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Banks' Balance-Sheet Costs, Monetary Policy, and the ON RRP

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Abstract

Using a quasi-natural experiment, we show that quantitative easing (QE) interacts with bank regulation, impacting the size and portfolio choices of non-banks. In 2021, upon the expiration of the Supplementary Leverage Ratio relief, banks were incentivized to reduce leverage, shedding deposits and reducing the supply of wholesale debt. We show that as a result, money-market funds experienced large inflows and shifted their portfolios toward the Federal Reserve’s ONRRP facility. Our results imply that when non-banks can access the central-bank balance sheet, they end up holding a share of central-bank liabilities, draining reserves and affecting the impact of QE through banks.

Key words: balance sheet constraints, banks, leverage ratio, monetary policy, money market funds, ONRRP

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1 Introduction

In this paper, we use a quasi-natural experiment to show that quantitative easing (QE) interacts with bank regulation and, by increasing banks' balance-sheet costs, impacts both the size and portfolio choices of non-bank financial institutions.

After the Global Financial Crisis (GFC), the Federal Reserve grew its balance sheet sharply to stimulate the economy through QE, increasing bank reserves, deposits, and leverage. Concurrently, US regulators implemented several reforms that penalize banks' balance-sheet expansions; the goal of these regulations is to reduce bank risk-taking by curbing bank leverage. The most notable example of these rules is the Supplementary Leverage Ratio (SLR), which sets an explicit limit on the amount of leverage that large banks can take.[1] This regulatory constraint makes balance-sheet expansions more costly for banks; moreover, since the SLR ratio is not risk-weighted, the cost is especially high for balance-sheet expansions associated with safe and low-margin activities, such as intermediation in the market for repurchase agreements (repos) collateralized by Treasuries.

Several recent papers have highlighted the importance of banks' balance-sheet costs in explaining arbitrage deviations in asset prices and excess volatility in money-market rates. It is less clear, however, how the interaction of banks' balance-sheet costs with the central bank's balance-sheet policies affects non-bank financial institutions, their portfolio choices, and, in turn, the effectiveness of QE itself.

An increase in balance-sheet costs incentivizes banks to reduce their debt. This can have two effects on non-bank financial institutions. First, banks could push their depositors into non-bank financial institutions that are seen as close substitutes to bank deposits, increasing the size of these non-banks. Second, banks could also borrow less in the wholesale market, including from non-banks, changing the portfolio composition of these non-banks. If non-banks have access to the central bank's balance sheet, they can accommodate the increase in size or change in investment opportunities by investing at the central bank.

In this paper, we identify these two effects by focusing on a key type of non-bank financial institution, money market funds (MMFs). We do this for two reasons. First, MMFs are

[1]The SLR, which was implemented as part of the Basel III reforms, was approved in July 2013 and became effective in the US on January 1, 2018.

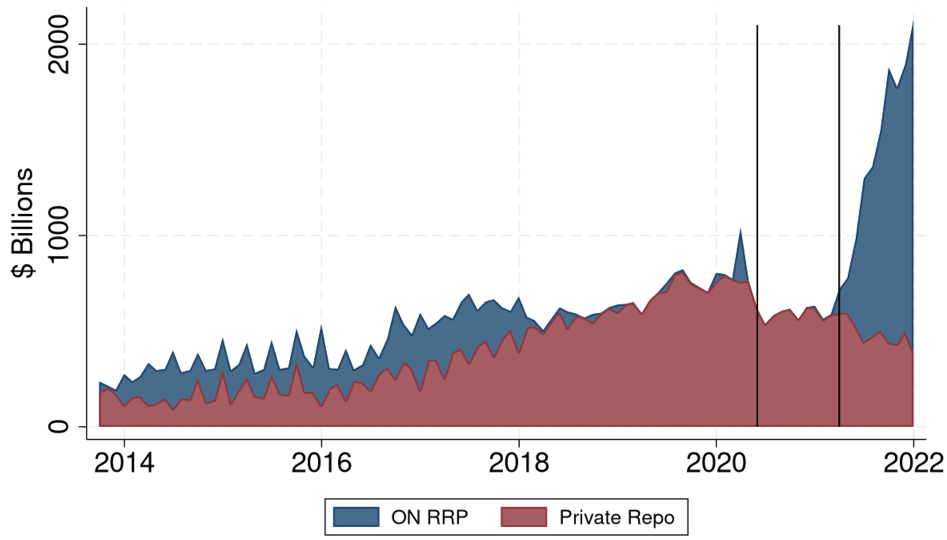

Figure 1: **Public and Private Overnight Treasury-Backed Repo Investment by Money Market Funds (MMFs).** Investment is measured in billions of dollars at the monthly frequency (month ends). The blue area represents MMF investment at the ON RRP; the red area represents MMF investment with private counterparties. Data are from the Office of Financial Research (OFR) Short-term Funding Monitor. The vertical lines indicate the start-date and end-date of the SLR relief for depository institutions: June 1, 2020, and March 31, 2021.

both the main non-bank substitutes to bank deposits—with $4.7 trillion in assets under management (AUM) at the end of December 2021—and the main providers of short-term wholesale liquidity to large banks; therefore, when banks' balance-sheet costs tighten, MMFs are the non-bank financial institutions more likely to be impacted. Second, MMFs can invest at the Federal Reserve through the ON RRP, a facility set up to support the implementation of monetary policy; MMFs are the main users of this facility, representing 82% of total usage on average between the facility inception in September 2013 and December 2021. As Figure 1 shows, investment in the ON RRP by MMFs increased dramatically between April 2021 and December 2021, accompanied by a reduction in MMF holdings of private overnight Treasury repos. Indeed, overall ON RRP take-up grew from a few billions at the beginning of April 2021 to $1.9 trillion at the end of December 2021, with 91% of the increase due to MMFs.

To identify the effect of banks' balance-sheet costs on the size and portfolio composition of MMFs, we use a difference-in-differences strategy around an episode of exogenous variation in the tightness of the SLR constraint. The variation comes from the end of the 2020–2021 "SLR relief." The SLR relief—a regulatory change put in place when the Federal Reserve expanded its balance sheet by several trillion dollars in response to the Covid-19 pandemic—temporarily excluded US Treasury securities and central bank reserves from bank assets in the SLR calculation; therefore, after the SLR relief ended (March 31, 2021), banks' balance-sheet costs increased immediately and permanently, as banks had to once again include their Treasury and reserve holdings in their SLR calculations.

To identify the impact of banks' balance-sheet costs on the size of the MMF industry, we compare MMFs affiliated with banks subject to the SLR regulation with other MMFs. The former should receive larger investor flows around the end of the relief, as their affiliated banks try to shed depositors to improve their SLR. The reason is twofold: banks have an incentive to keep their clients within the company, and investors have an incentive to stay within the same company to lower their switching costs. Consistent with this hypothesis, we find that in the two quarters around the end of the SLR relief, the AUM of MMFs affiliated with banks subject to the SLR increased more than the AUM of other MMFs by an average of $3.4 billion per fund, for a total of $364 billion.

We strengthen our identification in two ways. First, we use regulatory data on banks' SLR and show that, within those MMFs affiliated with banks subject to the SLR, funds whose banks were closer to the regulatory requirement experienced larger inflows (as their banks had stronger incentives to push away depositors than banks with larger buffers). Importantly, the SLRs of all banks in our sample were above the requirement, suggesting that banks target higher SLR levels and that the constraint may become binding even above the regulatory minimum. Second, we exploit the differential regulatory treatment of custodial banks, which were allowed to permanently exclude reserves from their SLR calculation before the SLR relief came into place; as a result, the increase in balance-sheet costs caused by the end of the relief was smaller for these banks. Consistent with this, we find that MMFs affiliated with custodial banks subject to the SLR experienced significantly smaller inflows than MMFs affiliated with other banks subject to the SLR.

In addition to increasing the size of non-bank financial institutions, banks' balance-sheet costs also affect non-bank financial institutions by tilting their portfolio choices, as banks respond to tighter constraints by reducing the supply of wholesale debt. To identify this effect, we focus on the share of MMF portfolio invested at the ON RRP and rely on the fact that this channel should be stronger for government MMFs than for prime MMFs. There are two reasons for this. First, government MMFs have more limited investment options: in addition to the ON RRP, they can only invest in government debt or private repos collateralized by government debt, which are typically issued by banks subject to the SLR or their affiliated dealers; prime MMFs, in contrast, can invest in a broader set of instruments and counterparties, including commercial paper issued by non-financial firms. Second, the increase in balance-sheet costs caused by the end of the SLR relief had a stronger effect on bank Treasury repos than on other forms of bank wholesale debt; this is because the SLR is not risk weighted and penalizes safe, low-margin activities such as matched-book Treasury-repo intermediation. Consistent with this, we find that after the expiration of the SLR relief, the portfolio share of government MMFs invested at the ON RRP increased by 19 percentage points more than that of prime MMFs.

We strengthen our identification in two ways. First, one concern is that, right after the end of the SLR relief, some factor other than a reduction in banks' repo supply may have affected the ON RRP portfolio share of government MMFs more than that of prime MMFs. To control for this, we restrict our analysis to government MMFs and show that government funds that invested relatively more in private repos in 2019—and were therefore more exposed to changes in the banking sector's supply of such assets—increased their portfolio share at the ON RRP more than other government MMFs (i.e., those relying relative more on outright purchases of government debt) after the SLR relief ended. A ten-percentage-point increase in the pre-sample share of private repos in government fund portfolios increases the share invested at the ON RRP by 2.4 percentage points after the expiration of SLR relief. This robustness check is important because it also shows that the effect we identify is not caused by an increase in the size of government MMFs relative to prime MMFs.

