

# 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 might have 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). By providing “liquidity of last resort,” the MMLF stopped the MMF run and stabilized short-term funding markets.

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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 a set 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%.<sup>1</sup> 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.”<sup>2</sup>

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. 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. These incentives to redeem ahead of others are likely to increase when funds’ WLAs get closer to the 30% regulatory threshold. 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.<sup>3</sup>

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

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<sup>1</sup>Henceforth, we refer to this reform as the 2016 MMF reform.

<sup>2</sup>See <https://www.sec.gov/news/public-statement/2014-07-23-open-meeting-statement-mjw>.

<sup>3</sup>See <https://www.sec.gov/news/public-statement/2014-07-23-open-meeting-statement-kms>.

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. Fitch Ratings echoed the same sentiment, stating that investors' attention is all about funds' WLAs.<sup>4</sup>

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 fund can raise overnight rather than later in the week.<sup>5</sup> 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

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<sup>4</sup>See source: [Fed's money market move lifts Northern Trust fund above key threshold](#).

<sup>5</sup>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.

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. 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.

While the existing regulations on MMFs do not seem to have prevented the run from happening, we find that emergency interventions by the Federal Reserve were effective in stemming outflows from MMFs and stabilizing short-term funding markets. 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.<sup>6</sup> 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. By stabilizing prime MMFs, the MMLF also increased their confidence in investing in longer-term securities, which ultimately led to broader improvements in funding markets. Our findings are consistent with the classical lender of last resort theory ([Bagehot, 1873](#)), which suggests that the key to calming markets is to stabilize the institutions that are suffering runs. Indeed, using micro-level data from the MMLF, we find that funds that suffered larger declines in WLAs during the crisis relied more on the "liquidity of last resort" provided by the MMLF.

One potential complication in evaluating the effect of the MMLF is that a number of liquidity and credit facilities were created by the Federal Reserve around the same time. Some of those facilities could have potentially helped to stabilize prime MMF flows by improving liquidity conditions in the CP and CD markets. To address this concern, we exploit the presence of similar but MMLF-ineligible funds, namely offshore institutional USD prime MMFs that invest in the same pool of assets (including CP and CDs) and experienced severe outflows (about 25% of AUMs) during the Covid-19 crisis. If the stabilization of institutional prime fund flows during the post-MMLF period was mainly due to broad-based improvements in CP and CD market conditions, we should observe a similar rebound in fund flows for offshore USD prime MMFs as well. However, our results show that domestic institutional prime MMFs had a much quicker and larger rebound in

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<sup>6</sup>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.

their flows following the implementation of the MMLF relative to the MMLF-ineligible offshore funds.

Conditions in the CP and CD markets also started to improve following the launch of the MMLF. We develop various strategies to differentiate the MMLF effects on the CP and CD markets from those of other Federal Reserve facilities. First, we exploit the differential eligibility requirements on credit ratings to evaluate the MMLF impact. Only instruments with the highest ratings are eligible under the MMLF, while other facilities also accepted those with lower ratings. Consistent with a stabilizing effect of the MMLF, we find that the improvements in market conditions were concentrated among top-rated instruments. Second, we show that corporations that relied more heavily on prime MMFs before the crisis experienced larger reductions in yield spreads and greater issuance volumes during the post-MMLF period. Finally, given the pricing terms of the MMLF, only securities with yields greater than 125 basis points (bps) were economical for banks to pledge at the facility. We confirm that the rebound in issuance after the implementation of the MMLF was indeed concentrated among those securities.

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](#)).<sup>7</sup> 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

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<sup>7</sup>Relatedly, [Kacperczyk and Schnabl \(2010\)](#); [Covitz, Liang and Suarez \(2013\)](#); [Pérignon, Thesmar and Vuillemy \(2017\)](#); [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.

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 understand the mechanisms through which Fed interventions stabilize MMF flows and restore short-term funding market conditions in a crisis. 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. In addition, we are the first to study the effect of the MMLF on normalizing issuance in the CP market and the first to expand the analysis to the CD market.

Furthermore, we contribute to the discussion on the post-2008 liquidity regulations and reforms.<sup>8</sup> 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.

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<sup>8</sup>Macchiavelli and Pettit (2020), Roberts, Sarkar and Shachar (2018), and Xiao and Sundaresan (2020) study the impact of the liquidity coverage ratio (LCR) on maturity and liquidity transformation by broker-dealers and commercial banks.

## 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.

### 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.<sup>9</sup>

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.

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<sup>9</sup>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 to 60 days.

## 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 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.<sup>10</sup> 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.<sup>11</sup> The MMLF was created under the authority granted by Section 13(3) of the Federal Reserve Act, which allows the Federal

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<sup>10</sup>It is worth noting that the secondary markets for CP and CDs depend on dealer intermediation and are very illiquid even in normal times.

<sup>11</sup>For a complete timeline of the Federal Reserve interventions during the Covid-19 crisis, see Appendix Table A.1.

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.<sup>12</sup> Initially, MMLF-eligible assets included CP as well as government 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.<sup>13</sup> 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).<sup>14</sup> 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

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<sup>12</sup>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.

<sup>13</sup>Variable-rate demand notes (VRDNs) are variable-rate notes issued by municipalities, usually with 1-day or 7-day demand features. Tax-exempt MMFs are major investors in VRDNs.

<sup>14</sup>WLA, DLA, NAV information is not available before 2016, and NAV information is for institutional prime MMFs only.

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.

To evaluate the effectiveness of the MMLF, we collect additional data from several sources. First, to identify the effect of the MMLF in stemming redemptions from prime 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.

Second, 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.

Lastly, we obtain the confidential micro level CP and CD data from DTCC Solutions LLC, an affiliate of The Depository Trust & Clearing Corporation (DTCC).<sup>15</sup> The DTCC data provide detailed information for each primary market trade in CP and CDs, including CUSIP, transaction date, maturity date, yield, and issued amount. They also include daily total par amount outstanding for each instrument. We merge the DTCC data with

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MMFs' security-level holdings data from their N-MFP filings to identify the effect of MMLF on CP and CD markets.

## 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 \(2005\)](#).<sup>16</sup> 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.<sup>17</sup> For mutual 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.

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<sup>16</sup>[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.

<sup>17</sup>For empirical evidence, see [Chen, Goldstein and Jiang \(2010\)](#) and [Goldstein, Jiang and Ng \(2017\)](#).

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  $i$ .  $WLA_{i,t-2}$  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.<sup>18</sup> 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

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<sup>18</sup>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.

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 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 1.92% in the crisis period relative to normal times. In contrast, the same drop in WLA for funds with WLA above 50% is associated with 1.43% additional daily outflows. 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. If our results are indeed driven by asset 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.

In sum, the results of Table 3 support hypothesis H3 and highlight the role played by

the potential imposition of gates and fees (rather than asset illiquidity) in exacerbating runs during the Covid-19 crisis. These results also alleviate the concern that our findings are driven by enhanced disclosure requirements on fund liquidity conditions. 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 on a daily basis. To the extent that such public disclosure provides a precise signal on the true liquidity conditions of MMFs, it could also intensify strategic complementarities in investor redemptions (Goldstein and Pauzner, 2005). However, since funds are required to disclose both DLA and WLA, our finding that investor flows respond only to WLA but 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.

