Runs and Interventions in the Time of Covid-19: Evidence from Money 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 during crises. However, we find evidence that they might have exacerbated the run on prime MMFs during the Covid-19 crisis. Severe outflows from prime MMFs amid frozen short-term funding markets led the Federal Reserve to intervene with the Money Market Mutual Fund Liquidity Facility (MMLF). By providing "liquidity of last resort," the MMLF successfully stopped the run on prime MMFs and gradually stabilized conditions in short-term funding markets.

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1 Introduction

In the aftermath of the 2007-09 financial crisis, financial regulators worldwide introduced a new wave of regulations aimed at promoting financial stability. Various liquidity regulations were designed to make financial institutions capable of withstanding funding stress without the need for emergency interventions. As the financial crisis revealed the fragility of money market funds (MMFs), the Securities and Exchange Commission (SEC) introduced a set of reforms to enhance the stability of the MMF industry. In particular, the reform adopted by the SEC in 2014 introduced new liquidity rules for prime MMFs, which can invest in relatively risky securities, such as commercial paper (CP) and negotiable certificates of deposit (CDs). This reform, implemented in 2016, allows prime MMFs to impose redemption gates and liquidity fees on their investors once their liquidity buffers, namely weekly liquid assets (WLA) that can be converted into cash within a week, fall below 30% of total assets.[1]

The intention of such reform was to endow MMFs with tools to stem investor runs on their own. Their proponents, including then-SEC Chair Mary Jo White, argued that redemption gates and liquidity fees would "mitigate [the run] risk and the potential impact for investors and markets."[2] However, the possibility that MMFs may impose gates and fees when their liquidity buffers fall below a certain threshold could incentivize investors to run *preemptively* before such liquidity restrictions are imposed. In a public statement, SEC Commissioner Kara Stein questioned whether gates and fees were the right tool to address run risk. She noted that allowing funds to impose gates and fees "could actually increase an investor's incentive to redeem," especially in a crisis.[3]

In this paper, we study the anatomy of the run on prime MMFs during the Covid-19 crisis to understand how the MMF liquidity rules might have changed the dynamics of fund flows under strained liquidity conditions. We find that the possibility of imposing gates and fees might have exacerbated the run on prime MMFs (especially the less liq-

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

uid ones) in March 2020. Unlike during the 2008 financial crisis and the 2011 Eurozone sovereign debt crisis, prime MMF outflows were more severe for funds with lower liquidity buffers during the Covid-19 crisis. In an attempt to preserve liquidity amid heavy outflows, prime funds stopped providing term financing to banks and corporations. Faced with an ever-worsening liquidity crisis, the Federal Reserve intervened.

We show that the Money Market Mutual Fund Liquidity Facility (MMLF) launched by the Federal Reserve was effective in stemming outflows from MMFs. 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 liquidity buffers during the crisis relied more on the "liquidity of last resort" provided by the MMLF. In addition to stopping MMF runs, we also identify significant stabilizing effects of the MMLF on short-term funding markets, lending support to the arguments that the lender of last resort enables financial institutions to continue to supply credit to the ultimate borrowers (Moulton, 1918; Tucker, 2014).

In late February, with increasing Covid-19 cases in the U.S. and Europe, capital markets started to experience turmoil (panel (a) in Figure 1). By mid-March, yield spreads on various short-term funding securities, including CP and CDs, had surged 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.

Institutional investors ran more intensely on funds with lower liquidity buffers (panel (b) of Figure 2). Although net flows were similar across funds with different levels of WLAs before mid-March, lower WLA funds experienced substantially larger outflows between mid-March and the Federal Reserve interventions. To assess the potential impact of contingent liquidity restrictions (i.e., gates and fees) on fund outflows, we compare the run during the Covid-19 crisis to the previous two prominent MMF runs, namely the run surrounding the September 2008 Lehman bankruptcy (Duygan-Bump et al., 2013; Kacperczyk and Schnabl, 2013; Schmidt, Timmermann and Wermers, 2016) and the Eurozone sovereign debt crisis run in the summer of 2011 (Chernenko and Sunderam, 2014; Gallagher et al., 2020). The Covid-19 and 2008 runs are fairly similar in terms of speed and intensity, with institutional prime funds losing about 30% of assets in about 2 weeks (Figure 3), while the 2011 run is relatively milder and more gradual. We find that fund outflows were highly sensitive to fund liquidity holdings during the 2020 crisis, but such relationship was absent in either the 2008 or the 2011 crisis.

In particular, during the 2020 crisis, a one-standard-deviation (6.4%) decrease in WLA is associated with an additional 0.9 percentage-point increase in daily outflows relative to normal times. This effect is both statisitcally and economically significant, representing about one third of the average daily outflow during the crisis period. In addition, the sensitivity of outflows to fund liquidity is larger for less liquid funds during the Covid-19 crisis, while this is not the case during the two previous crises. Our findings suggest that the contingent liquidity restrictions might have exacerbated the run during the 2020 Covid-19 crisis.[4]

The run on MMFs led them to hoard liquidity and refrain from investing in instruments with maturities longer than one week, putting further pressure on the already strained CP and CD markets. In response to the precarious conditions in money markets, the Federal Reserve announced in the late evening of March 18 a plan to launch the Money Market Mutual Fund Liquidity Facility (MMLF) to support MMFs and related markets. The MMLF enabled MMFs to liquidate some of their assets to meet redemptions and increased their confidence in investing in longer-tenor securities.[5] Dur-

[4]The 2016 MMF reform also required institutional prime MMFs to transact at a floating net asset value (NAV). However, we do not find evidence that lower floating NAVs drive additional outflows during the Covid-19 crisis (see Appendix Table A.2). While funds' NAVs saw some declines during the crisis, they were never close to "breaking the buck".

[5]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

ing the two weeks following the launch of the MMLF, institutional prime funds' daily flows rebounded by about 2 percentage points on average. Moreover, funds with lower WLA experienced a stronger rebound in flows, suggesting that the facility was especially beneficial to less liquid funds. Indeed, using micro-level data from the MMLF, we find that funds that suffered larger declines in liquidity 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 potentially help stabilize prime MMF flows by improving liquidity conditions in the CP and CD markets. To address this concern, we design two additional tests to identify the incremental effect of the MMLF relative to other interventions. First, 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 their flows following the implementation of the MMLF relative to the MMLF-ineligible offshore funds. Second, we use the security-level holdings of MMFs from their N-MFP filings at the end of February 2020 and test whether the recovery in fund flows was stronger for funds that held more MMLF-eligible assets. Our results show that prime funds with more MMLF-eligible holdings indeed experienced a larger rebound in flows after the MMLF was launched. Overall, our analyses lend strong support to the view that the MMLF helped stabilize the MMF industry during the Covid-19 crisis.

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 effect on the

similar to banks selling the assets that they bought from MMFs to the Fed.

CP and CD markets from that 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 accept 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 instruments that were more heavily held by prime MMFs before the crisis experienced larger reductions in yield spreads and greater issuance volume 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 volume after the implementation of the MMLF was indeed concentrated among those securities.

Our paper lies at the intersection of a few literatures. 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). 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). Relatedly, Kacperczyk and Schnabl (2010); Covitz, Liang and Suarez (2013); Pérignon, Thesmar and Vuillemey (2017); Gorton and Metrick (2012); Copeland, Martin and Walker (2014) document the funding freeze in asset-backed commercial paper (ABCP), CDs, and repurchase agreements in 2008. We contribute to the MMF run literature by identifying a new run pattern driven by investors' heightened sensitivity to fund liquidity, which suggests that the potential imposition of liquidity restrictions can be especially destabilizing during a crisis.