Second, we explicitly control for two other possible drivers of ON RRP investment that are likely to affect government MMFs more strongly: interest-rate risk and the supply of Treasury bills (T-bills). Since MMFs hold debt securities, higher interest-rate uncertainty should push them to tilt their portfolios towards short-term investments such as the ON RRP, with the effect being stronger for government funds because they have fewer options to manage interest-rate risk. Similarly, by reducing MMFs' investment opportunities, a decrease in T-bill supply should tilt MMF portfolios towards the ON RRP; this effect should also be stronger for government MMFs as their investment options are more limited than those of prime funds.[2]

Our results on the effect of banks' balance-sheet costs on the share of MMF portfolio invested at the ON RRP are robust to controlling for these confounding factors. Importantly, we also show that both interest-rate risk and T-bill supply have significant effects that are consistent with the conjectures outlined in the previous paragraph. A 10-point increase in the MOVE index—a measure of interest rate uncertainty—increases the share of ON RRP investment in government-MMF portfolios by 3.3 percentage points more than it does in prime-MMF portfolios. A monthly decrease of T-bill issuance by $100 billion increases the portfolio share of ON RRP investment significantly more in government MMFs than in prime MMFs, by 0.8 percentage points.

Finally, we show that the surge in banks' balance-sheet costs caused by the end of the SLR relief significantly contributed to the increase in ON RRP take-up of 2020–2021 highlighted in Figure 1; in particular, we quantify the effect of banks' balance-sheet costs on MMFs' ON RRP investment in dollar terms, through both their effect on MMF size and their effect on MMF portfolio allocation. MMFs affiliated with banks subject to the SLR—whose AUM increased on average by $3.4 billion per fund between January and June 2021—grew their daily ON RRP investment by $1.2 billion per fund relative to other MMFs after the end of the SLR relief. Similarly, government MMFs increased their daily ON RRP investment by $7.6 billion per fund relative to prime MMFs.

Our results have important implications for monetary policy implementation. When MMFs invest in the ON RRP, they use their banks to execute the investment, which, in turn, use their reserve balances to make the transfer. This transfer results in an increase in ON RRP take-up and an equal decrease in the aggregate reserves available to the banking system, without any intervention by the Federal Reserve. Variation in the drivers of ON RRP take-up may therefore limit the Federal Reserve ability to efficiently expand and contract its balance sheet, as this variation affects bank reserves through factors outside the Federal Reserve control. A persistent increase in the ON RRP while the Federal Reserve reduces

[2] For MMF investment, T-bills are significantly more important than longer-term Treasuries because, by regulation, MMFs cannot hold securities with a remaining maturity greater than 397 days.

its balance sheet, for instance, would increase the speed at which bank reserves decline; this would pose a challenge both to banks, as they need to quickly adjust to lower reserve levels, and to the Federal Reserve, as it assesses the effect of lower reserves on interest rate control.

Our results also have important implications for monetary policy transmission. Diamond et al. (2023) show that injections of central bank reserves through QE have the unintended consequence of crowding out bank lending because they increase bank balance-sheet costs; they refer to this mechanism as the "reserve supply channel" of unconventional monetary policy. Our results suggest that the presence of the ON RRP—and more generally, giving non-banks access to the central bank balance sheet—may attenuate this channel as banks are able to get rid of reserves through their affiliated MMFs; absent the ON RRP, instead, the quantity of reserves in the system would be fixed, preventing the banking system from relaxing the constraint.

Importantly, the findings of this paper explain not only the dramatic increase in ON RRP take-up that started in 2021 and continued through the first half of 2022 but also the sharp reduction in ON RRP take-up that we observed since July 2023. Over the past two years, the ON RRP dropped from an average of $2.2 trillion in March 2023 to an average of $180 billion in March 2025. This decline is consistent with the three channels of ON RRP investment we identify in our paper. First, banks' balance-sheet constraints have loosened since 2022 because the size of their balance sheet has plateaued, while their reserves have declined as a result of the Federal Reserve latest quantitative tightening (QT) cycle. Second, interest rate uncertainty has been decreasing since its all-time high of March 2023. Finally, the supply of T-bills sharply picked up in 2023, as a result of the federal government fiscal expansion. The sharp reduction of investment in the ON RRP allows the Federal Reserve to reduce the size of its balance sheet without creating scarcity in the supply of reserves.

This paper is related to several strands of literature. The first is the empirical literature studying the effects of post-crisis capital regulation, and especially banks' balance-sheet costs, on financial markets. The closest paper in this literature is Diamond et al. (2023), which we describe above. Other related papers are Munyan (2017) and Allahrakha et al. (2018), who show that after the introduction of the SLR, broker-dealers affiliated with bank holding companies decreased their repo borrowing. Similarly, Boyarchenko et al. (2020) study the effect of the SLR on the relationship between hedge funds and prime brokers affiliated with global systemically important banks. Other papers, instead, have focused on the effect of balance-sheet costs on asset prices and market liquidity (Duffie and Krishnamurthy 2016, Adrian et al. 2017, Duffie 2018, Du et al. 2018, Andersen et al. 2019, Jermann 2020, Fleckenstein and Longstaff 2020). We contribute to this literature by studying the effects of bank balance-sheet costs—namely, those generated by the SLR—on non-bank financial intermediaries such as MMFs, both in terms of their size and in terms of their portfolio choices.

Our paper is also related to the growing literature on non-reserve central bank liabilities and the central bank's ability to supply safe assets to the financial sector. Two theoretical papers closely related to ours are d'Avernas and Vandeweyer (2023) and d'Avernas et al. (2024); their models show that, by allowing non-banks to directly hold central bank liquidity, reverse repo facilities such as the ON RRP provide a floor to repo rates when the combination of large amounts of reserves and bank balance-sheet costs reduces bank intermediation. Similarly, Eisenschmidt et al. (2024) and Huber (2023) show how reverse repo facilities offered to non-bank cash lenders can mitigate the adverse effects of imperfect competition on money market rates, improving monetary policy transmission. Doerr et al. (2023) and Stein and Wallen (2023), instead, study MMFs' portfolio choice between the ON RRP, private repos, and T-bills and how it affects the liquidity premium of T-bills and money-market liquidity. Finally, Carlson et al. (2016) and Greenwood et al. (2016) argue that the central bank can use its balance sheet, including non-reserve liabilities offered to non-banks, to improve financial stability by reducing the private sector's incentive to issue runnable short-term debt. We contribute to this literature by identifying the causal effects of banks' balance-sheet costs on MMF investment at the ON RRP.

There is also a recent literature on the relationship between bank deposits and MMF shares. This literature has focused on the so-called deposit channel of monetary policy: as the Federal Reserve increases the federal funds rate to tighten its monetary policy stance, depositors flow from low-beta bank deposits to high-beta MMF shares (Drechsler et al., 2017; Xiao, 2020). In the context of this strand of research, we show that bank balance-sheet costs also significantly affect investor investment in MMFs versus bank deposits. One important implication is that monetary policy affects MMF size not only through changes in the policy rate but also through changes in the quantity of reserves, by interacting with bank balance-sheet costs.

Finally, our paper contributes to our understanding of banks' demand for reserves after the GFC. Since changes in ON RRP take-up impact aggregate reserves, by showing that MMFs' ON RRP investment is affected by variation in banks' balance-sheet costs, we highlight the importance of controlling for endogenous ON RRP fluctuations when estimating the reserve demand curve (see Afonso et al., 2022, and Lagos and Navarro, 2023 for an analysis of reserve demand after the GFC).

The remainder of the paper is organized as follows. Section 2 introduces the institutional background. Section 3 describes the data. Section 4 estimates the effects of banks' balance-sheet costs on MMF flows. Section 5 identifies the effect of banks' balance-sheet costs on the share of MMFs' portfolio invested at the ON RRP; in this section, we also identify the effects of interest-rate risk and T-bill supply on MMFs' investment at the ON RRP and show that controlling for these channels does not reduce the importance of banks' balance-sheet costs. Section 6 concludes.

2 Institutional Background

2.1 The Supplementary Leverage Ratio

The SLR is the US implementation of the Basel III leverage ratio; it is the ratio between a bank's tier 1 capital and its "total leverage exposure," which includes both on-balance sheet assets and certain off-balance sheet exposures:[3]

$$\text{SLR} = \frac{\text{Tier 1 capital}}{\text{Total leverage exposure}}.$$

US bank regulators have set a minimum SLR for large banks and their depository institutions of 3%.[4] Additionally, bank holding companies (BHCs) with more than $700 billion

[3]Tier 1 capital is the core equity of a bank; it includes common stock and related surplus, retained earnings, accumulated other comprehensive income, non-cumulative perpetual preferred stock, and qualifying minority interest. The total leverage exposure includes on-balance sheet assets, derivatives exposures, repo-style exposures, and other off-balance sheet exposures.

[4]This minimum ratio applies to banking organizations with at least $250 billion in total consolidated

in total consolidated assets or more than $10 trillion in assets under custody are subject to a minimum SLR requirement of 5% for the BHCs themselves and of 6% for their their insured depository institutions (DIs).