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.<sup>19</sup> 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 4 presents summary statistics for institutional

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<sup>19</sup>For funds with both institutional and retail share classes, which were more common in 2008, we remove their retail share classes.

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. 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.<sup>20</sup> 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 5) 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.

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<sup>20</sup>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.

First, we consider another regulatory change that could have also affected investor redemption decisions in stressed market conditions. Specifically, in addition to the option 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 6 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.<sup>21</sup> 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

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<sup>21</sup>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 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.

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 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 Hortag̃su, 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 6 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 6).

Fourth, [Kacperczyk and Schnabl \(2013\)](#) show that MMFs' sponsorship could affect funds' risk taking behaviors and hence run patterns during a crisis.<sup>22</sup> 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 6 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. To address this concern, we re-estimate Equations 1 and 2 by further controlling for fund fixed effects. Table 7 shows that our results are robust to the inclusion of fund fixed effects.

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-

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<sup>22</sup>For details about sponsor support provided to MMFs during the Covid-19 crisis, see Appendix B.

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 8, 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

The run on prime MMFs during the Covid-19 crisis led the Federal Reserve to intervene by introducing the MMLF. In this section, we first empirically evaluate the effect of the MMLF in stemming large-scale outflows from prime MMFs, especially from those with lower WLA. Given the potential confounding effects of other policy actions around the same time, we design tests to identify MMLF-specific effects by comparing the behavior of MMLF-eligible and ineligible funds. In addition, we use the micro-level MMLF data and confirm that prime funds with larger declines in their WLA levels during the crisis indeed made greater use of the facility. Lastly, we evaluate the effectiveness of the MMLF in restoring conditions in CP and CD markets.

## 5.1 Prime MMF Flows around the Launch of the MMLF

Prime MMFs experienced significant outflows in the two weeks leading up to the implementation of the MMLF on March 23, 2020. 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:

$$Flow_{i,t} = \beta_1 MMLF_t + Controls_{i,t-1} + \varepsilon_{i,t}, \quad (3)$$

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 9 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 3. Column (2) of Table 9 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 3 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.

## 5.2 Identifying the MMLF Effect on Prime MMF Flows

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 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.<sup>23</sup> 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).<sup>24</sup> Since offshore USD prime funds are not eligible to participate in 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:

$$Flow_{i,t} = \beta_1 Domestic_i + \beta_2 MMLF_t + \beta_3 Domestic_i \times MMLF_t + \varepsilon_{i,t}, \quad (4)$$

where  $Domestic_i$  is a dummy that equals one for domestic institutional prime funds. All other variables are defined as in Equation 3, and standard errors are two-way clustered at the fund and day levels.

Column (1) of Table 10 suggests that broad-based improvements in short-term funding market conditions cannot fully explain the rebound in domestic prime fund flows. During

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<sup>23</sup>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.

<sup>24</sup>Offshore USD prime funds share many similar features with institutional prime funds. In addition 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%.

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. We divide the post-MMLF period into the first week of operations (*MMLF\_WeekOne*) and the second week (*MMLF\_WeekTwo*), and estimate the following model:

$$\begin{aligned} Flow_{i,t} = & \beta_1 Domestic_t + \beta_2 MMLF\_WeekOne_t + \beta_3 MMLF\_WeekTwo_t \\ & + \beta_4 MMLF\_WeekOne_t \times Domestic_i + \beta_5 MMLF\_WeekTwo_t \times Domestic_i + \varepsilon_{i,t}. \end{aligned} \quad (5)$$

Column (2) of Table 10 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, as shown by the positive and highly significant coefficient of *MMLF\_WeekTwo<sub>t</sub>* and the insignificant coefficient of its interaction with *Domestic<sub>i</sub>*. 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 CP and CD markets (documented in Section 5.4) ultimately benefited also offshore funds.

### 5.3 What Drives Actual Usage of the MMLF?

To further understand the direct impact of the MMLF on prime funds, we analyze the micro-level MMLF data and study how prime funds utilized the MMLF during its first two weeks of operation.<sup>25</sup> In particular, we aim to explore whether funds that lost more liquid buffers during the crisis period are more likely to use the facility. We also test whether securities that weigh more on MMFs' liquidity conditions, i.e. those with longer maturities, 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.<sup>26</sup> Finally, we merge fund-level information from iMoneyNet to the fund-CUSIP dataset.

We start by estimating the following regression on the sample of all prime MMFs:

$$\begin{aligned} SharePledged_{i,j} = & \beta_1 \text{Log}(\text{Time to Maturity}_j) + \beta_2 \text{Institutional}_i \\ & + \beta_3 \mathbb{1}(\text{Type})_j + \text{Controls}_j + \varepsilon_{i,j}, \quad (6) \end{aligned}$$

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.  $\text{Log}(\text{Time to Maturity}_j)$  is the logarithm of the residual days to maturity of the security as of the end of February.  $\text{Institutional}_i$  is a dummy variable that takes the value of one

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<sup>25</sup>The usage of the MMLF was substantial. Within the first seven business days of MMLF operations, MMFs in total were able to offload about \$53 billion worth of assets to the facility, representing 8% of all prime fund assets as of March 25. Public MMF data from ICI show that as of March 25, 2020, prime funds in total managed \$659 billion of assets, and institutional prime MMFs had \$223 billion of assets under management. Note that some tax-exempt MMFs also participated in the MMLF. Also, the usage of MMLF was concentrated in the first two weeks of operation, accounting for about 95% of its total usage, as of November 20, 2020.

<sup>26</sup>No Treasury securities or agency debt has been pledged under the MMLF. Only two municipal bonds were pledged to the MMLF by certain prime funds. We treat them as outliers.

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 (6) 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 changes in WLA are related to MMLF usage, we augment Equation (6) as follows:

$$SharePledged_{i,j} = \beta_1 \text{Log}(\text{Time to Maturity})_j + \beta_2 \text{Crisis } \Delta WLA_i + \beta_3 \mathbb{1}(Type)_j + Controls_j + Controls_i + \varepsilon_{i,j}, \quad (7)$$

where  $\text{Crisis } \Delta WLA_i$  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 (6) 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  $\text{CrisisFlow}_i$  (representing fund  $i$ ’s cumulative percentage flow during the crisis period) as an additional explanatory variable.  $\text{Crisis } \Delta WLA_i$  remains highly significant while  $\text{CrisisFlow}_i$  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.

## 5.4 The Effects of the MMLF on CP and CD Markets

As the MMLF stabilized MMF flows and restored their liquidity conditions, prime funds were once again able to purchase CP and CDs at tenors greater than one week. We now turn to evaluate the impact of the MMLF on CP and CD markets, focusing on the set of instruments that are more likely to benefit from the MMLF. In particular, given that money funds tend to lend to firms with which they have pre-existing relationships (Chernenko and Sunderam, 2014; Li, 2020), we expect the MMLF effect to be stronger for firms that rely more heavily on money funds for funding. In addition, since only top rated CP is MMLF-eligible and only CP issued at a rate higher than the MMLF loan rate is economically beneficial to pledge, we expect stronger MMLF effects for those instruments.