A number of papers study the effectiveness of Federal Reserve emergency lending during the 2007-09 crisis (Armantier et al., 2015; Acharya et al., 2017; Carlson and Macchiavelli, 2020). In particular, Duygan-Bump et al. (2013) study the effects of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF) on stemming the run on money funds and normalizing ABCP yield spreads. Echoing Duygan-Bump et al. (2013), we show the effectiveness of the MMLF in stabilizing money fund flows and bringing down CP and CD yield spreads. In addition, we show that market condition improvements are not only in lowering spreads but also in restoring issuance, and that such improvements occurred specifically for the instruments more heavily held by prime MMFs. We also add to Duygan-Bump et al. (2013) by studying both fund-level and security-level determinants of MMLF usage.

Furthermore, we contribute to the literature on the post-2008 liquidity regulations. Macchiavelli and Pettit (2018), 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. On the topic of MMF reforms, Hanson, Scharfstein and Sunderam (2015) evaluate various 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, both McCabe et al. (2013) and Hanson, Scharfstein and Sunderam (2015) argue that redemption gates could exacerbate runs from distressed MMFs. In a theoretical framework, Cipriani et al. (2014) discuss the possibility that the introduction of redemption gates and liquidity fees may trigger preemptive runs.[6] Baghai, Giannetti and Jäger (2018); Cipriani and La Spada (forthcoming) study the effects of the 2016 MMF reform on the premium paid by investors to maintain moneyness and on the risk-taking of the surviving prime funds. 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.

Lastly, we contribute to the literature on CP and CD markets. Covitz and Downing (2007) show that both liquidity and credit risks are important determinants of CP yield spreads. Kahl, Shivdasani and Wang (2015) document that CP is an important source of short-term funding for nonfinancial firms, with the benefit of low transaction costs

[6] Relatedly, Ma (2015) has a structural model of repo runs and compares the implications of safe harbor and automatic stay.

but carrying substantial rollover risk. Kacperczyk, Perignon and Vuillemey (2017) study prices and issuance of CDs in Europe and find that CD issuance is sensitive to the information environment. In this paper, we show that interventions to stabilize MMFs can quickly restore the functioning of CP and CD markets.

2 Institutional Background

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

2.1 Money Market Funds

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 monetary policy transmission (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 2007-09 financial crisis, which saw one prime fund "breaking the buck" due to its exposure to Lehman Brothers and the subsequent 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.[7]

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 fall 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 "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,

[7]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.

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 MMFs during the Covid-19 crisis.

2.2 The Money Market Mutual Fund Liquidity Facility (MMLF)

As short-term funding markets started to show signs of stress in early March 2020, investors began to run from prime MMFs. MMFs had to tap into their liquidity buffers to meet investor redemptions, as the secondary markets for CP and CDs were essentially frozen. Many prime funds saw their WLAs declining quickly, some close to or even below the 30% minimum requirement. In order to preserve liquidity, prime funds stopped lending at tenors greater than one week, adding further pressure to the CP and CD markets.

To restore liquidity and functioning in short-term funding markets and stabilize the MMF industry, the Federal Reserve announced the establishment of the Money Market Mutual Fund Liquidity Facility (MMLF) on March 18.[8] The MMLF was created under the authority granted by Section 13(3) of the Federal Reserve Act, which allows the Federal Reserve to establish facilities with broad-based eligibility to lend to any market participant in case of "unusual and exigent circumstances". Operated by the Federal Reserve Bank of Boston, the facility provided nonrecourse loans for banks to purchase certain high-quality assets from MMFs. Banks would pledge those assets as collateral for the loans. Economically, pledging assets to the MMLF is similar to selling the assets to the Federal Reserve.[9] The MMLF began operations on March 23.

Initially, MMLF-eligible assets included CP as well as government securities. The list of eligible assets was expanded on two occasions: on March 20 to include short-term

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

[9]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.

municipal debt and on March 23 to include CDs and variable-rate demand notes.[10] The MMLF loans are priced at a fixed spread over the Primary Credit Rate (PCR, or discount rate), depending on the type of the collateral. For example, loans secured by CP and CDs are priced at PCR plus 100 bps.

Due to the strong demand for MMLF liquidity, banks quickly set up their operations and started to purchase assets from prime MMFs as soon as the facility went into operation. The Federal Reserve's H.4.1 data show that MMLF loans outstanding spiked to $30.6 billion on March 25 in just two days of operations, climbed to $52.7 billion on April 1, and reached $53.2 billion on April 7.[11]

3 Data

Our data come from multiple sources. First, we obtain share class level MMF information from iMoneyNet. The iMoneyNet data include three files with various information reported at different frequencies. For both domestic MMFs (i.e., 2a-7 funds, as defined by the SEC) and offshore U.S. Dollar MMFs, we obtain assets under management (AUM) from the daily file, and weekly liquid assets (WLA), fund yields, expense ratios, as well as funds' portfolio compositions from the weekly file.[12] Some additional information, such as fund inception date and bank affiliation, is retrieved from the monthly file for domestic funds. iMoneyNet also provides investor type information (i.e., institutional or retail) for domestic MMFs. We manually collect investor type information for offshore USD prime funds from their prospectus. All share class level information from iMoneyNet is aggregated to the fund level.

[10] 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.

[11] As the runs on prime funds subsided, so did new loans under the MMLF. Indeed, as fewer new loans were originated than the matured ones, MMLF loans outstanding started to decline after April 7, to $50.7 billion on April 15 and $48.8 billion on April 22.

[12] Note that neither the official concept of WLA nor the minimum requirement existed in 2008. We calculate the WLA in 2008 as the sum of assets maturing in 7 days, Treasury securities, and government agency debt, which is the closest estimate based on the definition of WLA. Also, in some additional analyses, we use fund floating NAVs, which were also obtained from the daily files.

Second, the confidential micro-level CP and CD data are obtained from DTCC Solutions LLC, an affiliate of The Depository Trust & Clearing Corporation (DTCC).[13] The DTCC data include both transaction level data for each trade in CP and CDs and daily total par amount outstanding for each instrument. The transaction data provide detailed information for each primary market trade, including CUSIP, transaction date, maturity date, yield, and issued amount. We rely on the DTCC data to evaluate the impact of the MMLF on the CP and CD markets.

Third, we complement the iMoneyNet and DTCC data with MMFs' security-level holdings data from their N-MFP filings to the SEC. Each 2a-7 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. The N-MFP data are essential in identifying the effect of MMLF on fund flows and CP and CD market conditions. Specifically, with MMFs' holdings data, we are able to analyze whether funds with more MMLF-eligible assets benefited more from the MMLF and whether the MMLF had a larger effect on CP and CDs more heavily held by MMFs.

Finally, we obtain 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 collateral CUSIP, the amount pledged, and the MMF that sold the collateral to the borrowing bank.

4 Runs on prime MMFs: What is new this time?

From late February to early March 2020, as equity and bond markets went into a tailspin, stress in short-term funding markets mounted and prime MMFs saw large redemptions

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from their institutional investors in mid-March (Figures 1 and 2). Prime MMFs potentially have two ways to find cash 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 buffer (i.e., WLA) fall below 30% of their assets, depleting liquidity buffers may accelerate investors' runs from the funds, fearing an imminent imposition of gates and fees. At the same time, the secondary markets for CP and CDs were essentially frozen.[14] As the flight to liquidity emerged and MMFs pulled back from new investments in CP and CDs, the market conditions deteriorated further, in turn triggering even larger redemptions from MMF investors.

4.1 Sample periods and summary statistics

To gauge the magnitude of the MMF run during the Covid-19 crisis and explore whether the 2016 MMF reform changed the dynamics of the run, in this section we compare the Covid-19 run with two previous prominent MMF runs: the financial crisis run in September 2008 and the Eurozone sovereign debt crisis run in the summer of 2011. One crucial difference between the Covid-19 run and the 2008 and 2011 ones is that MMF investors were not subject to contingent liquidity restrictions (redemption gates and liquidity fees) in either 2008 or 2011. We focus on institutional prime funds in our analyses, as they are much more susceptible to investor runs (Gallagher et al., 2020).[15] Indeed, all three runs were concentrated among institutional investors. Figure 3 shows the patterns of MMF outflows during the three crises. The 2008 and 2020 runs are fairly similar. They both spanned a period of about 2 weeks, over which both saw an outflow of about 30% of AUMs. On the other hand, the 2011 run on prime funds during the Eurozone sovereign

[14] It is worth noting that the secondary markets for CP and CDs depend on dealer intermediation and are very illiquid even in normal times.

