, and the security type fixed effects are included in all specifications. Fund-level controls include abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), logarithms of fund size, expense ratio, bank affiliation dummy, and fund age, as of the most recent Tuesday before the launch of the MMLF. Standard errors (in parentheses) are two-way clustered at the fund and CUSIP level.

Dependent variable: share of securities pledged at the MMLF				
	(1)	(2)	(3)	(4)
log(Time to maturity)	5.722***	6.605***	6.498***	6.337***
	(0.805)	(0.963)	(0.950)	(0.950)
Institutional	9.437***			
	(2.734)			
Crisis ΔWLA		-1.010***	-1.290***	
		(0.410)	(0.411)	
Crisis fund flow			0.136	
			(0.138)	
Sample	All prime	Institutional	Institutional	Institutional
Adj. R^2	0.163	0.189	0.189	0.208
Obs.	4784	2303	2303	2303
Security-level controls	Yes	Yes	Yes	Yes
Security type FE	Yes	Yes	Yes	Yes
Fund-level controls		Yes	Yes	
Fund FE				Yes

Table 12: **Prime MMF flows around the launch of the MMLF**

The daily sample goes from March 9, 2020 to April 3, 2020. Columns (1)–(3) include both retail and institutional prime MMFs, while Columns (4)–(5) only institutional funds. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. $Institutional$ is a dummy equal to one for institutional prime funds. $MMLF$ is a dummy equal to one from March 23 onwards. $Flow_{t-1}$ is the one-day lag of the dependent variable. Controls are lagged variables including WLA, abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), logarithms of fund size, expense ratio, bank affiliation dummy, and fund age. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow					
	All Prime MMFs			**Institutional Prime**	
	(1)	(2)	(3)	(4)	(5)
Flow_{t-1}	0.236***	0.217***	0.163***	0.215***	0.102*
	(0.055)	(0.052)	(0.044)	(0.058)	(0.050)
MMLF	0.864**	-0.042		1.520**	
	(0.337)	(0.167)		(0.556)	
Institutional		-1.295***	-1.371***		
		(0.362)	(0.388)		
MMLF × Institutional		1.638***	1.704***		
		(0.504)	(0.540)		
MMLF × WLA					-0.102**
					(0.036)
Adj. R^2	0.143	0.159	0.204	0.137	0.225
Obs.	1154	1154	1154	647	647
Controls	Yes	Yes	Yes	Yes	Yes
Day FE			Yes		Yes

Table 13: **The effect of the MMLF: domestic vs. offshore prime MMFs**

The daily sample goes from March 9, 2020 to April 3, 2020 and includes (domestic) institutional prime funds and offshore USD institutional prime funds. The dependent variable is the daily percentage change in fund AUM on day t, winsorized at the 0.5% and 99.5% levels. *Domestic* is a dummy equal to one for domestic institutional prime funds. $MMLF$ is a dummy equal to one from March 23 onwards. $MMLF\_WeekOne$ equals one during the first week of the post-MMLF period and $MMLF\_WeekTwo$ equals one during the second week. $Flow_{t-1}$ is the one-day lag of the dependent variable. Controls are as of the most recent Tuesday for domestic funds and the most recent Friday for offshore funds, including WLA (the share of weekly liquid assets in total assets, in percent), abnormal yield (in excess of cross-sectional average), safe holdings (Treasury and agency debt as share of fund AUM), risky holdings (CP and CDs), and logarithms of fund size. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent variable: daily fund percentage flow				
	(1)	(2)	(3)	(4)
Flow_{t-1}			0.165***	0.093**
			(0.042)	(0.033)
MMLF	0.980			
	(0.569)			
Domestic	-1.170**	-1.170**	0.930	0.996
	(0.544)	(0.544)	(0.682)	(0.700)
MMLF × Domestic	0.941*			
	(0.529)			
MMLF_WeekOne		0.109	0.218	
		(0.718)	(0.713)	
MMLF_WeekOne × Domestic		1.324**	1.017*	1.171*
		(0.521)	(0.542)	(0.620)
MMLF_WeekTwo		1.851***	1.361***	
		(0.410)	(0.331)	
MMLF_WeekTwo × Domestic		0.558	0.511	0.582
		(0.573)	(0.529)	(0.597)
Adj. R^2	0.047	0.059	0.108	0.165
Obs.	1079	1079	1022	1022
Controls			Yes	Yes
Day FE				Yes