We use DTCC’s transaction level data which cover all trades in U.S. commercial paper and contain detailed information on each CP issuance, including yield, maturity, and amount issued. We also obtain CP ratings from Moody’s and S&P.<sup>27</sup> Based on the number of days to maturity, we assign each CP to one of the following ten term buckets: overnight, 1 and 2 weeks, 1, 2, 3, 4, 5, 6 and 9 months.<sup>28</sup> For each CP issuance, its spread to OIS is calculated by subtracting from its yield the OIS rate for the same term bucket. Lastly, we calculate the volume weighted average spread across instruments issued by the same CP issuer  $j$ , on the same day  $t$ , and within the same term bucket  $m$  ( $Spread_{j,t,m}$ ). Our final dataset consists of issuer-day-term level observations for the period that spans

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<sup>27</sup>As CP can be rated differently by these two rating agencies, we follow the principle used by the MMLF in determining the CP’s credit quality and assign the lower of the two ratings. CP with ratings in the top two notches (A1 (including A1+)/P1 and A2/P2) account for 91% of the data, with those in the top notch alone accounting for 62%.

<sup>28</sup>Trades in these 10 term buckets together account for over 99% of the data. CP with time to maturity longer than 9 months are excluded from our study due to very limited issuance at those terms.

two weeks before and two weeks after the launch of the MMLF, namely from March 9, 2020 to April 3, 2020.

Our first identification strategy focuses on the differential effect of the MMLF across CP of different credit quality. To be eligible for the MMLF, CP must carry the highest rating, i.e. A1/P1. If the MMLF stabilized the CP market following its launch on March 23, we would expect such effect to be stronger among MMLF-eligible CP, namely top rated CP. To test this hypothesis, we create the dummy  $TopRating_{j,t}$  that takes the value of one if CP issuer  $j$ 's rating is A1/P1 (including A1+) on day  $t$ , and estimate the following model:

$$Spread_{j,t,m} = \beta MMLF_t \times TopRating_{j,t} + \mu_j + \mu_t + \mu_m + \mu_r + \varepsilon_{j,t,m} \quad (8)$$

where  $MMLF_t$  is a dummy for the two weeks following the launch of MMLF, and  $\mu_j$ ,  $\mu_t$ ,  $\mu_m$ ,  $\mu_r$  represent issuer, day, maturity, and rating fixed effects, respectively. Standard errors are two-way clustered at the issuer and day levels. Consistent with our expectation, Column (1) of Table 12 shows that spreads for top rated CP declined more following the launch of the MMLF. The coefficient of the interaction of  $MMLF$  and  $TopRating$  is negative and highly significant. The magnitude is also economically meaningful. A1/P1-rated CP experienced an additional 45 bps decline in spreads compared to other lower-rated CP during the two weeks post MMLF.

Our second test identifies the MMLF effect based on our earlier findings on the impact of the MMLF on money fund flows. Since CP issuers rely on MMFs for funding to different degrees, we test whether CP issuers that depend more on MMFs benefit more from the MMLF than those less dependent on MMFs. We use the end-of-February security-level holdings of MMFs to capture each CP issuer's reliance on MMFs for funding prior to the launch of the MMLF. Specifically, for each CP issuer, we aggregate the total amount of its CP held by MMFs at the end of February 2020. We normalize that amount by the average daily CP outstanding amount during February 2020 for the issuer (data obtained

from DTCC) and name it  $ShareMMF_{j,t}$ . We hypothesize that if the MMLF stabilized the CP market by stemming money fund outflows, its impact on CP spreads would be stronger for CP more heavily held by money funds.

To test this hypothesis, we replace  $TopRating_{j,t}$  with  $ShareMMF_{j,t}$  and re-estimate Equation 8. Consistent with our hypothesis, the coefficient of the interaction between  $MMLF$  and  $ShareMMF$  is negative and highly significant (Table 12, Column (2)), suggesting that spreads declined by more for CP more heavily held by money funds. As prime funds are more likely to sell CP with longer maturity to the MMLF, we re-estimate Equation 8 on term CP (excluding overnight paper) and get somewhat stronger results (Column (3)).

It is worth noting that right before the launch of the MMLF, the Federal Reserve created the Primary Dealer Credit Facility (PDCF) to aid primary dealers and support smooth market functioning (see Appendix Table A.1). As the credit extended to primary dealers under the PDCF improved dealers' funding conditions, one might argue that it could have also contributed to the improvements in CP spreads during the post-MMLF period. While we are not able to completely rule out this possibility, we note that the MMLF effect that we identified is likely to be above and beyond the PDCF effect. Unlike the MMLF, the PDCF accepts both A1/P1 and A2/P2 rated CP as eligible collateral. The incremental decline in spreads for A1/P1 rated CP likely reflects the impact of the MMLF on CP spreads. Moreover, dealers can pledge at the PDCF CP that they bought from all types of market participants, not just money funds. The stronger effect on issuers more reliant on MMFs suggests that the MMLF had a significant effect over and above the PDCF. These findings also alleviate the concern that the CP spread improvements were driven by the announcement of the Commercial Paper Funding Facility (CPFF) on March 17, as its CP purchases are broad-based and independent from the levels of MMF holdings. Finally, the fact that we find a similar effect on the CD market, as discussed later in this section, further supports an MMLF, rather than a CPFF, effect.

In addition to lowering the spreads, the MMLF was also believed to have contributed

to more robust CP issuance. In the days prior to the creation of the MMLF, CP issuance dropped precipitously and many market participants viewed the CP market as essentially frozen. After the launch of the MMLF, money funds were once again willing to buy CP, knowing that they could offload it to the MMLF for cash in case of future runs.

To evaluate the MMLF effect on CP issuance, we use the same CP sample and estimate the following model:

$$\text{Log}(Issuance)_{j,t,m} = \beta MMLF_t \times TopRating_{j,t} + \mu_j + \mu_t + \mu_m + \mu_r + \varepsilon_{j,t,m} \quad (9)$$

where  $\text{Log}(Issuance)_{j,t,m}$  is the logarithm of one plus the amount issued by borrower  $j$  on day  $t$  with time to maturity within maturity bucket  $m$ . Since no issuance on a given day is also valuable information, we treat issuer-day-term observations with no issuance as zero issuance.

Results in Table 12 (Columns (4) to (10)) support the view that the MMLF improved the CP market by resuming new issuance. Top-rated CP issuers experienced a larger increase in issuance volume in the post-MMLF period (Column (4)). In addition, borrowers that rely more heavily on MMFs for funding were able to issue more CP after the implementation of the MMLF. When we replace  $TopRating_{j,t}$  with  $ShareMMF_{j,t}$  and re-estimate Equation 9, the coefficient of the interaction of  $MMLF$  and  $ShareMMF$  is positive and highly significant (Column (5)). The MMLF effect on CP issuance is also evident when we focus on term CP (Column (6)).