[15] For funds with both institutional and retail share classes, which were more common in 2008 and 2011, we strip away the retail share classes from these funds.

debt crisis was milder but lasted longer, resulting in a 10% decline in AUMs in over a month.

Table 1 presents summary statistics for institutional prime MMFs during the three MMF runs. For each episode, we define a "normal" period before the run and a "crisis" period. The crisis period starts on the date when large investor redemptions began and ends either on the Federal Reserve intervention date (AMLF in 2008 and MMLF in 2020) or when fund AUMs stabilized (in 2011). The normal period is a period of roughly the same length prior to the start of the crisis period. Specifically, the 2020 sample goes from February 24 to March 20, with crisis starting on March 9. The 2008 sample goes from August 28 to September 19, with September 10 being the beginning of the crisis period. The 2011 sample goes from May 9 to July 5, with June 10 being the beginning of the crisis period.

During the normal periods before large redemptions began, the average fund size is comparable across the three events, with about $9 billion of assets under management for an average institutional prime MMF, and funds on average experienced little fluctuations in their AUMs. However, during the crisis periods, funds experienced significant redemptions. Compared to the two previous episodes, prime funds hold more WLA in 2020. The average WLA as a share of fund assets is 39% and 40% in the normal periods of 2008 and 2011, and 43% in the normal period of 2020, which is consistent with the notion that institutional prime MMFs hold larger liquidity buffers after the 2016 reform.

4.2 Empirical design and regression results

We empirically test whether the introduction of contingent liquidity restrictions in the 2016 reform changed the dynamics of investor runs on MMFs. We start by analyzing the impact of fund liquidity buffers on MMF flows during the 2020 run. Specifically, we use the sample of institutional prime funds that spans both normal and crisis periods for the

2020 run (i.e., February 24-March 20) and estimate the following model:

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

where $Flow_{i,t}$ is the daily percentage change in the AUM for fund i. $WLA_{i,t-1}$ is the share of weekly liquid assets in total assets for fund i during the week that ends before day t. $Crisis_t$ is a dummy that equals one if day t is in the crisis period (i.e., March 9-20). Following the literature (McCabe, 2010; Duygan-Bump et al., 2013), we control for a battery of lagged fund characteristics: abnormal gross yield, expense ratio, fund age, safe holdings (Treasury and agency debt, as a percent of total assets), and risky holdings (CP and CDs, as a percent of total assets). We also include fund fixed effects (μ_i) to control for time-invariant fund characteristics. Standard errors are two-way clustered at the fund and day levels.

Estimation results for Equation (1) are reported in Table 2. Consistent with stronger flow sensitivity to fund liquidity buffers during the crisis period, the coefficient of the interaction between $Crisis_t$ and $WLA_{i,t-1}$ is positive and highly significant (Column (1)). The increase in flow sensitivity to liquidity buffers during the crisis is also economically significant. Relative to normal times, a one-standard-deviation (6.4%) decrease in WLA is associated with an additional 0.9 percentage point increase in daily outflows during the crisis period, which is equivalent to about one third of average daily outflow during that period. In Column (2), we add day fixed effects to the model to further control for potential time trends in fund flows and liquidity conditions, and our results remain qualitatively similar.

The 2016 MMF reform allows funds to impose redemption gates and liquidity fees when their WLA fall below 30% of assets. The critics of the reform have argued that fund outflows may accelerate when funds WLA gets closer to the 30% threshold. The 2020 crisis provides the first chance to empirically test such prediction. We revise Equation

(1) to test whether the sensitivity of fund flows to WLA intensifies when funds move closer to that threshold. Specifically, we split the WLA variable into three segments: $WLA(High)$ equals WLA for funds in the top quartile of WLA in the daily cross-section and zero otherwise, $WLA(Middle)$ equals WLA for funds in the middle two quartiles and zero otherwise, and $WLA(Low)$ equals WLA for funds in the bottom quartile and zero otherwise.[16] We then use the same sample of institutional prime funds and estimate the following model:

$$\begin{aligned} Flow_{i,t} = \beta_1 Crisis_t + \beta_2 WLA(Low)_{i,t-1} + \beta_{low} Crisis \times WLA(Low)_{i,t-1} \\ + \beta_3 WLA(Middle)_{i,t-1} + \beta_{middle} Crisis \times WLA(Middle)_{i,t-1} \\ + \beta_4 WLA(High)_{i,t-1} + \beta_{high} Crisis \times WLA(High)_{i,t-1} \\ + Controls_{i,t-1} + \mu_i + \varepsilon_{i,t}. \quad (2) \end{aligned}$$

Column (3) of Table 2 shows that the estimates of β_{low}, β_{middle}, and β_{high} are all positive and highly significant, suggesting that during the crisis period, outflows were larger for funds with lower WLA within all three liquidity groups. More importantly, the sensitivity of fund flows to WLA is notably greater for the low-WLA group that is closer to the 30% threshold during the crisis. For funds in the low WLA group, a one-percentage-point decrease in WLA is associated with 0.34 percentage-point additional daily outflows in the crisis relative to the normal period. In comparison, the same drop in WLA is associated with 0.28 and 0.25 percentage-point more daily outflows for funds in the middle and high WLA groups, respectively. The differences in flow sensitivity across WLA groups are statistically significant. In particular, the F-test of the difference between β_{low} and β_{middle} has a p-value of 0.03 and a similar difference test on β_{low} and β_{high} has a p-value of 0.01. Our results remain qualitatively the same when controlling for day fixed effects (Column (4)).

[16] The median WLA for funds in the High, Middle, and Low WLA groups is 50%, 40% and 36%, respectively.

To further analyze whether the greater sensitivity of fund flows to liquidity buffers during crisis is attributable to the gates and fees introduced by the 2016 MMF reform, we conduct similar analyses on the two pre-reform MMF runs in 2008 and 2011. As in the 2020 sample, the samples for these two earlier runs include only institutional prime funds and cover both the normal and crisis periods, as defined in Table 1. Using each of the two samples, we re-estimate Equations 1 and 2 and report the results in Table 3.

In contrast to the 2020 episode, the coefficient of the interaction between $WLA_{i,t-1}$ and $Crisis_t$ is not significant for the 2008 or 2011 sample (Columns (1) and (5)). The magnitude of the estimates is also much smaller than that for the 2020 sample. Controlling for day fixed effects does not materially change our results (Columns (2) and (6)). When we divide funds into three groups based on their lagged WLA (i.e., Low, Middle, and High WLA funds), we do not find significant relationships between fund flows and WLA for any of the three groups in either 2008 or 2011 (Columns (3) and (7)). Again, these results are robust to the inclusion of day fixed effects (Columns (4) and (8)). Taken together, results in Tables 2 and 3 suggest that the contingent liquidity restrictions introduced in the 2016 MMF reform might have exacerbated the run on MMFs during the Covid-19 crisis, inducing investors to run on the less liquid funds.