This regulation was adopted in response to the GFC, which highlighted how excessive bank leverage can become a key driver of financial turmoil (BIS, 2014). Similarly to traditional capital ratios, the SLR requirement limits a bank's ability to expand its balance sheet by issuing more debt. Importantly, however, since this leverage constraint is not risk-weighted, it particularly penalizes balance-sheet expansions used to finance safe assets, such as reserves and US Treasury securities, or safe intermediation activities, such as overnight Treasury-repo intermediation.

In April 2020, US regulators temporarily revised the SLR calculation to alleviate strains in the Treasury market that arose at the beginning of the COVID-19 pandemic. The change, usually referred to as the "SLR relief," excluded on-balance sheet holdings of US Treasury securities and reserves from the calculation of the SLR denominator, temporarily relaxing banks' balance-sheet constraints by increasing their SLRs (Federal Register, 2020b).[5] At the BHC level, the relief became effective on April 14, 2020; it was extended to the SLR of DIs on May 15, becoming effective on June 1. At the time of its introduction, the regulators also stated that the temporary relief would end on March 31, 2021, for both BHCs and DIs.

Figure 2 shows the SLRs of the six largest US BHCs from the first quarter of 2018, when the SLR requirement was introduced, to the last quarter of 2021. Although there is variability both across time and across banks, the SLRs of these banks increased significantly during the relief period, to then decline sharply immediately after it ended. In our analysis, we focus on the period around the end of the relief so that results are not contaminated by the money-market turmoil of March–April 2020. The sudden tightening of the SLR constraint due to the end of the relief sharply increased banks' regulatory costs associated with balance-sheet size; as discussed above, this increase in balance-sheet costs was particularly material for safe, low-return intermediation activities, such as intermediation in Treasury repos.

assets or at least $10 billion in total on-balance sheet foreign exposure. The 2013 final rule required these large banks to disclose their SLRs to investors starting on January 1, 2015, and to comply with the minimum SLR requirement starting on January 1, 2018.

[5]This interim final rule applied to BHCs, savings and loan holding companies, and US intermediate holding companies of foreign banking organizations.

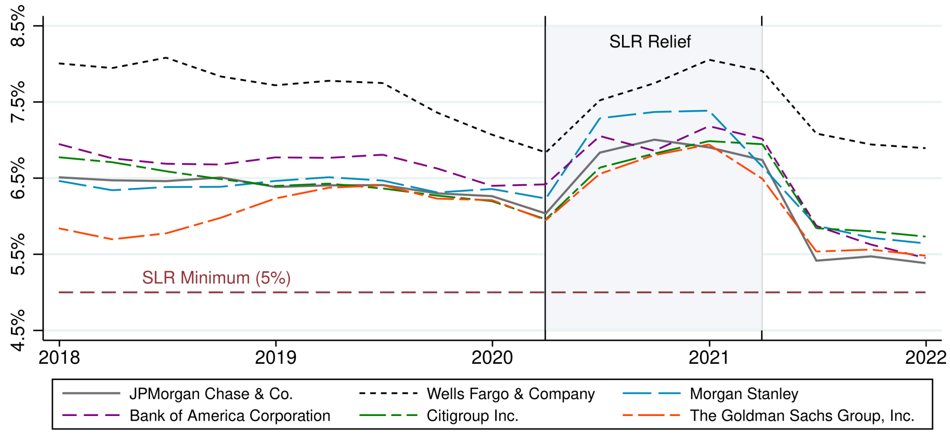

Figure 2: **Supplementary Leverage Ratio (SLR) of the Six Largest US Bank Holding Companies (BHCs).** The SLR is measured in percent; data are quarterly from the regulatory form FR Y-9C. The sample include the 6 largest US BHCs in the last quarter of 2022: "JP Morgan Chase & Co." (solid grey line), "Bank of America Corporation" (dashed purple line), "Wells Fargo & Company" (dotted black line), "Citigroup Inc." (dashed green line), "Morgan Stanley" (dashed blue line), and "The Goldman Sachs Group, Inc." (dashed orange line). The horizontal dashed red line represents the minimum SLR requirement for these BHCs (5%). The grey-shaded vertical region represents the SLR-relief period: 2020Q2–2021Q1.

In our empirical strategy, we also exploit the fact that the end of the SLR relief affected custodial banks—banks whose main business purpose is to hold assets on behalf of their clients—significantly less than other banks. The reason is that US bank regulators had *permanently* excluded reserves from the calculation of custodial banks' SLRs in January 2020, with the change becoming effective on April 1, 2020, long before the end of the SLR relief (Federal Register, 2020a).[6]

2.2 Money Market Funds (MMFs)

MMFs are open-end mutual funds investing in money-market instruments with the aim of keeping the value of their shares stable. They are regulated by the Securities and Exchange Commission (SEC) under Rule 2a-7 of the Investment Company Act of 1940. By regulation,

[6]Under this rule, a custodial banking organization is defined as a depository institution holding company with a ratio of assets under custody to total assets of at least 30. There are three custodial banks in the US: the Bank of New York Mellon, Northern Trust Corporation, and State Street Corporation.

MMFs must invest in short-term debt of high credit quality. For example, they must hold securities with remaining maturity within 397 days; the weighted average maturity of their portfolios (WAM) must be within 60 days; and at least 30% of their portfolios must be invested in Weekly Liquid Assets (WLA)—that is, cash, Treasuries, agency discount notes with remaining maturities within 60 days, and securities that mature or are subject to a demand feature that is exercisable and payable within 5 business days.[7]

Based on their portfolio holdings, MMFs can be divided in two types: government MMFs—which can only hold Treasuries, agency debt, and repos collateralized by these asset classes—and prime MMFs—which can also hold commercial paper, certificates of deposit, floating-rate notes, and repos backed by non-government collateral. Over the last decade, government funds have grown significantly more than prime funds: on average, between January 2020 and December 2021, government MMFs represented 84% of the industry's $4.3 trillion in total AUM.[8]

Two episodes, in particular, contributed to the relative growth of government MMFs. The first one was the 2014 SEC reform, which, by making prime MMFs less money-like, led investors to move more than $1 trillion from prime to government MMFs between November 2015 and the reform compliance date of October 14, 2016 (Cipriani and La Spada, 2021). The second episode is the turmoil of March 2020, when investors withdrew $130 billion from prime funds and poured $830 billion in government funds; the run from prime MMFs only abated at the end of the month, after the introduction of the Money Market Mutual Fund Liquidity Facility (MMLF) and the other 13(3) emergency facilities, while government MMFs kept experiencing significant inflows ($340 billion) throughout April 2020 (Cipriani and La Spada, 2020; Cipriani et al., 2020; Li et al., 2021; Anadu et al., 2022).

MMFs can be offered by stand-alone asset managers or BHCs. Importantly, the AUM of the MMFs offered by a bank are not part of the bank's balance sheet and are not included in the calculation of the bank's SLR.

[7]MMFs are also required to hold at least 10% of their portfolios in Daily Liquid Assets (DLA): cash, Treasuries, and securities that mature or are subject to a demand feature that is exercisable and payable within one business day. In July 2023, the SEC increased the required minimum levels of WLA and DLA to 50% and 25% (Securities Exchange Commission, 2023), a change that became effective in April 2024.

[8]There is a third type of MMF, tax-exempt funds, which mainly invest in short-term floating-rate debt issued by local governments and authorities. They are much smaller than prime and government funds; on average, between January 2020 and December 2021, they held 1.8% of MMF total AUM.

2.3 The Overnight Reverse Repo Facility (ON RRP)

The ON RRP is a policy tool to support monetary policy implementation and manage overnight interest rates.[9] Through the ON RRP, banks, primary dealers, MMFs, and government sponsored enterprises invest at the Federal Reserve via overnight Treasury repos with a fixed interest rate, which is set by the Federal Open Market Committee (FOMC).[10] The ON RRP rate has been always set below the interest rate on reserve balances (IORB).[11]

The ON RRP is a liability on the balance sheet of the Federal Reserve. ON RRP investment does not change the size of the Federal Reserve's balance sheet: the securities backing the repos still show as assets held by the Federal Reserve. ON RRP investment, however, changes the composition of the Federal Reserve liabilities: all else being equal, it lowers the supply of reserves in the banking system. When an institution invests in the ON RRP, there is a transfer from its reserve account or from the reserve account of its bank (if the institution does not have a reserve account, like an MMF) to the Federal Reserve; such transfer reduces reserve liabilities on the Federal Reserve's balance sheet and increases ON RRP liabilities by the same amount. An opposite movement from ON RRP to reserves takes place when an ON RRP investor closes its position with the Federal Reserve.[12]

In addition to banks and primary dealers, the only other institutions eligible to invest at the ON RRP are MMFs and government-sponsored enterprises (GSEs).[13] These institutions, especially MMFs, are the main providers of overnight wholesale liquidity to the banking sector, both secured and unsecured. However, MMFs do not have accounts with the Federal

[9] The Federal Reserve began testing ON RRPs in September 2013 and announced the intention to use the facility as a supplementary policy tool in September 2014.

[10] The FOMC also sets a counterparty limit for ON RRP investment, currently at $160 billion; in addition, the facility has an aggregate limit, currently set equal to the value of unencumbered Treasury securities held by the Federal Reserve. Neither the counterparty limit nor the aggregate limit is binding in our sample. Also, technically, the FOMC sets the maximum rate that the Federal Reserve is willing to pay—the offering rate; the actual rate is determined through an auction process. Only if the amount bid exceeds the aggregate amount offered, the two rates will differ. Such an occurrence, however, is unlikely given the amount of Treasury securities held by the Federal Reserve. In fact, in the history of the facility, the amount bid exceeded the amount offered only once, at the end of September 2014, when the aggregate cap was only $300 billion. Finally, ON RRP transactions are cleared and settled in the tri-party repo platform, on the books of a clearing bank (Bank of New York Mellon).