Another salient feature of the MMLF is its pricing schedule. Under the MMLF, banks can pledge CP and CDs (purchased from MMFs) as collateral and obtain funding at the rate of 125 bps (100 bps above the discount window's primary credit rate). Because of this MMLF pricing, CP issued at 125 bps or above would be more attractive for MMFs because it could be pledged to the MMLF without either the MMF or the bank incurring a loss. Hence, the MMLF effect should be stronger for CP issued at or above 125 bps.

Exploring this pricing feature, we develop our third test to identify the MMLF effect

on the CP market. Specifically, we re-estimate Equation 9 separately for CP issued at rates above and below 125 bps. We find that CP with rate above 125 bps benefited particularly from the MMLF. Columns (7) and (8) of Table 12 show that issuance rebounded significantly more for CP issuers more reliant on MMFs only when the CP rate is above 125 bps. The coefficient of the interaction between *MMLF* and *ShareMMF* is positive and highly significant for CP with rates above 125 bps, but negative and insignificant for rates below 125 bps. Excluding overnight issuance from the sample yields similar findings (Columns (9) and (10)). The limited effect of the MMLF on issuance of more expensive CP (with rates below 125 bps) suggests that MMFs were not particularly interested in purchasing these instruments since they may not have been able to offload them to the MMLF without incurring a loss.

Similar MMLF effects are also present in the CD market. Using the DTCC data for CDs, we estimate similar models for the yield spread to OIS and issuance volume at the issuer-term-day level. Results in Table 13 are consistent with a stabilizing effect of the MMLF on short-term funding markets. Borrowers more reliant on funding from MMFs experienced significantly larger declines in borrowing costs (Column (1)) and greater issuance (Column (2)) after the implementation of the MMLF. The issuance effect is concentrated among CD instruments offering more than 125 bps, similarly to what we found for CP instruments (Columns (3) and (4)).<sup>29</sup>

## 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

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<sup>29</sup>The sample size for CD is smaller than that for CP due to the fact that CDs have significantly longer maturities and therefore they do not need to be rolled over as frequently as it is the case for CP. Also, there are more CP issuers, both financial and non-financial, than CD issuers, which are mostly foreign banks in need of dollar funding.

of having gates and fees imposed on them generates strong strategic complementarities among MMF investors, leading to large-scale 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.

We also show that the MMLF was effective in stemming prime fund outflows and normalizing short-term funding market conditions. Using a battery of identification strategies, we show that the estimated stabilization effects on both prime funds and short-term funding markets can be attributed to the MMLF, and are not driven by other concurrent policy actions.

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.<sup>30</sup> 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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<sup>30</sup>See, for example, <https://www.wsj.com/articles/money-market-fund-rules-likely-fall-short-policy-makers-say-11601413919>.

## References

- Acharya, Viral V, Michael J Fleming, Warren B Hrungr, and Asani Sarkar.** 2017. “Dealer financial conditions and lender-of-last-resort facilities.” *Journal of Financial Economics*, 123(1): 81–107.
- Armantier, Olivier, Eric Ghysels, Asani Sarkar, and Jeffrey Shrader.** 2015. “Discount window stigma during the 2007–2008 financial crisis.” *Journal of Financial Economics*, 118(2): 317–335.
- Bagehot, Walter.** 1873. *Lombard Street, A Description of the Money Market*. Henry King and Co.: London and reprinted in 1907 Charles Scribner’s Sons: New York.
- Borusyak, Kirill, and Xavier Jaravel.** 2017. “Revisiting event study designs.” *Available at SSRN 2826228*.
- Carlson, Mark, and Marco Macchiavelli.** 2020. “Emergency loans and collateral upgrades: How broker-dealers used Federal Reserve credit during the 2008 financial crisis.” *Journal of Financial Economics*.
- Chen, Qi, Itay Goldstein, and Wei Jiang.** 2010. “Payoff complementarities and financial fragility: Evidence from mutual fund outflows.” *Journal of Financial Economics*, 97(2): 239–262.
- Chernenko, Sergey, and Adi Sunderam.** 2014. “Frictions in shadow banking: Evidence from the lending behavior of money market mutual funds.” *The Review of Financial Studies*, 27(6): 1717–1750.
- Chernenko, Sergey, and Adi Sunderam.** 2016. “Liquidity transformation in asset management: Evidence from the cash holdings of mutual funds.” *NBER Working Paper*.
- Chernenko, Sergey, and Adi Sunderam.** 2020. “Do fire sales create externalities?” *Journal of Financial Economics*, 135(3): 602–628.

- Cipriani, Marco, Antoine Martin, Patrick E McCabe, and Bruno Maria Parigi.** 2014. “Gates, fees, and preemptive runs.” *FRB of New York Staff Report*, , (670).
- Copeland, Adam, Antoine Martin, and Michael Walker.** 2014. “Repo Runs: Evidence from the Tri-Party Repo Market.” *The Journal of Finance*, 69(6): 2343–2380.
- Covitz, Daniel, Nellie Liang, and Gustavo Suarez.** 2013. “The Evolution of a Financial Crisis: Collapse of the Asset-Backed Commercial Paper Market.” *Journal of Finance*, 68(3): 815–848.
- Diamond, Douglas W, and Philip H Dybvig.** 1983. “Bank runs, deposit insurance, and liquidity.” *Journal of Political Economy*, 91(3): 401–419.
- Duygan-Bump, Burcu, Patrick Parkinson, Eric Rosengren, Gustavo A Suarez, and Paul Willen.** 2013. “How effective were the Federal Reserve emergency liquidity facilities? Evidence from the asset-backed commercial paper money market mutual fund liquidity facility.” *The Journal of Finance*, 68(2): 715–737.
- Falato, Antonio, Itay Goldstein, and Ali Hortaçsu.** 2020. “Financial fragility in the COVID-19 crisis: The case of investment funds in corporate bond markets.” *NBER Working Paper*.
- Gallagher, Emily A., Lawrence D.W. Schmidt, Allan Timmermann, and Ross Wermers.** 2020. “Investor Information Acquisition and Money Market Fund Risk Rebalancing during the 20112012 Eurozone Crisis.” *Review of Financial Studies*, 33(4): 1445–1483.
- Goldstein, Itay, and Ady Pauzner.** 2005. “Demand–deposit contracts and the probability of bank runs.” *Journal of Finance*, 60(3): 1293–1327.
- Goldstein, Itay, Hao Jiang, and David T Ng.** 2017. “Investor flows and fragility in corporate bond funds.” *Journal of Financial Economics*, 126(3): 592–613.