It is worth noting that the 2016 MMF reform not only allows institutional prime funds to impose gates and fees when their WLA falls below 30%, but it also requires them to transact at a floating NAV, which takes into account fluctuations in the market value of fund assets. To rule out the possibility that our results are driven by the introduction of floating NAVs, we estimate the flow sensitivity to both WLA and floating NAV in Appendix Table A.2. We do not find any evidence that lower NAVs significantly increase outflows during the Covid-19 crisis. One possible reason for this finding is that MMFs' NAVs did not fall much during the Covid-19 crisis, while WLA for some funds had fallen 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%.[17]

5 The MMLF and stabilization of prime MMFs

The run on prime MMFs during the Covid-19 crisis led the Federal Reserve to intervene by introducing the MMLF. 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.[18] 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 liquidity buffers. Given the potential confounding effects of other policy actions around the same time, we design two tests to identify MMLF-specific effects. The first test compares the behavior of MMLF-eligible and ineligible funds. The second test exploits the variation in the amount of assets held by MMFs that are pledgeable to the MMLF. Finally, we use the micro-level MMLF data and confirm that prime funds with larger declines in their liquidity levels during the crisis indeed made greater use of the facility.

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. As in the previous section, we define these two weeks as the "crisis" period. 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

[17]Note that NAV falling below $0.995 is considered as "breaking the buck" for fixed-NAV funds and would generally trigger runs.

[18]The Federal Reserve's H.4.1 data show that MMLF loans outstanding were $52.7 billion on April 1 (i.e., the seventh business day after the operation began). 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.

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 effectivenss of the MMLF, investors continued to redeem shares quickly, 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:

$$Flow_{i,t} = \beta_1 MMLF_t + Controls_{i,t-1} + \mu_i + \varepsilon_{i,t}, \tag{3}$$

where $MMLF_t$ is a dummy that takes the value of one during the MMLF period. $Controls_{i,t-1}$ includes lagged time-varying fund characteristics, such as WLA, abnormal gross yield (in excess of the cross-sectional mean), risky holdings (CP and CDs, as a percent of total assets), and safe holdings (Treasury and agency debt, as a percent of total assets), and μ_i represents fund fixed effects. Standard errors are two-way clustered at the fund and day levels.

Column (1) of Table 4 shows that, after controlling for fund characteristics, prime funds' daily flows on average rebounded by about 1 percentage point in the MMLF period. The rebound in fund flows was concentrated among institutional funds. Specifically, we create a dummy, *Institutional* that takes the value of one for prime institutional funds, and add *Institutional* and its interaction with $MMLF_t$ to Equation 3. Column (2) of Table 4 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 2.3 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 and re-estimate Equation 3, we confirm that institutional MMFs' flows indeed rebounded by about 2 percentage points after the launch of the MMLF (Column (4)).

In Section 4 we documented that institutional prime MMFs with lower liquidity buffers experienced larger outflows during the crisis period. If the MMLF provided liquidity backstop to MMFs, we expect its impact to be stronger for less liquid funds. To test this prediction, we include the interaction of $MMLF_t$ and $WLA_{i,t-1}$ 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 liquidity buffers, which characterized the pre-MMLF flow 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. Our results are robust to the inclusion of day fixed effects (Column (6)).

5.2 The stabilizing effect of the MMLF on prime MMFs

One potential concern about our findings is that they might be driven by policy actions other than the MMLF. Around the 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.[19] 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.

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

To address these concerns, we design two 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, and experienced similar runs prior to the launch of the MMLF.[20] Since offshore USD prime funds are not eligible to participate at 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 period from two weeks before to two weeks after the launch of the MMLF. We estimate the following model:

$$Flow_{i,t} = \beta_1 Domestic_i + \beta_2 MMLF_t + \beta_3 Domestic_i \times MMLF_t + Controls_{i,t-1} + \mu_i + \varepsilon_{i,t}, \quad (4)$$

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 5 suggests that broad-based improvements in short-term funding market conditions cannot fully explain the rebound in domestic prime fund flows. During the two weeks following the MMLF, fund flows rebounded significantly more for domestic funds relative to their offshore counterparts. Although offshore USD prime funds also experienced a rebound in flows, its magnitude is much smaller and not statistically significant. Our results are qualitatively the same when we control for day fixed effects

[20]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 fess. 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%.

(Column (2)).

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 MMLF period into the first week of operations ($MMLF\_WeekOne$) and the second week ($MMLF\_WeekTwo$), and estimate the following model:

$$\begin{aligned} Flow_{i,t} = \beta_1 Domestic_t + \beta_2 MMLF\_WeekOne_t + \beta_3 MMLF\_WeekTwo_t \\ + \beta_4 MMLF\_WeekOne_t \times Domestic_i + \beta_5 MMLF\_WeekTwo_t \times Domestic_i \\ + Controls_{i,t-1} + \mu_i + \varepsilon_{i,t}. \end{aligned} \quad (5)$$

Column (3) of Table 5 shows that, relative to the pre-MMLF period, offshore funds actually experienced marginally more outflows (although statistically insignificant) during the first week after the launch of the MMLF, while flows of the domestic funds recovered by 2 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 $MMLF\_WeekTwo_t$ and the insignificant coefficient of its interaction with $Domestic_i$. Controlling for day fixed effects leads to similar results (Column (4)). In sum, the differences in the magnitude and speed of the recovery between domestic and offshore prime funds are consistent with a significant effect of the MMLF on domestic prime MMFs.

To further address concerns that the stabilization of prime fund flows was attributed to the improvement in market sentiment brought about by other policy actions, we explore potential differential MMLF effects across MMFs. Specifically, we examine whether the recovery in fund flows was stronger for funds that held more MMLF-eligible assets. Ideally, one would obtain the security-level holdings of each fund right before the launch of the MMLF and examine whether those holding more MMLF-eligible assets experienced a greater recovery in flows. However, such information is not available. The best alternative that we rely on is the security-level holdings of each fund at the end of February 2020, obtained from their N-MFP filings. We believe that the end-of-February holdings of MMFs provide a rather accurate picture for MMFs' pre-MMLF holdings of MMLF-eligible CP and CDs. Between early March and the implementation of the MMLF, trading in those assets was likely to be very limited given that the secondary markets for CP and CDs were mostly frozen. In addition, to preserve liquidity, MMFs were reluctant to purchase new CP and CDs with maturities longer than one week. To ensure that we capture the share of a fund's assets that can be actually pledged when the MMLF is launched, we classify securities held at the end of February as MMLF-eligible if they can be pledged at the MMLF (ABCP, unsecured CP, and CDs with A1/P1 rating or higher) and if they mature at least one week after the MMLF starts operations, namely on April 1 or later. Treasuries and agency debt are eligible collaterals under the MMLF but are excluded from this measure, as these government securities are already part of the fund's weekly liquid assets and therefore did not need to be converted into cash at the MMLF. Indeed, micro-level MMLF data confirms that Treasuries and agency debt were never pledged as collateral under the MMLF by prime MMFs. The average (median) share of a fund's assets that are MMLF-eligible is 26% (36%) for institutional prime MMFs in our sample.

Using the sample of institutional prime funds that includes both the pre-MMLF and MMLF periods, we estimate the following model:

$$Flow_{i,t} = \beta_1 MMLF_t + \beta_2 \%Eligible_i + \beta_3 MMLF_t \times \%Eligible_i + Controls_{i,t-1} + \mu_i + \varepsilon_{i,t}, \quad (6)$$

where $\%Eligible_i$ is the share of MMLF-eligible assets relative to the AUM of fund i as of February 28. All other variables are defined as in Equation 3, and standard errors are two-way clustered at the fund and day levels.

Results in Table 6 support the view that the MMLF helped stabilize prime fund flows. Column (1) shows that the interaction between $\%Eligible_i$ and $MMLF_t$ is positive and significant, indicating that prime funds with more MMLF-eligible holdings experienced a larger rebound in flows after the MMLF was launched. Our results remain unchanged when controlling for day fixed effects (Column (2)).