[11] The IORB is the interest rate that DIs earn on their reserve balances with the Federal Reserve.

[12] See Frost et al. (2015) and Cipriani and La Spada (2022) for a discussion on the design of the ON RRP.

[13] The list of counterparties is available at `https://www.newyorkfed.org/markets/rrp_counterparties`.

Reserve and, therefore, cannot earn IORB; similarly, GSEs do not earn the IORB on their Federal Reserve cash holdings. By offering MMFs and GSEs a safe overnight investment option at a fixed rate, the ON RRP helps set a floor under money-market rates.

As shown in Figure 3 and Table 1, MMFs are the main ON RRP investors, accounting for 82% of total investment on average from the inception of the facility in September 2013 to December 2021. Investment by government MMFs, in particular, accounts for the largest share, representing on average 79% of total MMF ON RRP take-up during this period.

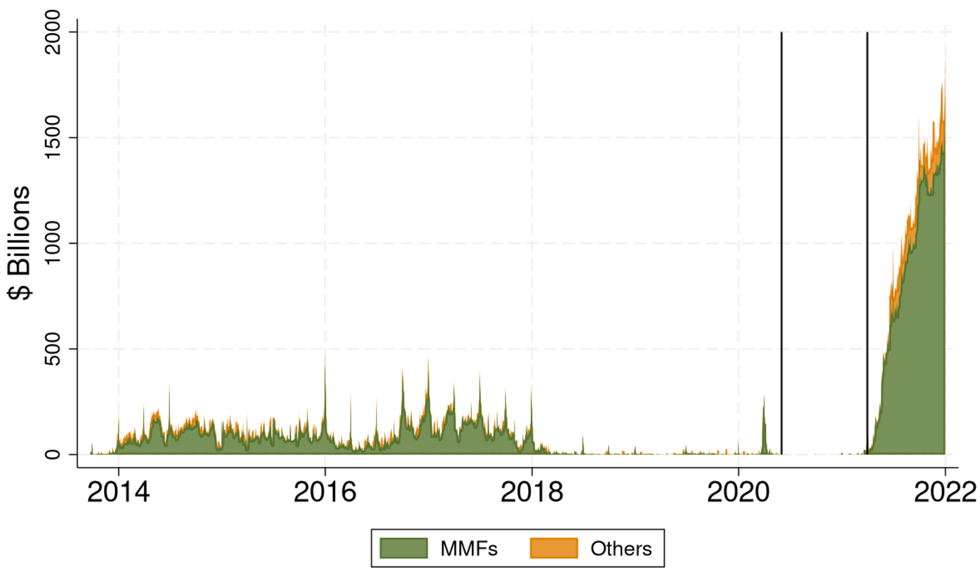

Figure 3: **ON RRP Take-up by Counterparty Type.** ON RRP investment is calculated in billions of dollars, at the daily frequency. Data are from the Federal Reserve Bank of New York (`https://www.newyorkfed.org/markets/desk-operations/reverse-repo`). The green area represents take-up by money market funds (MMFs); the orange area shows take-up by other counterparties. The vertical lines indicate the start-date and end-date of the SLR relief for depository institutions: June 1, 2020 and March 31, 2021.

Take-up at the ON RRP facility has fluctuated significantly since its inception. During the last four months of 2013, average take-up hovered around $15 billion, whereas over the next four years, it oscillated around $120 billion. Average daily take-up decreased to $9 billion over the 2018–2020 period, as the Federal Reserve shrank its balance sheet, and remained at around $8 billion through the end of March 2021. At that time, daily investment at the ON RRP facility started to increase steadily, reaching an average of $1.6 trillion in December

	Daily ON RRP Take-up								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total ($ billions)	15	123	112	104	145	12	5	9	725
MMF Share (%)	72	84	89	87	93	80	53	93	89
Gov-MMF Share of MMF Take-up (%)	59	72	74	83	79	87	79	79	87

Table 1: **ON RRP Take-up.** The first row shows the average daily total take-up (i.e., by all counterparties) at the ON RRP in billions of dollars for each calendar year, from the facility introduction (September 2013) to December 2021. The second row presents the average daily take-up by MMFs as a percentage of total take-up. The third row shows the average daily take-up by government MMFs as a percentage of total MMF take-up.

2021—a growth rate of $177 billion per month. Volume continued to increase through 2022, with take-up reaching an average of around $2 trillion in 2022.

3 Data

To study the impact of banks' balance-sheet costs on MMF size, we use daily data on MMFs' AUM, net yields, and bank affiliation from iMoneyNet;[14] we use the data on fund AUM and net yield to calculate daily net flows.[15] These data also allow us to distinguish between prime and government MMFs. Finally, we complement iMoneyNet data with the monthly N-MFP filings submitted by MMFs to the SEC, which are publicly available on the SEC website; these filings allow us to identify feeder funds, which we drop from our MMF sample.

For each MMF affiliated with a bank, we match iMoneyNet fund-level data with publicly available bank data, including whether the bank is subject to the SLR requirement, whether it is a custodial bank, its minimum SLR requirement, and its quarterly SLR, both at the BHC and at the DI levels.

To study the impact of banks' balance-sheet costs on MMFs' investment at the ON RRP, we use Federal Reserve confidential data about ON RRP investment at the individual fund level and daily frequency.[16] We match these data with the MMF-level data from iMoneyNet

[14] `https://financialintelligence.informa.com/products-and-services/data-analysis-and-tools/imoneynet`.

[15] Daily net dollar flows are $\text{Flow}_{it} = \text{AUM}_{it} - (1 + y_{it})\text{AUM}_{i,t-1}$, where y_{it} is the fund's daily net yield.

[16] Aggregated daily data on ON RRP take-up by institution type (e.g., MMF, primary dealer) are publicly

based on the funds' SEC series IDs, which are available in both datasets. By doing so, we can calculate the daily share of a fund's portfolio invested in the ON RRP (i.e., the fund's ON RRP dollar investment divided by the fund's AUM) and the weekly amount of a fund's portfolio invested in private repos (i.e., the fund's total repo investment minus the fund's ON RRP investment).[17]

For this analysis, we also use monthly data on MMFs' investment in "sponsored repos" from the Office of Financial Research (OFR);[18] sponsored repos are a particular type of Treasury repos that are cleared on the Fixed Income Clearing Corporation's (FICC) repo platform and can be netted, lowering balance-sheet costs (see Section 5). From the OFR dataset, we also obtained monthly data on MMF holdings of other forms of bank wholesale debt, including financial commercial paper, certificates of deposit, and other deposits.

Finally, to measure interest-rate uncertainty, we use the MOVE index, publicly available at the daily frequency from Yahoo!Finance (`https://finance.yahoo.com/quote/%5EMOVE/`); and to measure the T-bill supply, we use publicly available, monthly data on T-bill issuance and the total amount of T-bills outstanding from Haver Analytics (`https://www.haver.com/`).

4 Banks' Balance-sheet Costs and MMF Flows

In this section, we show that, in 2020-2021, banks reacted to increased balance-sheet costs by shedding their deposits, which then flew into MMF shares—the closest substitute to bank deposits.

To identify the impact of balance-sheet costs, we exploit as a quasi-natural experiment the SLR regulatory relief of 2021, which allowed banks to temporarily exclude Treasury securities and reserves from their SLR calculations. For banks subject to the SLR, balance-

available at `https://www.newyorkfed.org/markets/desk-operations/reverse-repo`.

[17] iMoneyNet data on funds' AUM are available daily, whereas their data on funds' investments by asset class, such as repos, are only available weekly.

[18] `https://www.financialresearch.gov/short-term-funding-monitor/datasets/mmf/`. OFR data on MMF portfolios are based on N-MFP filings, which report MMF security-level holdings at the end of each month.

sheet costs increased markedly after the end of the relief on March 31, 2021.[19] We focus on the end of the relief to avoid our results being confounded by the money-market turmoil of March–April 2020, which caused substantial volatility in MMF flows (Cipriani and La Spada, 2020).

Ceteris paribus, transferring funds from a bank's deposit account to a MMF sponsored by the same bank—rather than to a third-party's MMF—is easier for depositors, who minimize search costs, and more convenient for the bank, which retains its clients. Therefore, in our identification, we exploit the fact that, if banks became constrained after the end of the SLR relief, we should observe greater inflows in MMFs that are affiliated with banks subject to the SLR requirement.

Importantly, the assets and liabilities of affiliated MMFs are not included in the calculation of banks' SLR; as a result, flows from bank deposits to MMF shares increase banks' SLR, pushing it away from the constraint.[20] For this reason, around the end of the SLR relief, banks' subject to the SLR rule had an incentive to push their depositors into their affiliated MMFs, so as to increase their SLR and counteract the increase in balance-sheet costs due to the end of the relief.

Figure 4 shows the cumulative dollar flows in MMFs affiliated with banks subject to the SLR requirement ("SLR banks") and in all other MMFs, that is, MMFs that are not affiliated with banks or that are affiliated with banks that are not subject to the SLR. Consistent with our hypothesis, around the end of the SLR-relief period, funds affiliated with SLR banks grew more than the other funds. The growth of MMFs affiliated with SLR banks started in the first quarter of 2021, as the end date of the SLR relief had been announced at the time of its introduction. Investor flows usually happen in the months ahead of the implementation of pre-announced regulatory changes, as happened for instance in the aftermath of the 2014 SEC reform of the MMF industry, when flows from prime to government MMFs were observed a year before the reform came into effect (Cipriani and La Spada, 2021).