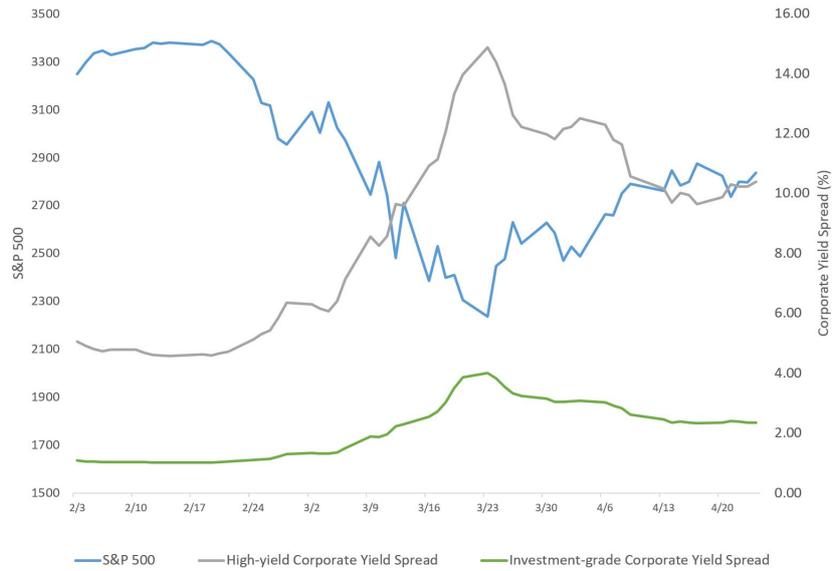
- Gorton, Gary, and Andrew Metrick.** 2010. “Regulating the Shadow Banking System.” *Brookings Paper on Economic Activity*, 261–312.
- Gorton, Gary, and Andrew Metrick.** 2012. “Securitized banking and the run on repo.” *Journal of Financial Economics*, 104(3): 425–451.
- Hanson, Samuel G., David S. Scharfstein, and Adi Sunderam.** 2015. “An Evaluation of Money Market Fund Reform Proposals.” *IMF Economic Review*, 63: 984–1023.
- Ivashina, Victoria, David S Scharfstein, and Jeremy C Stein.** 2015. “Dollar funding and the lending behavior of global banks.” *The Quarterly Journal of Economics*, 130(3): 1241–1281.
- Kacperczyk, Marcin, and Philipp Schnabl.** 2010. “When Safe Proved Risky: Commercial Paper during the Financial Crisis of 2007–2009.” *Journal of Economic Perspectives*, 24: 29–50.
- Kacperczyk, Marcin, and Philipp Schnabl.** 2013. “How safe are money market funds?” *The Quarterly Journal of Economics*, 128(3): 1073–1122.
- La Spada, Gabriele.** 2018. “Competition, reach for yield, and money market funds.” *Journal of Financial Economics*, 129(1): 87–110.
- Lenkey, Stephen, and Fenghua Song.** 2016. “Redemption Fees and Information-Based Runs.” *Available at SSRN 2796717*.
- Li, Yi.** 2020. “Reciprocal lending relationships in shadow banking.” *Journal of Financial Economics (forthcoming)*.
- Macchiavelli, Marco, and Luke Pettit.** 2020. “Liquidity Regulation and Financial Intermediaries.” *Journal of Financial and Quantitative Analysis (forthcoming)*.
- McCabe, Patrick E.** 2010. “The Cross Section of Money Market Fund Risks and Financial Crises.” *FEDS Working Paper*.

- McCabe, Patrick E., Marco Cipriani, Michael Holscher, and Antoine Martin.** 2013. “The Minimum Balance at Risk: A Proposal to Mitigate the Systemic Risks Posed by Money Market Funds.” *Brookings Papers on Economic Activity*, 211–256.
- Pérignon, Christophe, David Thesmar, and Guillaume Vuillemeys.** 2017. “Wholesale Funding Dry-Ups.” *The Journal of Finance*.
- Roberts, Daniel, Asani Sarkar, and Or Shachar.** 2018. “Bank liquidity provision and Basel liquidity regulations.” *Federal Reserve Bank of New York Staff Reports*, no. 852.
- Schmidt, Lawrence, Allan Timmermann, and Russ Wermers.** 2016. “Runs on money market mutual funds.” *American Economic Review*, 106(9): 2625–57.
- Strahan, Philip E, and Başak Tanyeri.** 2015. “Once burned, twice shy: Money market fund responses to a systemic liquidity shock.” *Journal of Financial and Quantitative Analysis*, 50(1-2): 119–144.
- Xiao, Kairong.** 2020. “Monetary transmission through shadow banks.” *Review of Financial Studies*, 33(6): 2379–2420.
- Xiao, Kairong, and Suresh M. Sundaresan.** 2020. “Unintended Consequences of Post-Crisis Liquidity Regulation.” *Working Paper*.
- Zeng, Yao.** 2017. “A dynamic theory of mutual fund runs and liquidity management.” *Available at SSRN 2907718*.

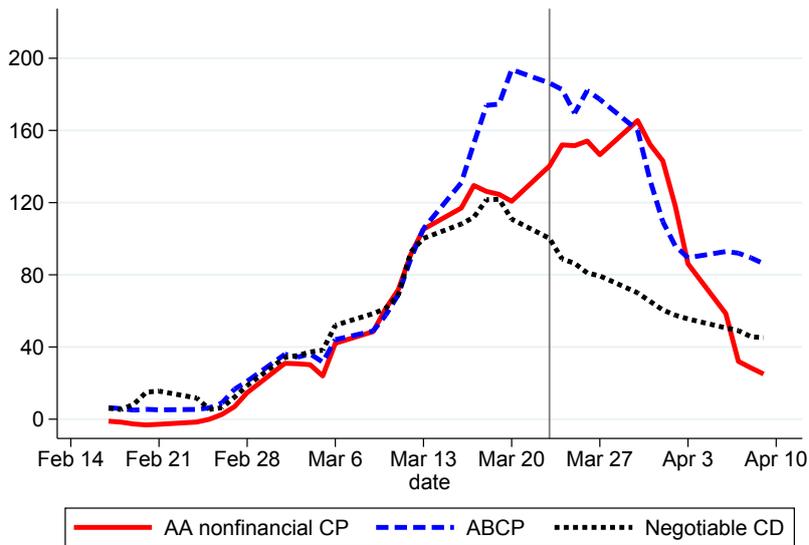
Figure 1: **Distress in funding markets during the Covid-19 crisis**

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)



Note: Yield spreads are calculated as three-day moving averages.

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.