Compared to CDs, CP on average has much shorter time to maturity. To test whether the MMLF had a stronger stabilization effect on prime funds with more longer-tenor assets, we divide MMLF-eligible assets into eligible CP and eligible CDs, and define $\%EligibleCP_i$ and $\%EligibleCD_i$ accordingly. We then replace $\%Eligible_i$ with either $\%EligibleCP_i$ or $\%EligibleCD_i$ and re-estimate Equation 6. Results in columns (3)–(6) indicate that most of the stability-enhancing effect of the MMLF comes from the ability of MMFs to sell longer-tenor assets to the facility. Indeed, the coefficient of the interaction between $MMLF_t$ and $\%EligibleCP_i$ is no longer statistically significant, while the interaction of $MMLF_t$ and $\%EligibleCD_i$ remains positive and highly significant. Overall, our analyses lend strong support to the view that the MMLF helped stabilize prime funds that suffered severe outflows during the Covid-19 crisis.

5.3 What drives actual usage of the MMLF?

To further understand the direct impact of the MMLF on prime funds, we analyze the MMLF micro-level data and study how prime funds utilized the MMLF during the first two weeks of operation.[21] 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, the last N-MFP reporting date before the MMLF became operational. 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

[21] Note that the usage of MMLF was concentrated in the first two weeks of operation, accounting for about 95% of its total usage, as of July 1, 2020.

focus on CP (including ABCP) and CDs as they are the only types of assets pledged to the MMLF by prime funds.[22] 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:

$$SharePledged_{i,j} = \beta_1 Log(Time\ to\ Maturity_j) + \beta_2 Institutional_i + \beta_3 \mathbb{1}(Type)_j + Controls_j + \varepsilon_{i,j}, \quad (7)$$

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

Estimation results for Equation (7) are reported in Column (1) of Table 7. Securities with longer maturities were much more likely to be pledged to the MMLF, suggesting that funds prioritized to sell more illiquid assets to the MMLF. In addition, institutional funds sold 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' liquidity buffers. To test whether changes in liquidity buffers are related to MMLF usage,

[22] 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.

we augment Equation (7) as follows:

$$SharePledged_{i,j} = \beta_1 Log(Time\ to\ Maturity)_j + \beta_2 Crisis\ \Delta WLA_i + \\ \beta_3 CrisisFlow_i + \beta_4 \mathbb{1}(Type)_j + Controls_j + Controls_i + \varepsilon_{i,j}, \quad (8)$$

where $Crisis\ \Delta WLA_i$ is the net change in fund i's lagged WLA during the crisis period, and $CrisisFlow_i$ is fund i's cumulative percentage flow during the crisis period. Fund-level controls, $Controls_i$, include log(AUM), abnormal gross yield, expense ratio, WLA, fund age, and bank affiliation as of the week before the launch of the MMLF. Other variables are defined the same as in Equation (7), and standard errors are two-way clustered at the fund and security level.

Column (2) of Table 7 shows that funds that experienced larger declines in WLA, and therefore in more urgent need to restore liquidity, sold more securities to the MMLF. This result echoes our earlier finding of a stronger MMLF effect for less liquid funds. In Column (3) we include $CrisisFlow_i$ as an additional explanatory variable. $Crisis\ \Delta WLA_i$ remains highly significant while $CrisisFlow_i$ is insignificant. This result highlights the importance of fund liquidity 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.

6 The effects of the MMLF on CP and CD markets

As the MMLF stabilized their flows and liquidity conditions, prime funds were once again able to purchase CP and CDs at tenors greater than one week. In this section, we 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, 2017), 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 start with DTCC's transaction level data for all trades in U.S. commercial paper. These data contain detailed information on each CP issuance, including yield and amount issued. We then obtain CP ratings from Moody's and S&P. 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 a composite rating to each CP on each day. Specifically, if an instrument is rated by only one of the two rating agencies, the rating that it receives is set to be its composite rating. For CP rated by both agencies, we take the lower of the two ratings as its composite rating. 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%. 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.[23] 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 the issuer-day-term level observations for the period that spans 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 with 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 composite rating is A1/P1 (including A1+) on day t, and

[23] 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.

estimate the following model:

$$Spread_{j,t,m} = \beta MMLF_t \times TopRating_{j,t} + \mu_j + \mu_t + \mu_m + \mu_r + \varepsilon_{j,t,m} \tag{9}$$

where $MMLF_t$ is a dummy for the two weeks following the launch of MMLF, and μ_j, μ_t, μ_m, μ_r represent issuer, day, maturity, and composite rating fixed effects, respectively. Standard errors are two-way clustered at the issuer and day levels. Consistent with our expectation, Column (1) of Table 8 shows that spreads for top rated CP declined by more following the launch of the MMLF. The coefficient of the interaction of $MMLF_t$ and $TopRating_{j,t}$ 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. As before, 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 9. Consistent with our hypothesis, the coefficient of the interaction between $MMLF_t$ and $ShareMMF_{j,t}$ is negative and highly significant (Table 8, 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 9 on term CP (excluding overnight paper) and get somewhat stronger results (Table 8, 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 pledge 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:

$$Log(Issuance)_{j,t,m} = \beta MMLF_t \times TopRating_{j,t} + \mu_j + \mu_t + \mu_m + \mu_r + \varepsilon_{j,t,m} \qquad (10)$$

where $Log(Issuance)_{j,t,m}$ 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 9 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 (1)). 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 10, the coefficient of the interaction of $MMLF_t$ and $ShareMMF_t$ is positive and highly significant (Column (2)). The MMLF effect on CP issuance is also evident when we focus on term CP (Column (3)).

One 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 the 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 10 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 (4) and (5) of Table 9 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 (6) and (7)). The limited effect of the MMLF on issuance of more expensive CP (with rate below 125 bps) suggests that MMFs were not particularly interested in purchasing these instruments since they may not have been able to sell them to the MMLF without suffering 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 10 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 and greater issuance after the implementation of the MMLF (Columns (1) and (2)). 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)).[24]

Once again, the fact that spread reduction and increased issuance are concentrated among instruments that are heavily held by money funds and economically beneficial to pledge under the MMLF suggests that the MMLF has an incremental stabilizing effect on short-term funding markets beyond the effects of both PDCF and CPFF.

7 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. In this paper we compare three runs on prime MMFs, two of which happened prior to the introduction of contingent liquidity restrictions on investors and one that occurred after these rules were put in place. We find evidence consistent with the notion that the introduction of redemption gates and liquidity fees might have exacerbated the run on prime MMFs during the Covid-19 crisis, especially on less liquid funds.

We show that the MMLF was effective in stemming prime fund outflows and normalizing short-term funding market conditions. Using a battery of identification strategies

[24]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.

and micro-level data on MMFs, CP and CDs, we show that the stabilization of prime fund flows and improvements in the CP and CD market conditions can be attributed to the launch of the MMLF.

Our findings raise the question of whether the fragility in the MMF industry could be fully addressed by current MMF regulations. Given the notable role of MMFs in the short-term funding markets and in the shadow banking system, more research and collaborative regulatory efforts are warranted to enhance the stability of the industry.