[19] Our estimation strategy does not imply that the SLR requirement is the only driver of banks' balance-sheet constraints; we are focusing on the SLR because the temporary relief of 2020–2021 allows us to exploit material time-series variation in the tightness of this specific balance-sheet constraint.

[20] Also note that MMF shares are a fund's equity; all else being equal, inflows decreases a fund's leverage. Moreover, although the SEC limits the amount of mutual funds' borrowing to 1/3 of their total assets (i.e., the minimum leverage ratio measured as equity over assets is 2/3), MMF borrowing is practically zero.

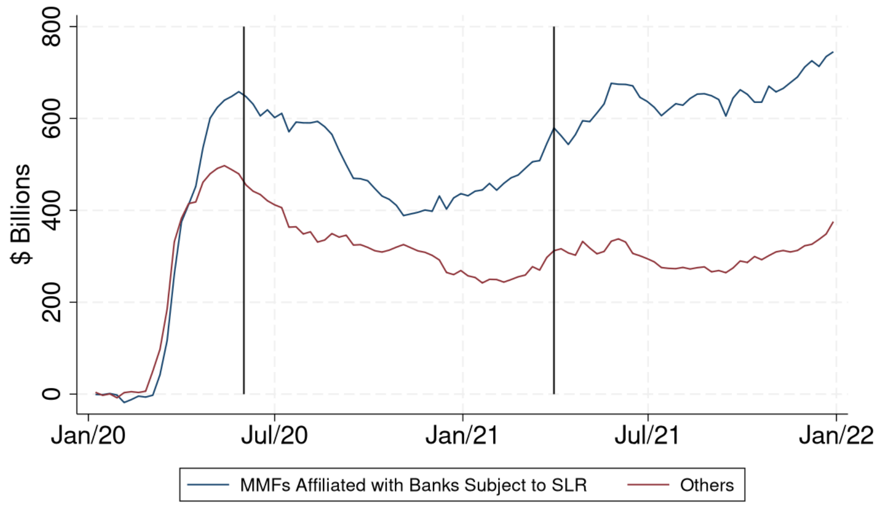

Figure 4: **MMF Cumulative Flows from January 2020 to December 2021, by Affiliation to SLR Banks.** Flows are calculated in billions of dollars, at the daily frequency. The blue line represents aggregate flows in MMFs affiliated with banks subject to the SLR; the red line is for all other MMFs. Data are from iMoneyNet. The vertical lines represent the start-date and end-date of the SLR relief for depository institutions: June 1, 2020, and March 31, 2021.

Note that the two groups of MMFs—those affiliated with banks subject to the SLR and those not affiliated with banks subject to the SLR—are similar in terms of other fund features. Columns (1)–(3) of Table 2 compare them along several characteristics, measured in 2019Q4. The two groups were very similar in terms of AUM and daily flows, with the difference being statistically insignificant for both characteristics; the share of government MMFs is also the same across the two groups (72%). The two groups are also statistically indistinguishable in terms of ON RRP eligibility and investment: the share of AUM eligible to be invested at the ON RRP was 80% for MMFs affiliated to SLR banks and 87% for the other MMFs (t-stat $= -0.781$), while the share of the portfolio invested at the facility was within 0.1% for both groups. The only characteristic that is statistically significantly different across the two groups is the fund net yield, which is greater for MMFs affiliated with SLR banks; economically, however, the difference is small (1.6% versus 1.5% in annualized terms), and, in all our regressions, we include the lagged net yield to control for this heterogeneity.

To formalize the observation in Figure 4, we run the following panel regression at the fund level and daily frequency, from June 1, 2020 (when the SLR relief became effective for

	SLR-Bank MMFs	Others		Gov	Prime	
	(1)	(2)	(3)	(4)	(5)	(6)
AUM ($bn)	19.575	13.381		16.622	11.915	
	(29.030)	(30.555)		(31.979)	(24.990)	
Net Yield (%)	1.557	1.467	***	1.424	1.672	***
	(0.240)	(0.282)		(0.255)	(0.235)	
Flow ($bn)	0.019	0.011		0.015	0.012	
	(0.553)	(0.351)		(0.486)	(0.194)	
SLR-Bank MMF Share	1.000	0.000		0.307	0.307	
	(0.000)	(0.000)		(0.461)	(0.461)	
Gov MMF Share	0.716	0.715		1.000	0.000	
	(0.451)	(0.451)		(0.000)	(0.000)	
Share of AUM eligible for ONRRP	0.803	0.866		0.824	0.902	
	(0.398)	(0.341)		(0.381)	(0.298)	
Share of AUM invested at ONRRP	0.001	0.000		0.001	0.000	*
	(0.010)	(0.007)		(0.009)	(0.001)	
Sample Period	10/19–12/19	10/19–12/19		10/19–12/19	10/19–12/19	
Number of funds	69	154		159	64	

Table 2: **Summary Statistics of MMF Characteristics.** For each characteristic, this table shows simple averages within different MMF types based on daily observations from 2019Q4; standard deviations are in parentheses. AUM is MMF assets under management in billions of dollars; Net Yield is annualized net yield in percentage points; Flow is the daily net flow in billions of dollars. SLR-bank MMF Share is the share of MMFs that are affiliated with banks subject to the SLR; Gov MMF share is the share of MMFs that are government funds. Column (1) shows statistics for SLR-bank affiliated MMFs; Column (2) for all other MMFs. Column (4) shows statistics for Government MMFs; Column (5) for Prime MMFs. Columns (3) and (6) show whether the t-statistic for the difference between group means is statistically significant at given confidence levels. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

DIs) to December 31, 2021:

$$\begin{aligned} \text{Flow}_{it} =& \beta_1 \, 2021\text{Q1}_t \times \text{SLR-Bank MMF}_i + \beta_2 \, 2021\text{Q2}_t \times \text{SLR-Bank MMF}_i \\ &+ \Gamma X_{i,t-1} + \alpha_i + \mu_t + \varepsilon_{it}. \end{aligned} \tag{1}$$

Flow_{it} is fund i's net flow on day t in billions of dollars. Since the end of the relief implied an immediate, permanent jump in banks' balance-sheet costs and the expiration date (March 31, 2021) was announced when the relief was introduced, we study the effects on MMF flows in the quarter before and the quarter after the end of the relief; these quarters are represented by the dummies 2021Q1_t and 2021Q2_t. SLR-Bank MMF_i is a dummy for funds affiliated with

SLR banks. $X_{i,t-1}$ is a fund-level vector of lagged time-varying controls, including net flows (to control for flow persistence) and net yield (to control for flow-performance relations). Finally, α_i are fund-fixed effects, and μ_t are time-fixed effects. Results are in Table 3; standard errors are robust to heteroskedasticity, serial correlation, and cross-correlation.[21]

	Flow$_{it}$ (\$bn)			
	(1) MMF	(2) MMF	(3) MMF	(4) Gov MMF
2021Q1$_t$ × SLR-Bank MMF$_i$	0.033**		0.037**	0.043**
	(0.015)		(0.018)	(0.021)
2021Q2$_t$ × SLR-Bank MMF$_i$	0.022		0.021	0.028
	(0.019)		(0.021)	(0.026)
Linear Trend × SLR-Bank MMF$_i$		0.000		
		(0.000)		
2021Q1$_t$ × Bank MMF$_i$			-0.004	
			(0.007)	
2021Q2$_t$ × Bank MMF$_i$			0.001	
			(0.007)	
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.02	0.04	0.02	0.03
Sample Period	6/20–12/21	6/20–12/20	6/20–12/21	6/20–12/21
Observations	78219	30255	78219	57890

Table 3: **Banks' Balance-Sheet Costs and MMF Size.** This table shows the results of panel regressions at the fund-day level based on equation (1). In Columns (1)–(3), the sample includes all MMFs; in Column (4), the sample is restricted to government MMFs. In Columns (1), (3), and (4), the time period is June 1, 2020–December 31, 2021; in Column (2), the time period is June 1–December 31, 2020 ("pre period"). Flow$_{it}$ is the fund's daily net flow in billions of dollars. 2021Q1$_t$ and 2021Q2$_t$ are two dummies for the quarters immediately before and immediately after the end of the SLR relief (March 31, 2021). SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR. Bank MMF$_i$ is a dummy for MMFs affiliated to any bank. Linear Trend is a linear time trend in days. All regressions include fund and day fixed effects, as well as the fund's lagged net yield and net flow as controls. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Column (1) of Table 3 shows that, in the quarter prior to the end of the SLR relief, net

[21] Throughout the paper, we use Driscoll-Kraay standard errors with 5 lags (Driscoll and Kraay, 1998).

flows in MMFs affiliated with a bank subject to the SLR requirement increased significantly more than those in other MMFs by \$33 million per day per fund (p-value = 0.028).[22] The effect in the following quarter is positive but insignificant, consistent with banks acting mostly ahead of end of the relief. In total, over the two quarters around the end of the relief, these net flows correspond to an additional increase in AUM of \$3.4 billion per fund. Since there are 107 MMFs affiliated with SLR banks, these funds grew by an additional \$364 billion in the six months around the end of the SLR relief program, relative to the rest of the industry—whose size was relatively stable during this period.