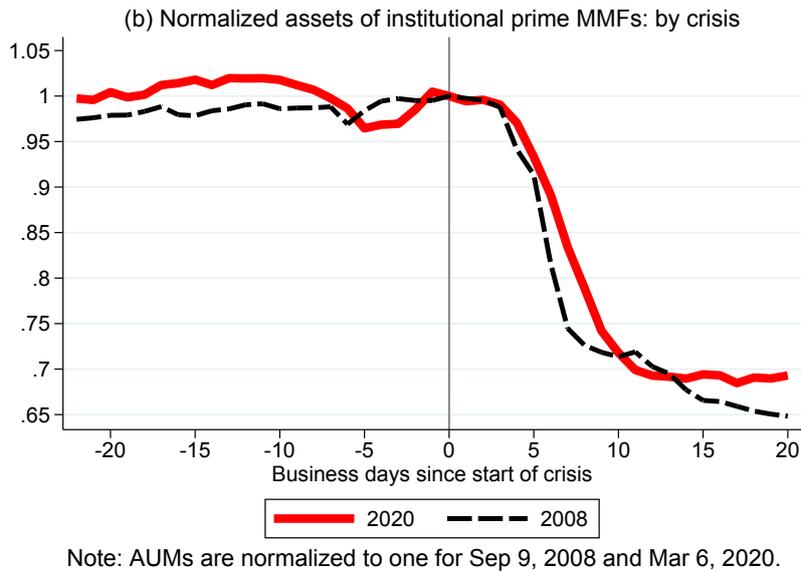
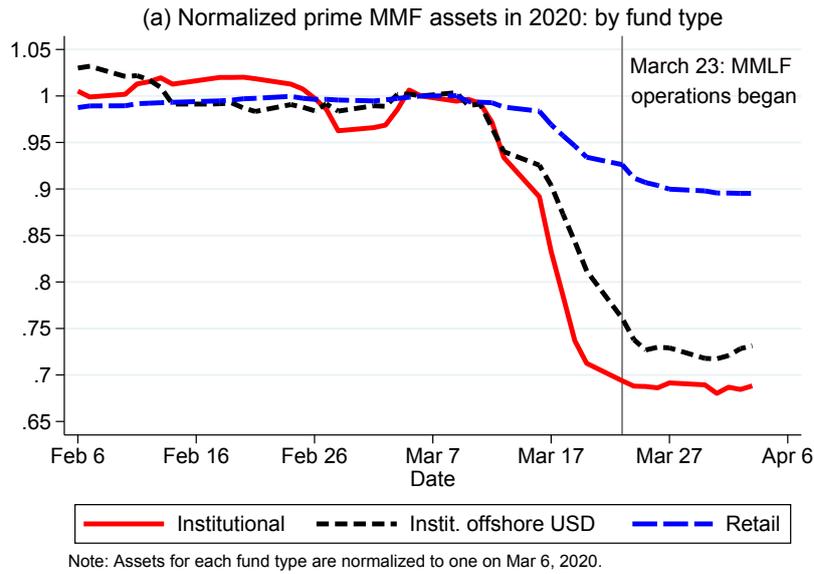


Figure 3: **WLA levels and prime MMF runs**

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  $WLA \leq 40$ ,  $WLA$  between 40 and 50, and  $WLA > 50$ ), rebalanced daily. Assets of each WLA group are normalized to one on March 6, 2020.