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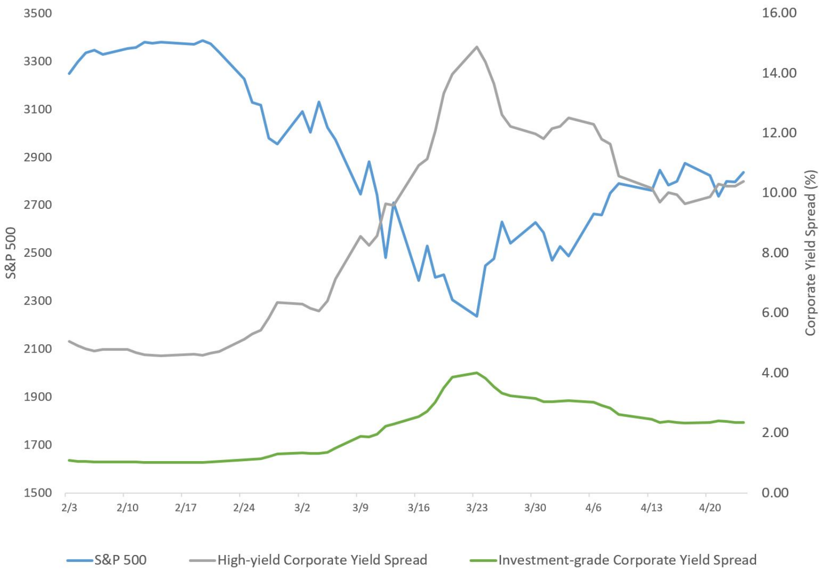
Figure 1: **Distress in Funding Markets during the Covid-19 Crisis**

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

(a) Equity Prices and Bond Yield Spreads



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

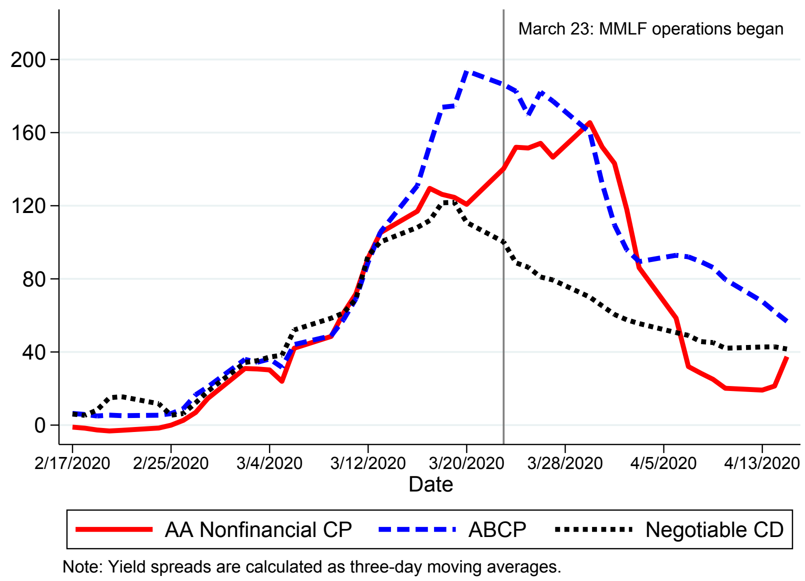
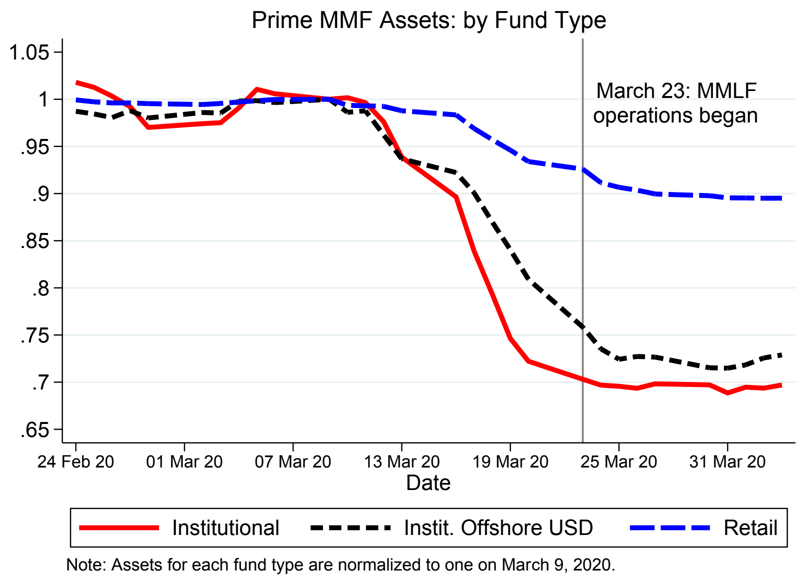


Figure 2: **Runs on MMFs during the Covid-19 Crisis**

Panel (a) plots the 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 9, 2020. Panel (b) plots the AUMs of institutional prime MMFs in the top, middle, and bottom terciles based on their weekly liquidity asset (WLA) holdings, rebalanced every week. Assets of each WLA group are normalized to one on March 9, 2020.

(a) Runs on Prime MMFs



(b) Runs on low-WLA Prime MMFs

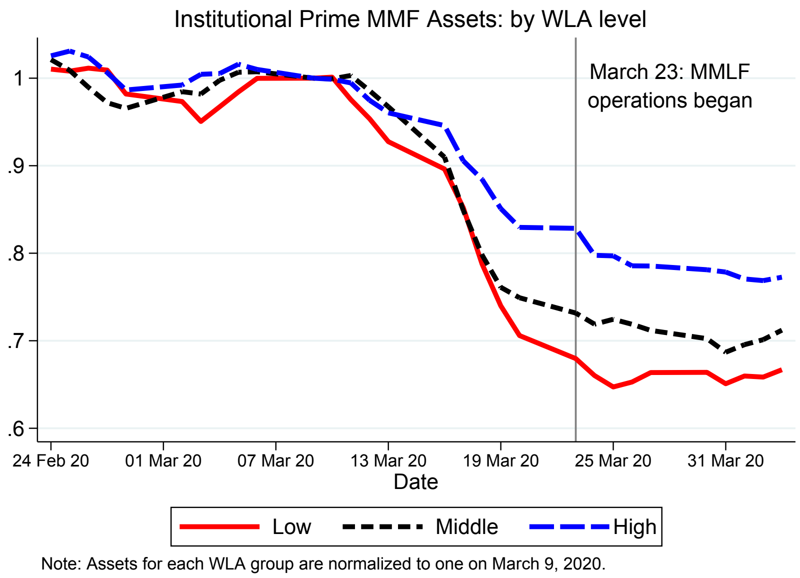


Figure 3: **Comparison of Three MMF Runs**

This chart compares three runs on institutional prime MMFs: the 2008 financial crisis run starting on September 10, 2008, 2011 Eurozone sovereign debt crisis run starting on June 10, 2011, and the 2020 Covid-19 crisis run starting on March 9, 2020. Prime MMF AUMs for each crisis are normalized to one on the first day of the crisis.