As Figure 4 shows, our results are not driven by a violation of the parallel trend assumption: during June-December 2020, flows in MMFs affiliated with banks subject to the SLR were not increasing relative to those in other MMFs—if anything, they were decreasing; their relative growth starts around the expiration of the SLR relief. To show this formally, in Column (2), we regress daily fund flows against the interaction of a linear time trend (in days) with the dummy for MMFs affiliated to SLR banks on June–December 2020 ("pre period"); we also include the same set of controls and fixed effects as in regression (1). The coefficient on Linear Trend $\times$ SLR-Bank MMF$_i$ is both economically and statistically insignificant, indicating that the parallel trend assumption holds in our data.

One concern with our results could be that the flows in MMFs affiliated with SLR banks increased more around the end of the SLR relief simply because those funds are affiliated with banks, not because the banks are subject to the SLR requirement. To rule out this possibility, we re-estimate regression (1) adding the interactions of the dummies for the quarters around the relief's end with a dummy for MMFs affiliated with any bank. Results are in the Column (3) of Table 3. Bank affiliation does not per se lead to larger inflows around the end of the SLR relief; only MMFs affiliated with banks subject to the SLR experience greater flows: in the quarter ahead of the expiration of the SLR relief, being affiliated to an SLR bank (the sum of the two coefficients in the new regression) leads to additional inflows of \$33 million per day (p-value = 0.028), identical to what we estimated in Column (1).

In Column (4) of Table 3, we replicate Column (1) restricting our sample to government MMFs. The effect of banks' balance-sheet costs on MMF size is even stronger: flows in

[22] In the analysis, we rely on the bank-affiliation dummy provided by iMoneyNet. For seven funds, the fund name suggests that the fund is affiliated to an SLR bank, but iMoneyNet bank-affiliation dummy is equal to zero. In Table C.1 of Appendix C, we rerun the analysis dropping these funds; results are unchanged.

government MMFs affiliated with SLR banks increase more than those in other government MMFs by $43 million per day per fund in the quarter before the end of the relief (p-value = 0.045) and by $28 million in the following quarter; this leads to a relative increase in AUM of $4.4 billion per fund over the first six months of 2021.

To rule out more general forms of endogeneity, we strengthen our identification in two ways. First, we exploit the differential regulatory treatment of custodial banks. As we explain in Section 2, custodial banks have been allowed to *permanently* exclude their central bank reserves from the SLR calculation since April 2020.[23] As a result, their balance-sheet costs tightened less than those of other SLR banks after the end of the SLR relief.[24] For this reason, custodial banks had lower incentives to push deposits into affiliated MMFs around March 2021. In our regression analysis, if banks respond to increased balance-sheet costs by pushing deposits into affiliated MMFs, we should observe MMFs affiliated with custodial banks experiencing smaller inflows around the end of the relief than MMFs affiliated with other SLR banks.

Column (1) in Table 4 replicates the results in Column (1) of Table 3, separating MMFs affiliated to SLR banks based on whether the bank is a custodial bank or not. Namely, we replace the SLR-Bank MMF_i dummy with two dummies: Custodial SLR-Bank MMF_i and Non-custodial SLR-Bank MMF_i. Consistent with our hypothesis, around the end of the relief, MMFs affiliated with custodial banks received significantly less inflows than MMFs affiliated with other banks subject to the SLR requirement. In both the quarter before and the quarter after the end of the relief, the net flows in custodial SLR banks are positive but both economically and statistically insignificant, both for all MMFs (Column (1)) and when we restrict the sample to government MMFs (Column (2)). In contrast, the effect on the flows in MMFs affiliated to non-custodial SLR banks is even stronger than in our baseline regressions: additional $49 million per day per fund in 2021Q1 when considering all MMFs (p-value = 0.015), and $64 million when considering only government MMFs (p-value = 0.029).

Our second way to strengthen our identification is to use data on individual banks' SLR levels: the incentive to shed deposits and push them into affiliated MMFs should be stronger

[23]All custodial banks in our sample are subject to the SLR.

[24]Because the different regulatory treatment of custodial banks regarding the SLR is limited to reserves—and does not include Treasuries—their SLR constraint also tightened after the end of the relief.

for banks whose SLR is closer to the regulatory requirement. To identify this effect, we therefore restrict our sample to MMFs affiliated with banks subject to the SLR requirement and run the following daily regression at the fund level:

$$\begin{aligned}\text{Flow}_{it} = &\beta_1\, 2021\text{Q1}_t \times (\text{SLR} - \text{SLR Req})_{i,2019Q4} + \beta_2\, 2021\text{Q2}_t \times (\text{SLR} - \text{SLR Req})_{i,2019Q4} \\ &+ \Gamma X_{i,t-1} + \alpha_i + \mu_t + \varepsilon_{it}, \end{aligned} \tag{2}$$

where $(\text{SLR} - \text{SLR Req})_{i,2019Q4}$ is the difference between the SLR and the required SLR of the bank to which MMF i is affiliated, calculated in 2019Q4 to control for endogeneity.

The results of regression (2) are in Column (3) of Table 4. MMFs affiliated with SLR banks whose SLR is closer to the minimum requirement experience significantly greater inflows in the quarter prior to the end of the SLR relief: a 10-percentage-point reduction in a bank's SLR buffer leads to inflows into the affiliated MMFs of \$50 million per day per fund (p-value = 0.018), corresponding to an increase in fund AUM of \$3 billion per fund over 2021Q1. As in regression (1), results for the quarter following the end of the relief have the same sign but are smaller in magnitude and statistically insignificant. Results are practically the same when we restrict the sample to government MMFs (Column (4)).

In Appendix A, we run several robustness checks. First, we replicate Tables 3 and 4 starting the sample on April 14, 2020—when the SLR relief became effective for BHCs—instead of June 1; see Tables A.1 and A.2. Second, instead of using the bank's SLR buffer in 2019Q4, we replicate regression (2) using the bank's SLR buffer lagged by one quarter, to capture time variation in the tightness of the balance-sheet constraint; see Table A.3. Finally, we also replicate Tables 3 and 4 using fund AUM as dependent variable instead of fund flows, that is, we run our analysis in levels rather than changes; see Tables A.4 and A.5. For all these robustness checks, results are similar to the ones presented here.

	Flow$_{it}$ (\$bn)			
	(1)	(2)	(3)	(4)
	MMF	Gov MMF	MMF	Gov MMF
2021Q1$_t$ × Non-Custodial SLR-Bank MMF$_i$	0.049**	0.064**		
	(0.020)	(0.029)		
2021Q2$_t$ × Non-Custodial SLR-Bank MMF$_i$	0.029	0.038		
	(0.026)	(0.035)		
2021Q1$_t$ × Custodial SLR-Bank MMF$_i$	0.009	0.012		
	(0.018)	(0.023)		
2021Q2$_t$ × Custodial SLR-Bank MMF$_i$	0.008	0.012		
	(0.021)	(0.027)		
2021Q1$_t$ × (SLR - SLR Req)$_{i2019Q4}$			-0.005**	-0.005**
			(0.002)	(0.003)
2021Q2$_t$ × (SLR - SLR Req)$_{i2019Q4}$			-0.002	-0.001
			(0.002)	(0.003)
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.02	0.03	0.05	0.06
Sample Period	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21
Observations	78219	57890	25100	18358

Table 4: **Banks' Balance-Sheet Costs and MMF Size: Identification through Custodial Banks and Banks' SLR Buffers.** This table shows the results of panel regressions at the fund-day level based on equations (1) and (2). In Columns (1) and (3), the sample includes all MMFs; in Columns (2) and (4), the sample is restricted to government MMFs. The time period is June 1, 2020–December 31, 2021. Flow$_{it}$ is the fund's daily net flow in billions of dollars. 2021Q1$_t$ and 2021Q2$_t$ are two dummies for the quarters immediately before and immediately after the end of the SLR relief (March 31, 2021). Non-custodial SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR that are not custodial banks. Custodial SLR-Bank MMF$_i$ is a dummy for MMFs affiliated to custodial banks subject to the SLR. (SLR-SLR Req)$_{i2019Q4}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the last quarter of 2019, in percentage points. All regressions include fund and day fixed effects, as well as the fund's lagged net yield and net flow as controls. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

5 Banks' Balance-sheet Costs and MMF Portfolios

5.1 The Effect of Balance-sheet Costs

In this section, we identify a different channel through which banks' balance-sheet costs affect MMFs: by reducing banks' incentive to borrow, higher balance-sheet costs also limit

MMFs' investment options. In other words, when banks' balance-sheet constraints tighten—as it happened after the end of the SLR relief—banks' supply of wholesale debt available for purchase shifts inward, and MMFs must find alternative similar investments, such as the ON RRP.

The inward shift in banks' supply of wholesale debt caused by a tightening of the SLR constraint is particularly strong for overnight repos backed by government collateral because the SLR is not risk-weighted; as a result, it especially penalizes the use of balance-sheet space for safe, low-margin activities such as matched-book repo intermediation (Duffie and Krishnamurthy, 2016; Duffie, 2018). Moreover, since the relief excluded Treasuries from the SLR calculation, matched-book Treasury repos did not take any balance-sheet space during the relief, but they did right afterwards.[25]

MMFs can absorb a negative shock to banks' supply of wholesale debt by substituting these assets with ON RRP investment. Consistent with this hypothesis, Figure 1 shows that MMF holdings of private overnight Treasury repos decreased steadily after March 2021, whereas their ON RRP investment—their closest substitute—increased steeply.[26] In contrast, MMF holdings of non-repo bank debt—such as financial commercial paper, certificates of deposit, and non-negotiable time deposits—did not change materially around the end of the SLR relief, confirming that the end of the relief had a significantly stronger effect on government-collateral repo (see Figure B.2 in Appendix B).