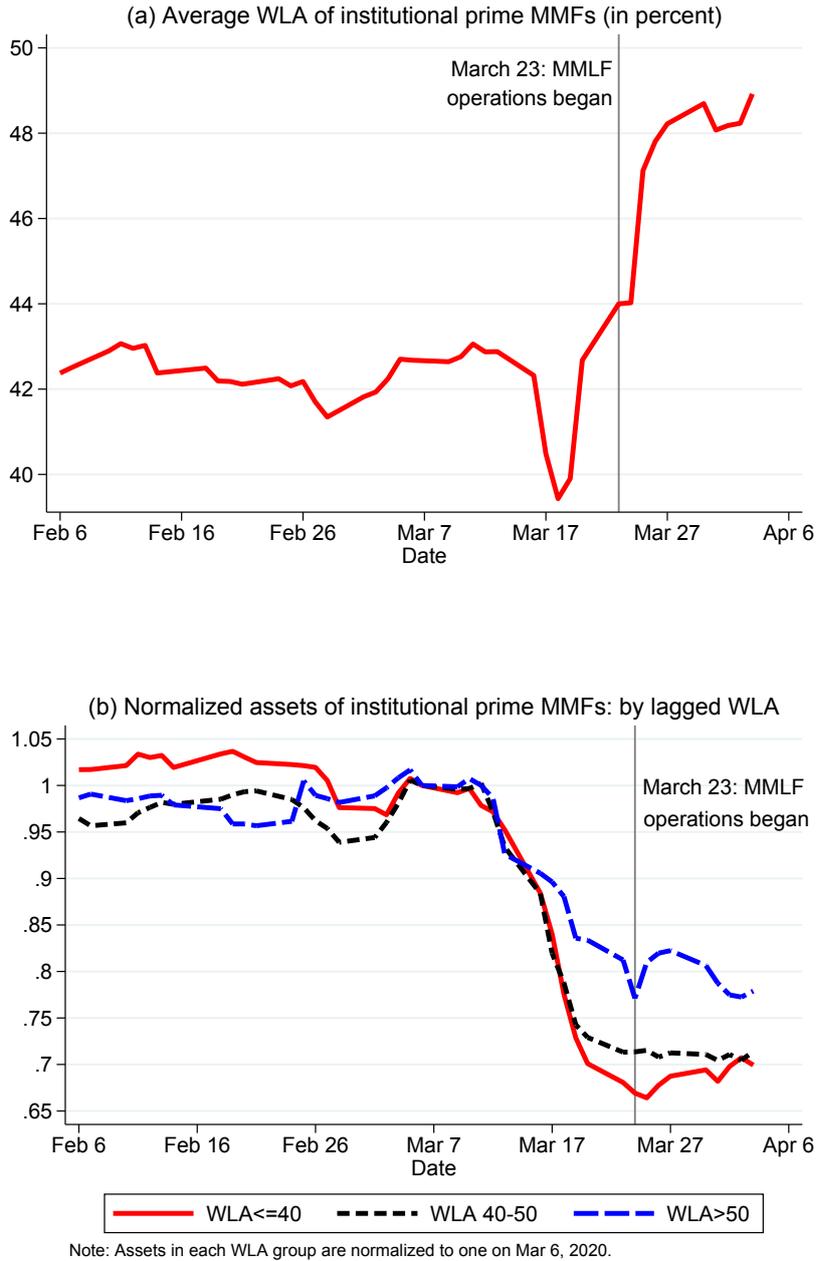


Table 1: **Fund WLA levels and crisis outflows**

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 $\times$ PreCrisis(-3)				0.008	0.012
				(0.036)	(0.037)
WLA $\times$ PreCrisis(-2)				0.031	0.030
				(0.032)	(0.035)
WLA $\times$ 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. 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 $\times$ $WLA(\leq 40)$	0.308*** (0.084)	0.297*** (0.089)	0.290*** (0.086)			
Crisis $\times$ $WLA(40-50)$	0.265*** (0.085)	0.258*** (0.083)	0.254*** (0.082)			
Crisis $\times$ $WLA(> 50)$	0.230*** (0.061)	0.228*** (0.063)	0.229*** (0.067)			
Crisis $\times$ $WLA(Low)$				0.206*** (0.031)	0.218*** (0.041)	0.220*** (0.049)
Crisis $\times$ $WLA(High)$				0.175*** (0.032)	0.188*** (0.037)	0.192*** (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 $\times$ L = Crisis $\times$ M	0.00	0.03	0.05	N/A	N/A	N/A
p-value: Crisis $\times$ L = Crisis $\times$ 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*** (1.266)		-6.982*** (2.087)	
DLA	-0.004 (0.015)	-0.006 (0.018)	0.004 (0.013)	0.003 (0.016)
Crisis $\times$ DLA	0.038 (0.039)	0.062 (0.043)	-0.020 (0.047)	0.007 (0.055)
WLA			-0.012 (0.026)	-0.014 (0.027)
Crisis $\times$ WLA			0.125** (0.058)	0.118* (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: **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 5: **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. 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 $\times$ WLA	0.023** (0.010)	0.022** (0.010)				
Crisis $\times$ WLA( $\leq 40$ )			-0.006 (0.024)	-0.027 (0.022)		
Crisis $\times$ WLA(40-50)			0.033* (0.019)	0.019 (0.016)		
Crisis $\times$ WLA( $> 50$ )			0.015 (0.012)	0.008 (0.011)		
Crisis $\times$ WLA(Low)					0.014 (0.021)	-0.001 (0.019)
Crisis $\times$ WLA(High)					0.021* (0.012)	0.016 (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 6: 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 (968.120)		-4.625 (3.734)		-9.100*** (2.568)		-9.694*** (2.349)		-5.688** (2.071)	
Alt Channel	0.060 (0.044)	-0.018 (0.044)	0.017 (0.016)	0.019 (0.018)	-0.010 (0.031)	-0.026 (0.041)	-1.664 (1.100)	-1.786 (1.280)	0.161 (0.248)	0.184 (0.270)
Crisis $\times$ Alt Channel	0.030 (0.097)	-0.091 (0.109)	-0.064 (0.049)	-0.077 (0.052)	0.152 (0.098)	0.178 (0.108)	9.447*** (2.364)	10.512*** (2.533)	-0.876* (0.507)	-1.021* (0.590)
WLA	-0.011 (0.033)	-0.009 (0.033)	-0.017 (0.041)	-0.025 (0.042)	-0.038 (0.032)	-0.050 (0.033)	-0.022 (0.027)	-0.029 (0.028)	-0.001 (0.030)	-0.004 (0.031)
Crisis $\times$ WLA	0.098** (0.044)	0.124*** (0.041)	0.105* (0.055)	0.104* (0.057)	0.147*** (0.046)	0.156*** (0.050)	0.135*** (0.039)	0.148*** (0.038)	0.090* (0.044)	0.096** (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 7: **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. 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 $\times$ WLA	0.187*** (0.054)	0.193*** (0.056)				
Crisis $\times$ WLA( $\leq 40$ )			0.398*** (0.131)	0.399*** (0.123)		
Crisis $\times$ WLA(40-50)			0.356*** (0.123)	0.357*** (0.116)		
Crisis $\times$ WLA( $> 50$ )			0.312*** (0.093)	0.315*** (0.092)		
Crisis $\times$ WLA(Low)					0.266*** (0.051)	0.269*** (0.053)
Crisis $\times$ WLA(High)					0.239*** (0.047)	0.243*** (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 $\times$ L = Crisis $\times$ M	N/A	N/A	0.02	0.03	N/A	N/A
p-value: Crisis $\times$ L = Crisis $\times$ H	N/A	N/A	0.04	0.02	0.08	0.10

Table 8: **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	
	(1)	(2)	(3)	(4)
			<b>First Stage</b>	
			<b>Dep. var.: WLA</b>	
Maturing			0.573***	0.571***
			(0.090)	(0.081)
			<b>Second Stage</b>	
	<b>Dependent variable: daily fund percentage flow</b>			
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 9: **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*** (0.055)	0.217*** (0.052)	0.163*** (0.044)	0.215*** (0.058)	0.102* (0.050)
MMLF	0.864** (0.337)	-0.042 (0.167)		1.520** (0.556)	
Institutional		-1.295*** (0.362)	-1.371*** (0.388)		
MMLF $\times$ Institutional		1.638*** (0.504)	1.704*** (0.540)		
MMLF $\times$ 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 10: **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*** (0.042)	0.093** (0.033)
MMLF	0.980 (0.569)			
Domestic	-1.170** (0.544)	-1.170** (0.544)	0.930 (0.682)	0.996 (0.700)
MMLF $\times$ Domestic	0.941* (0.529)			
MMLF_WeekOne		0.109 (0.718)	0.218 (0.713)	
MMLF_WeekOne $\times$ Domestic		1.324** (0.521)	1.017* (0.542)	1.171* (0.620)
MMLF_WeekTwo		1.851*** (0.410)	1.361*** (0.331)	
MMLF_WeekTwo $\times$ Domestic		0.558 (0.573)	0.511 (0.529)	0.582 (0.597)
Adj. $R^2$	0.047	0.059	0.108	0.165
Obs.	1079	1079	1022	1022
Controls			Yes	Yes
Day FE				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.  $\log(\text{Time to Maturity})$  is the logarithm of the residual days to maturity of the security as of the end of February.  $\text{Crisis } \Delta WLA$  is the net change in the fund's WLA during the crisis period.  $\text{Crisis fund flow}$  is the fund's cumulative percentage flow during the crisis period from March 9 to March 20.  $\text{Institutional}$  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.

<b>Dependent variable: share of securities pledged at the MMLF</b>				
	(1)	(2)	(3)	(4)
$\log(\text{Time to maturity})$	5.722*** (0.805)	6.605*** (0.963)	6.498*** (0.950)	6.337*** (0.950)
Institutional	9.437*** (2.734)			
Crisis $\Delta WLA$		-1.010*** (0.410)	-1.290*** (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: MMLF effects on the commercial paper market

The sample is at the issuer-day-term level and goes from March 9, 2020 to April 3, 2020. Spread is the difference in percentage points between the instrument yield and the OIS rate at equivalent maturity. Log(Issuance) is the logarithm of one plus the issuance amount by the issuer on a given day. TopRating equals one for the A1/P1 rated CP. MMLF equals one after the MMLF operations began on March 23, 2020. ShareMMF is the share of an issuer's instrument held by MMFs at the end of February 2020. Standard errors (in parentheses) are two-way clustered at the issuer and day levels.

Dependent variable:	Spread			Log(Issuance)			Log(Issuance)			
	(1)	(2)	(3)	(4)	(5)	(6)	$\geq 125bps$	$< 125bps$	$\geq 125bps$	$< 125bps$
Primary Market Rate:										
TopRating $\times$ MMLF	-0.446** (0.167)			3.012*** (0.733)						
ShareMMF $\times$ MMLF		-1.050*** (0.318)	-1.178*** (0.270)		3.894** (1.541)	3.897** (1.542)	4.228** (1.682)	-1.073 (0.933)	4.208** (1.675)	-1.055 (0.930)
Sample	Full	Full	Term	Full	Full	Term	Full	Full	Term	Term
Adj. R <sup>2</sup>	0.825	0.821	0.829	0.521	0.517	0.516	0.393	0.564	0.393	0.565
Obs.	7,820	7,820	4,911	99,000	99,000	89,100	99,000	99,000	89,100	89,100
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Term FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 13: **MMLF effects on the certificates of deposit market**

The sample is at the issuer-day-term level and goes from March 9, 2020 to April 3, 2020. Spread is the difference in percentage points between the instrument yield and the OIS rate at equivalent maturity. Log(Issuance) is the logarithm of one plus the issuance amount by the issuer on a given day. MMLF equals one after the MMLF operations began on March 23, 2020. ShareMMF is the share of an issuer's instrument held by MMFs at the end of February 2020. Standard errors (in parentheses) are two-way clustered at the issuer and day levels.