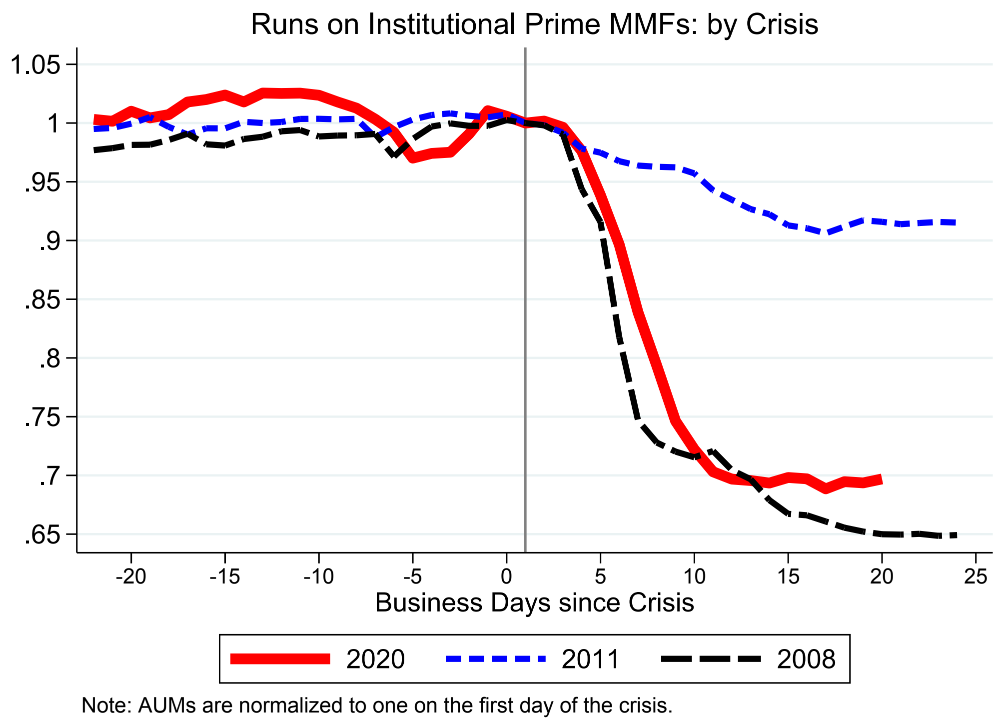


Table 1: **Summary Statistics – MMF Runs**

This table reports the averages of main variables in MMF run analyses during the "Normal" and "Crisis" periods for institutional prime MMFs during three MMF runs. The 2008 Financial Crisis Run sample goes from August 28, 2008 to September 19, 2008, with Crisis from September 10 to September 19; the 2011 Eurozone Crisis Run sample from May 9, 2011 to July 5, 2011, with Crisis from June 10 to July 5; and the 2020 Covid-19 Crisis Run sample from February 24, 2020 to March 20, 2020, with Crisis from March 9 to March 20. "Normal" refers to the time period prior to the Crisis in each sample. Fund AUM (million \$) is a fund's assets under management in millions. Daily Flow (million \$) is the daily change in fund AUM in millions. Daily % Flow is the daily percentage change in fund AUM. WLA (%) is weekly liquid assets as a percentage of total AUM. Gross Yield (%) is a fund's gross yield in percentage points. Expense Ratio (%) is a fund's expense ratio in percentage points. Age is a fund's age in years. 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.

	2008 Run		**2011 Run**		**2020 Run**	
	Normal	Crisis	Normal	Crisis	Normal	Crisis
Fund AUM (million $)	9260.49	8280.66	9472.84	9136.78	9190.86	8228.26
Daily Flow (million $)	14.62	-311.02	5.05	-56.53	-16.51	-261.91
Daily % Flow	0.06	-1.74	0.03	-0.26	-0.24	-2.69
WLA (%)	38.68	39.38	39.83	40.73	42.55	41.89
Gross Yield (%)	2.66	2.69	0.26	0.24	1.81	1.58
Expense Ratio (%)	0.29	0.30	0.19	0.19	0.18	0.18
Age (years)	11.95	12.10	14.78	14.89	18.93	18.93
Safe Holdings	0.09	0.09	0.10	0.10	0.02	0.02
Risky Holdings	0.59	0.60	0.53	0.52	0.54	0.54

Table 2: **MMF Liquidity and Runs during the 2020 Covid-19 Crisis**

The sample spans from February 24, 2020 to March 20, 2020, with Crisis equal to one from March 9 to March 20. The sample includes only institutional prime MMFs. The dependent variable is the daily percentage change in AUM, winsorized at the 1% and 99% levels. WLA is the lagged share of weekly liquid assets in total assets. $WLA(High)$ equals WLA for funds in the top quartile of WLA in the daily cross-section and zero otherwise. $WLA(Middle)$ equals WLA for funds in the middle two quartiles and zero otherwise, and $WLA(Low)$ equals WLA for funds in the bottom quartile and zero otherwise. Controls are lagged and include Abnormal Gross Yield (in excess of cross-sectional average), Expense Ratio, Fund Age, Safe Holdings, and Risky Holdings. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent Variable: Daily Percentage Flow				
	(1)	(2)	(3)	(4)
Crisis	-8.583***		-14.470***	
	(2.684)		(4.020)	
WLA	-0.119*	-0.109*		
	(0.062)	(0.062)		
Crisis × WLA	0.145**	0.127**		
	(0.052)	(0.049)		
WLA (Low)			-0.120**	-0.089
			(0.053)	(0.066)
Crisis × WLA (Low)			0.336***	0.254***
			(0.100)	(0.082)
WLA (Middle)			-0.104**	-0.081
			(0.050)	(0.059)
Crisis × WLA (Middle)			0.284***	0.215***
			(0.087)	(0.067)
WLA (High)			-0.118**	-0.095
			(0.053)	(0.060)
Crisis × WLA (High)			0.251***	0.197***
			(0.073)	(0.062)
Obs.	700	700	700	700
Adj. R^2	0.137	0.241	0.140	0.240
Controls	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓
Day FE		✓		✓

Table 3: **MMF Liquidity and Runs: Previous Crises**

The 2008 Financial Crisis Run sample goes from August 28, 2008 to September 19, 2008, with Crisis equal to one from September 10 to September 19; the 2011 Eurozone Crisis Run sample from May 9, 2011 to July 5, 2011, with Crisis equal to one from June 10 to July 5. Both samples include only institutional prime MMFs. The dependent variable is the daily percentage change in AUM, winsorized at the 1% and 99% levels. WLA is the lagged share of weekly liquid assets in total assets. $WLA(High)$ equals WLA for funds in the top quartile of WLA in the daily cross-section and zero otherwise. $WLA(Middle)$ equals WLA for funds in the middle two quartiles and zero otherwise, and $WLA(Low)$ equals WLA for funds in the bottom quartile and zero otherwise. Controls are lagged and include Abnormal Gross Yield (in excess of cross-sectional average), Expense Ratio, Fund Age, Safe Holdings, and Risky Holdings. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

	Dependent Variable: Daily Percentage Flow							
	2008 Financial Crisis				2011 Eurozone Crisis			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crisis	-2.695**		-1.326*		-0.781***		-0.591*	
	(0.964)		(0.723)		(0.194)		(0.338)	
WLA	0.037	0.019			-0.005	-0.008		
	(0.031)	(0.029)			(0.006)	(0.007)		
Crisis × WLA	0.028	0.027			0.009	0.010*		
	(0.016)	(0.016)			(0.005)	(0.005)		
WLA (Low)			0.016	0.008			0.006	-0.000
			(0.024)	(0.023)			(0.008)	(0.010)
Crisis × WLA (Low)			-0.033	-0.042			0.004	0.012
			(0.029)	(0.027)			(0.015)	(0.016)
WLA (Middle)			0.022	0.020			0.005	0.000
			(0.018)	(0.017)			(0.005)	(0.008)
Crisis × WLA (Middle)			-0.023	-0.029**			0.002	0.007
			(0.013)	(0.012)			(0.008)	(0.008)
WLA (High)			-0.018	-0.015			-0.006	-0.009
			(0.014)	(0.012)			(0.005)	(0.007)
Crisis × WLA (High)			0.013	0.012			0.007	0.010*
			(0.012)	(0.011)			(0.006)	(0.006)
Obs.	2158	2158	2158	2158	4634	4634	4634	4634
Adj. R^2	0.097	0.161	0.097	0.163	-0.009	0.001	-0.009	0.001
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓	✓	✓
Day FE		✓		✓		✓		✓

Table 4: **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)–(6) only institutional funds. The dependent variable is the daily percentage change in AUM. Institutional is a dummy equal to one for institutional prime funds. MMLF is a dummy equal to one from March 23 onwards. WLA is the lagged share of weekly liquid assets in total assets. Controls are lagged and include WLA, Abnormal Gross Yield (in excess of cross-sectional average), Risky Holdings, and Safe Holdings. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent Variable: Daily Percentage Flow						
	All Prime MMFs			Institutional Prime MMFs		
	(1)	(2)	(3)	(4)	(5)	(6)
MMLF	0.970**	-0.268		1.829**	6.671***	
	(0.432)	(0.236)		(0.693)	(2.177)	
MMLF × Institutional		2.273***	2.255***			
		(0.710)	(0.726)			
MMLF × WLA					-0.113**	-0.137***
					(0.043)	(0.030)
Obs.	1320	1320	1320	700	700	700
Adj. R^2	0.111	0.134	0.178	0.106	0.112	0.213
Controls	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓
Day FE			✓			✓