This shift from private to public repos by MMFs could also be the result of a negative demand shock; for instance, MMFs would likely demand less private repo if banks' riskiness increases as default is costly also in collateralized positions. Panel (a) of Figure 5 strongly suggests that this is not the case. The spread between the Secured Overnight Financing Rate (SOFR)—a broad measure of the interest rate on private overnight Treasury repos—and the ON RRP rate increases with the introduction of the relief and decreases as the relief ends; this evidence is consistent with the end of the SLR relief representing a negative shift to banks' repo supply that dominated any negative demand shocks that may have occurred

[25] Absent netting, the collateral used by an intermediary to borrow cash from MMFs and expand matched-book repo intermediation is an asset on the intermediary's balance sheet, entering the SLR calculation.

[26] Since the 2014 SEC reform of the MMF industry, which shrank prime funds and expanded government funds by more than $1 trillion dollars, repos have become the most important form of private debt available for investment to MMFs (Cipriani and La Spada, 2021).

around that time.[27]

Further evidence that MMFs' shift from private to public repos stems from a negative shock in banks' repo supply comes from the sponsored repo market. Sponsored repos are transactions in which a dealer sponsors non-dealer counterparties—such as MMFs (cash lenders) and hedge funds (cash borrowers)—on the cleared repo platform operated by FICC. For dealers affiliated with banks subject to the SLR, the benefit of sponsored repos is that the lending and borrowing legs of these transactions can be netted, reducing their balance-sheet footprint and mitigating their impact on the SLR. Panel (b) of Figure 5 shows that while total private repos held by MMFs declined sharply after the end of the SLR relief—by $295 billion from the end of March to the end of December 2021 (i.e., a drop of 31%)—the amount of sponsored repos in MMF portfolios remained stable.[28] That is, only the private repos that significantly contribute to banks' SLR calculations declined in MMF portfolios, supporting our conjecture that, after the end of the SLR relief, MMF reallocated their investments away from private repo because banks' balance-sheet constraints tightened.

To identify the effect of the surge in banks' balance-sheet costs caused by the end of the SLR relief on MMFs' ON RRP investment, we exploit the fact that government MMFs are more affected than prime MMFs. There are two reasons for this. First, government MMFs have fewer investment options to absorb the negative shift in banks' debt supply; the reason is that they can only lend to the private sector via repos backed by government debt, which are typically issued by dealers affiliated with large BHCs. Prime funds, in contrast, can invest in a broader set of assets that include non-bank debt, such as non-financial commercial paper and local government debt. Second, the type of bank debt held by government MMFs—overnight government-collateral repo—is more penalized by the SLR than the other forms of wholesale bank debt available to prime MMFs. For these reasons, if the tightening of bank balance-sheet costs caused by the end of the SLR relief led MMFs to shift their portfolios toward the ON RRP, we should observe a stronger impact on government MMFs. Consistent with this hypothesis, Figure 6 shows that between March and December 2021, government MMFs increased their portfolio share invested at the ON RRP significantly more than prime

[27] A negative demand shock would have resulted into a higher SOFR-ONRRP spread, not a lower one.

[28] By August 2022, total private repos held by MMFs declined by $408 billion, whereas the amount of sponsored repos in MMF portfolios stayed around $90 billion. See Figure B.1 in Appendix B.

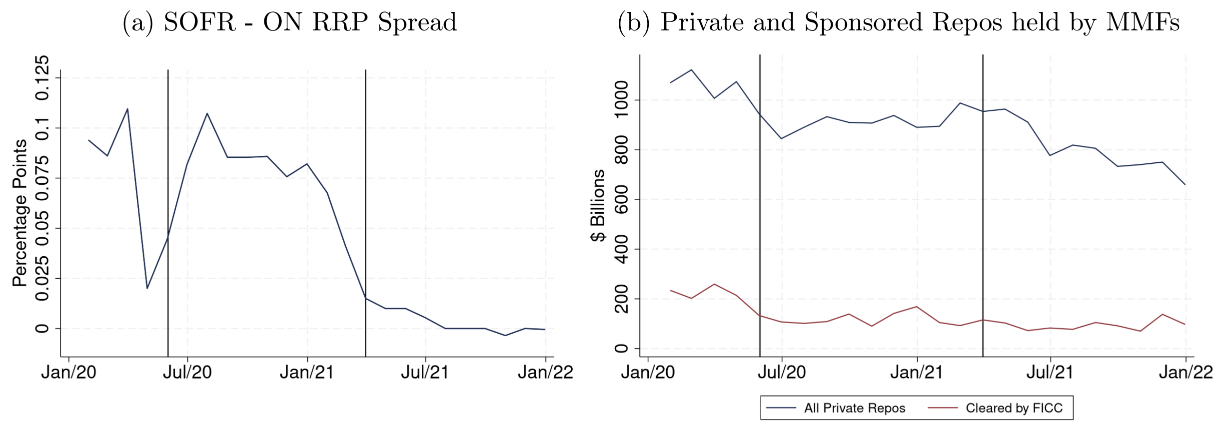

Figure 5: **Repo Spreads and MMF Investment in Sponsored Repos from January 2020 to December 2021.** Panel (a) shows the spread between the Secured Overnight Financing Rate (SOFR)—a broad measure of the interest rate on overnight Treasury-backed private repos—and the ON RRP rate. Rates are in percentage points; data are from FRED. Panel (b) shows the total amount of private repos held by MMFs (blue line) and the amount of private repos held by MMFs that are cleared by the Fixed Income Clearing Corporation (FICC) in its sponsored repo platform (red line). MMF holdings are in billions of dollars; data are from the from the Office of Financial Research (OFR) US Money Market Fund Monitor. The vertical lines represent the start-date and end-date of the SLR relief for depository institutions: June 1, 2020, and March 31, 2021.

MMFs.[29]

To test our hypothesis, we run the following panel regression at the fund level and daily frequency, on the sample of MMFs eligible to invest in the ON RRP, from June 2020 to December 2021:

$$\%\text{ONRRP}_{it} = \beta\,\text{Post SLR Relief}_t \times \text{Gov}_i + \Gamma X_{i,t-1} + \alpha_i + \mu_t + \varepsilon_{it},, \tag{3}$$

where $\%\text{ONRRP}_{it}$ is the percentage of MMF i's portfolio invested in the ON RRP on day t, Post SLR Relief_t is a dummy for the period after the SLR relief expired (March 31, 2021), and Gov_i is a dummy for government MMFs. $X_{i,t-1}$ is a set of lagged fund-level controls that, in addition to the same controls as in regression (1), also includes: (i) the interaction of the

[29]Prime MMFs' investment in the ON RRP spikes at month ends because European banks, whose overnight debt represents a sizable share of prime-MMF portfolios but a small share of government-MMF portfolios, reduce their wholesale short-term borrowing around those dates to "window-dress" their balance sheet.

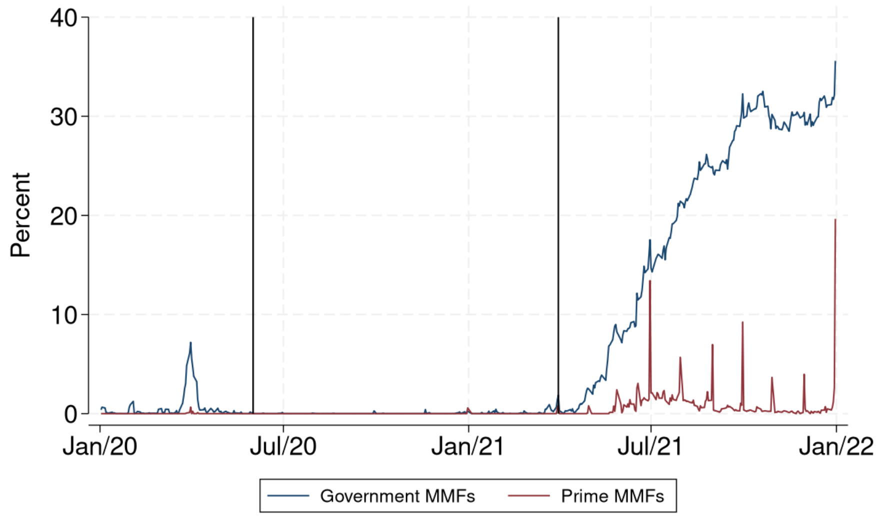

Figure 6: **Share of Portfolio Invested at the ON RRP by Government (blue line) and Prime MMFs (red line) from January 2020 to December 2021.** Portfolio shares are in percentage points; data are from the Federal Reserve Bank of New York and iMoneyNet. The vertical lines represent the start-date and end-date of the SLR relief for depository institutions: June 1, 2020, and March 31, 2021.

government-MMF dummy with a dummy for the first quarter of 2021 to allow for anticipatory effects, and (*ii*) the interactions of the government-MMF dummy with dummies for one-day windows around month-ends to allow for the differential effect of European banks' window-dressing; we include a different dummy for each month-end in the sample to allow this effect to vary over time. Finally, α_i and μ_t are fund and time fixed effects. Results are in Table 5; standard errors are robust to heteroskedasticity, serial correlation, and cross-correlation.[30]

Column (1) of Table 5 shows that, after the expiration of the SLR relief, the portfolio share invested at the ON RRP increased significantly more in government MMFs than in prime MMFs, by more than 19 percentage points (p-value < 0.01). As shown in Figure 6,

[30]Note that although government and prime MMFs have different portfolio constraints by regulation, in 2019Q4, they were similar in terms of AUM, flows, and affiliation to SLR banks, with the difference being statistically insignificant for all characteristics (see Table 2). Government and prime MMFs were also similar in terms of eligibility to invest at the ON RRP and actual ON RRP investment; the difference in actual ON RRP investment in 2019Q4 is mildly statistically significant (p-value $= 0.096$), but it is economically negligible: 0.1% for government MMFs versus 0.0% for prime MMFs. Unsurprisingly, the only significant difference between government and prime MMFs is the annualized net yield (1.4% versus 1.7%), for which we control in all our regressions.

our results are not driven by a violation of the parallel trend assumption: throughout the SLR-relief period, the percentage of fund portfolio invested at the ON RRP is practically zero for both government and prime MMFs. We run a formal test in Column (2), similar to the one in Table 3: the coefficient on the interaction between the government-MMF dummy and the linear time trend is zero and statistically insignificant.