Dependent variable:	Spread	Log(Issuance)		
		$\geq 125bps$	$< 125bps$	
Primary Market Rate:				
	(1)	(2)	(3)	(4)
ShareMMF $\times$ MMLF	-0.532** (0.249)	0.946* (0.462)	0.680** (0.263)	0.275 (0.298)
Adj. R <sup>2</sup>	0.679	0.060	0.041	0.034
Obs.	389	10,880	10,880	10,880
Issuer FE	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes
Term FE	Yes	Yes	Yes	Yes

## **Appendix A: MMLF and other emergency facilities**

There are a couple of other Federal Reserve facilities that were announced around the time of the MMLF announcement and might also have some impact on the CP and CD markets. The Commercial Paper Funding Facility (CPFF) was announced on March 17. CPFF supports liquidity in the CP market by purchasing paper directly from issuers and by giving investors confidence that issuers will be able to roll maturing CP. However, the CPFF was not operational until April 14, where the market conditions had improved substantially since MMLF operations began on March 23.

There are several important differences between CPFF and MMLF. First, while CPFF buys newly issued CP, MMLF loans are secured by assets that are purchased by banks from MMFs' existing holdings. Second, collaterals under MMLF can have maturity ranging from overnight to 12 months, while CPFF only buys 3-month CP. Lastly, the pricing of CP under MMLF and CPFF are quite different. To access the CPFF, issuers must pay an upfront facility fee equal to 10 basis points of the maximum amount of its commercial paper that CPFF may own. Under CPFF, for A1/P1 rated commercial paper, pricing will be based on the then-current 3-month overnight index swap (OIS) rate plus 110 basis points and for commercial paper rated A2/P2/F2, then-current 3-month OIS rate plus 200 basis points. On the other hand, MMLF has no facility fees. MMLF loans secured by CP are priced at PCR plus 100 bps.

The Primary Dealer Credit Facility (PDCF) was also announced on March 17. PDCF provides credit to primary dealers of the New York Fed against a broad range of collateral, including CP and CD. The maximum maturity of PDCF loans is 90 days and PDCF loans are priced at PCR regardless of loan maturity or collateral.

There are several important differences between PDCF and MMLF. First, PDCF is open only to the 24 primary dealers, while MMLF is accessible by all US banks, affiliates of US bank holding companies, and US branches of foreign banks. Second, PDCF loans have maturity up to 90 days, while MMLF loans have maturity up to 12 months. Third,

under PDCF, primary dealers cannot pledge securities issued by themselves as collateral for loans. There is no such limitation on MMLF collateral. Fourth, PDCF loans do not have preferential treatment with respect to regulatory capital ratios, and are made with recourse beyond the pledged collateral to the primary dealers. MMLF loans do not affect banks' capital ratios and have no recourse. Fifth, A2/P2-rates CP and CDs are eligible collateral for PDCF loans, while MMLF loans only accept A1/P1-rates CP and CDs as collateral. Last, the PDCF loans are priced at a fixed rate equal to the PCR, regardless of collateral type or loan maturity and loan amount is limited to the amount of margin-adjusted eligible collateral. MMLF loans have no margin-adjustments and are priced at a fixed spread over PCR, depending on the type of the collateral.

Table A.1: **Timeline of Main Federal Reserve Interventions**

This table summarizes the timeline of major interventions by the Federal Reserve during the Covid-19 crisis. CPFF refers to the Commercial Paper Funding Facility; PDCF to Primary Dealer Credit Facility; MMLF to Money Market Mutual Fund Liquidity Facility; PMCCF to Primary Market Corporate Credit Facility; SMCCF to Secondary Market Corporate Credit Facility; TALF to Term Asset-Backed Securities Loan Facility; PPPLF to Paycheck Protection Program Lending Facility; MLF to Municipal Liquidity Facility; MSLP to Main Street Lending Program. Finally, VRDNs stands for variable rate discount notes and CDs for certificates of deposit.

Date	Federal Reserve Actions & Announcements
March 3, 2020	Cut interest rate by 50 bps
March 15, 2020	Cut interest rates by another 100 bps to [0, 25] bps
March 15, 2020	Asset purchases resumed (\$500 bln Treasuries; \$200 bln agency MBS)
March 15, 2020	Primary credit rate (discount window) lowered to 25 bps
March 15, 2020	US dollar liquidity swap lines with major foreign central banks
March 17, 2020	Announcement of CPFF (to be operational on April 14)
March 17, 2020	Announcement of PDCF (to be operational on March 20)
March 18, 2020	Announcement of MMLF (to be operational on March 23)
March 20, 2020	MMLF expanded to accept short-term municipal debt
March 23, 2020	FOMC removes upper limit on asset purchases
March 23, 2020	MMLF became operational
March 23, 2020	MMLF expanded to accept VRDNs and CDs
March 23, 2020	Announcement of PMCCF & SMCCF & TALF
April 9, 2020	Announcement of PPPLF & MLF & MSLP

## **Appendix B: MMFs during the crisis: WLA breach and sponsor support**

During the Covid-19 crisis, only one institutional prime MMF had breached the 30% WLA threshold. Northern Institutional Prime Obligations Portfolio was one of the smallest institutional prime funds, with about \$4 billion of assets under management before the crisis. Over the two-week crisis period (March 9-20), the fund lost almost half of its AUMs (48%) due to investor redemptions.

On March 17, the fund's WLA fell below 30% to 27%. Prime MMFs are not required to impose gates or fees after their WLAs fall below 30%, though they cannot purchase any assets that do not qualify as WLAs until after their WLAs climb back to 30%. The board of Northern Institutional Prime Obligations Portfolio decided not to impose gates or fees on its investors. Nevertheless, the fund continued to experience outflows.

The fund quickly stocked up its WLA after the launch of the MMLF. By April 3 (i.e., two weeks after the launch of the MMLF), its WLA had reached a whopping 81%. However, such effort did not help to restore its AUMs as investors lost confidence in the fund. As a result, the board decided to liquidate the fund by July 10, 2020.

MMFs are required to disclose any form of financial support from their sponsor within one business day of receiving the support in Form N-CR. Only two MMF sponsors had provided support to their prime MMFs during the Covid-19 crisis. Bank of New York Mellon bought long-term securities (with maturity up to February 2021) from one of its institutional prime funds, Dreyfus Cash Management Fund, on March 18 and 19, after the fund's WLA dropped to 32% on March 17. With the liquidity support from its sponsor, the fund was able to keep its WLA above 35% on March 18 and 19.

Similarly, Goldman Sachs bought long-term securities from two of its institutional prime funds, Goldman Sachs Financial Square Money Market Fund and Goldman Sachs Financial Square Prime Obligations Fund, on March 19 and 20. These two funds' WLAs were 35% and 39% before the sponsor support.