Table 5: **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 AUM. 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. Controls are lagged and include WLA, Abnormal Gross Yield (in excess of cross-sectional average), Risky Holdings, and Safe Holdings. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent Variable: Daily Percentage Flow				
	(1)	(2)	(3)	(4)
MMLF	0.599			
	(0.884)			
MMLF × Domestic	1.417*	1.627*		
	(0.788)	(0.860)		
MMLF_WeekOne			-0.334	
			(1.190)	
MMLF_WeekOne × Domestic			1.961*	2.168**
			(0.937)	(0.973)
MMLF_WeekTwo			1.661**	
			(0.599)	
MMLF_WeekTwo × Domestic			1.018	1.103
			(0.763)	(0.854)
Obs.	1037	1037	1037	1037
Adj. R^2	0.061	0.140	0.068	0.140
Controls	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓
Day FE		✓		✓

Table 6: **The Effect of the MMLF: MMLF-Eligible Assets and Fund Flows**

The daily sample goes from March 9, 2020 to April 3, 2020 and includes non-feeder institutional prime MMFs. The dependent variable is the daily percentage change in AUM. MMLF is a dummy equal to one from March 23 onwards. %Eligible is the percentage of AUM invested A1/P1/F1-rated CP and CDs that mature at least one week after the operations of the MMLF began on March 23. %Eligible is based on security holdings as of the end of February. %Eligible (CP, CD) is the percentage of AUM invested in eligible CP (including ABCP) or CD, respectively. Controls are lagged and include WLA, Abnormal Gross Yield (in excess of cross-sectional average), Safe Holdings, and Risky Holdings. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

	Dependent Variable: Daily Percentage Flow					
	(1)	(2)	(3)	(4)	(5)	(6)
MMLF	0.664		0.892		0.567	
	(0.568)		(0.599)		(0.544)	
MMLF × %Eligible	0.037*	0.037*				
	(0.019)	(0.019)				
MMLF × %Eligible CP			0.053	0.054		
			(0.033)	(0.034)		
MMLF × %Eligible CD					0.088**	0.085**
					(0.039)	(0.040)
Obs.	540	540	540	540	540	540
Adj. R^2	0.145	0.269	0.140	0.265	0.149	0.272
Controls	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓
Day FE		✓		✓		✓

Table 7: **Prime MMFs' Liquidity Conditions 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 week of operations, ranging between 0 and 100. $Log(Time\ to\ Maturity)$ is the logarithm of the residual days to maturity of the security as of the end of February. $Crisis\ Flow$ is the fund's cumulative percentage flow during the crisis period from March 9 to March 20, and $Crisis\ \Delta WLA$ is the net change in the fund's lagged WLA during the crisis period. $Institutional$ equals 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 log(AUM), Abnormal Gross Yield, Expense Ratio, WLA, Fund Age, and Bank Affiliation as of the week before the launch of the MMLF. Standard errors (in parentheses) are two-way clustered at the fund and CUSIP level.

Dependent Variable: Share of Securities Pledged at the MMLF				
	(1)	(2)	(3)	(4)
log(Time to Maturity)	5.722***	6.784***	6.710***	6.337***
	(0.805)	(0.931)	(0.937)	(0.950)
Institutional	9.437***			
	(2.734)			
Crisis ΔWLA		-1.773***	-1.967***	
		(0.537)	(0.514)	
Crisis Flow			0.131	
			(0.181)	
Sample	All Prime	Institutional	Institutional	Institutional
Obs.	4784	2303	2303	2303
Adj. R^2	0.163	0.194	0.194	0.208
Security Level Controls	✓	✓	✓	✓
Security Type FE	✓	✓	✓	✓
Fund Level Controls		✓	✓	
Fund FE				✓

Table 8: **MMLF Effects on CP Spreads**

The sample is at the CP issuer-day-term level and goes from March 9, 2020 to April 3, 2020. Columns (1) and (2) include all CP issuances, while column (3) only issuances of term (excluding overnight) CP. The dependent variable, Spread, is the difference in percentage points between the CP rate and the OIS rate at equivalent maturity (or the federal funds rate if overnight).TopRating equals one for the A1/P1 rated CP (the highest rating). MMLF equals one after the MMLF operations began on March 23, 2020. ShareMMF is the share of an issuer's CP held by MMFs at the end of February 2020. Standard errors (in parentheses) are two-way clustered at the issuer and day levels.

	(1)	(2)	(3)
		Spread	
TopRating × MMLF	-0.446**		
	(0.167)		
ShareMMF × MMLF		-1.050***	-1.178***
		(0.318)	(0.270)
Sample	Full	Full	Term
Obs.	7,820	7,820	4,911
Adj. R^2	0.825	0.821	0.829
Term FE	✓	✓	✓
Rating FE	✓	✓	✓
Issuer FE	✓	✓	✓
Day FE	✓	✓	✓

Table 9: **MMLF Effects on CP Issuance**

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Log(Issuance)			Log(Issuance)			
Primary Mkt Rate:	All	All	All	$\geq 125bps$	$< 125bps$	$\geq 125bps$	$< 125bps$
TopRating × MMLF	3.012***						
	(0.733)						
ShareMMF × MMLF		3.894**	3.897**	4.228**	-1.073	4.208**	-1.055
		(1.541)	(1.542)	(1.682)	(0.933)	(1.675)	(0.930)
Sample	Full	Full	Term	Full	Full	Term	Term
Obs.	99,000	99,000	89,100	99,000	99,000	89,100	89,100
Adj. R^2	0.521	0.517	0.516	0.393	0.564	0.393	0.565
Rating FE	✓	✓	✓	✓	✓	✓	✓
Issuer FE	✓	✓	✓	✓	✓	✓	✓
Day FE	✓	✓	✓	✓	✓	✓	✓
Term FE	✓	✓	✓	✓	✓	✓	✓

Table 10: **MMLF Effects on CD Spreads and Issuance**

The sample is at the CD issuer-day-term level and goes from March 9, 2020 to April 3, 2020. The sample includes CDs with maturities between one week and one year. Spread is the difference in percentage points between the CD 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 CD held by MMFs at the end of February 2020. Standard errors (in parentheses) are two-way clustered at the issuer and day levels.

	(1)	(2)	(3)	(4)
	Spread	Log(Issuance)	Log(Issuance)	
Original Rate:			$\geq 125bps$	$< 125bps$
ShareMMF × MMLF	-0.532**	0.946*	0.680**	0.275
	(0.249)	(0.462)	(0.263)	(0.298)
Sample	Full	Full	Full	Full
Obs.	389	10,880	10,880	10,880
Adj. R^2	0.679	0.060	0.041	0.034
Issuer FE	✓	✓	✓	✓
Day FE	✓	✓	✓	✓
Term FE	✓	✓	✓	✓

Appendix: 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 & Announcement
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

Table A.2: **Effect of Floating NAV on Flows**

The daily sample goes from February 24 to March 20, 2020 and includes institutional prime funds. Flow is the daily percentage change in assets under management. Crisis equals one from March 9 to March 20. NAV_minus1 equals (lagged NAV -1) $\times$ 10000 (i.e., in basis points). WLA is the lagged share of weekly liquid assets in total assets. Controls are lagged and include Abnormal Gross Yield (in excess of cross-sectional average), Expense Ratio, Fund Age, Safe Holdings, and Risky Holdings. Standard errors (in parentheses) are two-way clustered at the fund and day levels.

Dependent Variable: Daily Percentage Flow				
	(1)	(2)	(3)	(4)
Crisis	-2.415***	-2.280***		
	(0.735)	(0.724)		
NAV_minus1	0.112	0.163	0.264	0.219
	(0.086)	(0.103)	(0.214)	(0.205)
Crisis × NAV_minus1	-0.010	-0.041	-0.267*	-0.240
	(0.127)	(0.128)	(0.144)	(0.148)
WLA				-0.081
				(0.062)
Crisis × WLA				0.104**
				(0.039)
Obs.	660	660	660	660
Adj. R^2	0.101	0.107	0.239	0.242
Controls		✓	✓	✓
Fund FE			✓	✓
Day FE			✓	✓