Another possible concern is that, right after the end of the SLR relief, some factor other than a shift in the supply of bank debt may have affected the ON RRP investment of government MMFs more than that of prime MMFs. In Section 4, for example, we show that the flows into MMFs caused by the end of the relief were greater for government MMFs; as a result, government MMFs may have increased their portfolio shares at the ON RRP because, around the end of the relief, they experienced larger inflows and decided to place the additional cash at the facility while searching for new investment opportunities; if this was the case, it would be the effect of balance-sheet costs on MMF flows that caused the change in the relative composition of MMF portfolios, not the supply of banks' wholesale short-term debt. We address this issue in two ways.

First, to strengthen our identification, we estimate regression (3) restricting the sample to government MMFs and using the average share of a fund's portfolio invested in private repos during 2019Q4 as our treatment variable.[31] A fund's private repo share measures its reliance on private repos as an investment option; we expect funds that rely more heavily on private repos to be more exposed to the negative supply shock caused by the end of the SLR relief. Results are in Column (3) of Table 5 and are consistent with those of our baseline specification: after the expiration of SLR relief, a ten-percentage-point increase in the pre-sample share of private repos in a government-MMF portfolio increases the fund's ON RRP portfolio share by 2.4 percentage points (p-value < 0.01).

Second, in Section 5.3, we show that the impact of the end of the SLR relief on MMFs' portfolio composition—and in particular on government funds' investment in the ON RRP—is not driven by the flow of SLR-bank deposits into government MMFs. That is, the effect of a tightening in banks' balance-sheet costs on MMF portfolios is separate from its effect on MMF size, consistent with our hypotheses.

[31] We measure the share of a fund's portfolio invested in repos during 2019Q4 to control for endogeneity issues; ON RRP take-up was practically zero in that time period, and most repos held by MMFs were private.

		$\%ONRRP_{it}$	
	(1)	(2)	(3)
	MMF	MMF	Gov MMF
Post SLR Relief$_t$ × Gov$_i$	19.251***		
	(1.682)		
Linear Trend × Gov$_i$		0.000	
		(0.000)	
Post SLR Relief$_t$ × Private Repo Share$_{i2019Q4}$			0.238***
			(0.023)
Fund FE	Y	Y	Y
Date FE	Y	Y	Y
Controls	Y	Y	Y
R^2	0.75	0.09	0.81
Sample Period	6/20–12/21	6/20–12/20	6/20–12/21
Observations	30850	11673	22496

Table 5: **Banks' Balance-Sheet Costs and the Share of MMF Portfolio Invested at the ON RRP.** The table shows the results of panel regressions at the fund-day level based on equation (3). In Columns (1) and (2), the sample includes all MMFs eligible to invest in the ON RRP; in Column (3), the sample is restricted to eligible government MMFs. In Columns (1) and (3), the time period is June 1, 2020–December 31, 2021; in Column (2), the time period is June 1–December 31, 2020 ("pre period"). $\%ONRRP_{it}$ is the percentage of fund AUM invested at the ON RRP. Post SLR Relief$_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). Gov$_i$ is a dummy for government MMFs; Private Repo Share$_{i,2019Q4}$ is the percentage of private repos in the fund portfolio in 2019Q4. Linear Trend is a linear time trend in days. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, and the interactions of month-end dummies (one for each month) with Gov$_i$ in Columns (1) and (2) and with Private Repo Share$_{i2019Q4}$ in Column (3). In Columns (1) and (3), the set of controls also includes the interaction of a dummy for 2021Q1 (i.e., one quarter ahead of the end of the SLR relief) with the relevant treatment variable (Gov$_i$ and Private Repo Share$_{i2019Q4}$, respectively). Driscoll-Kraay standard errors are in parentheses.

Finally, for robustness, in Appendix B, we replicate the regressions in Table 5 starting the sample on April 14, 2020—the day the SLR relief became effective for BHCs. Results are similar; see Table B.1.

5.2 Other Determinants of MMF Investment at the ON RRP

In this section, we identify two additional drivers of MMFs' investment at the ON RRP: interest rate uncertainty and the supply of T-bills. Both drivers should have stronger effects on government MMFs than on prime MMFs and could therefore confound our results. When we control for these drivers, however, the effect of banks' balance-sheet costs on the ON RRP share in MMF portfolios remains quantitatively similar and statistically significant.

5.2.1 Interest rate risk

When interest rate risk increases, MMFs—similarly to other fixed-income mutual funds—have an incentive to shorten the duration of their portfolios (La Spada, 2018; Afonso et al., 2021); since ON RRP investment is overnight, *ceteris paribus*, higher interest rate uncertainty leads MMFs to increase their portfolio share in the ON RRP.

This effect is stronger for government MMFs for two reasons. First, government MMFs have a more limited set of options to manage interest rate risk than prime MMFs, which can invest in a broader set of financial instruments to protect their portfolios against interest rate risk—including privately-issued floating-rate notes and overnight certificate of deposits and CP. Second, government-MMF portfolios have a higher share of Treasuries and agency debt, which tend to have longer duration than the other assets held by MMFs and are therefore more exposed to interest-rate risk.

To identify the effect of interest rate risk on government MMFs' investment in the ON RRP, we run the following fund-level panel regression at the daily frequency on ON RRP-eligible MMFs, from June 1, 2020 to December 31, 2021:

$$\%\text{ONRRP}_{it} = \beta\,\text{MOVE}_{t-1} \times \text{Gov}_i + \Gamma X_{i,t-1} + \alpha_i + \mu_t + \varepsilon_{it}, \tag{4}$$

where MOVE_{t-1} is the MOVE index—a measure of interest rate risk based on option-implied bond volatility—lagged by one day. The set of fund-level controls $X_{i,t-1}$ includes the lagged flow and net yield, as well as the interactions of the government-MMF dummy with the month-end dummies. All the other variables are defined as in regression (3).

The results of regression (4) are in Column (1) of Table 6; standard errors are robust to heteroskedasticity, serial correlation, and cross-correlation. Consistent with our conjecture, an increase in interest rate risk leads government MMFs to increase their ON RRP investment relatively more than prime MMFs: a 10-point increase in the MOVE index leads government MMFs to increase their portfolio share of ON RRP investment by 5.6 percentage points more than prime MMFs (p-value < 0.01). Since the standard deviation of the MOVE Index during June 2020–December 2021 was 11 points, the effect is economically important.

		$\%ONRRP_{it}$	
	(1)	(2)	(3)
	MMF	MMF	MMF
$MOVE_{t-1} \times Gov_i$	0.562^{***}		
	(0.057)		
T-Bills $Issuance_{t-30} \times Gov_i$		-14.823^{***}	
		(2.589)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}} \times Gov_i$			-40.545^{***}
			(4.958)
Fund FE	Y	Y	Y
Date FE	Y	Y	Y
Controls	Y	Y	Y
R^2	0.72	0.69	0.72
Sample Period	6/20–12/21	6/20–12/21	6/20–12/21
Observations	30850	30850	30850

Table 6: **Interest Rate Risk, T-bill Supply, and the Share of MMF Portfolio Invested at the ON RRP.** This table shows the results of panel regressions at the fund-day level based on equations (4) and (5). The sample includes all MMFs eligible to invest in the ON RRP. The time period is June 1, 2020–December 31, 2021. $\%ONRRP_{it}$ is the percentage of fund AUM invested at the ON RRP. Gov_i is a dummy for government MMFs. $MOVE_{t-1}$ is the MOVE index, lagged by one day. T-bill $Issuance_{t-30}$ is the total T-bill issuance in the previous calendar month in trillion dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, and the interactions of month-end dummies (one for each month) with Gov_i. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

5.2.2 T-bill Supply

A second driver of MMF investment at the ON RRP that could confound our identification strategy is the supply of T-bills. The availability of T-bills limits MMFs' investment options because MMFs are restricted by SEC regulation to invest in securities with remaining maturity less than 397 days; this effect is stronger for government MMFs, as these funds have more limited investment options and may therefore be pushed toward ON RRP investment when the availability of T-bills dwindles.

To identify the effect of T-bill supply on MMFs' investment at the ON RRP, we run the following fund-level panel regression at the daily frequency on ON RRP-eligible MMFs, from June 1, 2020 to December 31, 2021:

$$\%\text{ONRRP}_{it} = \beta\,\text{T-bill Supply}_{t-30} \times \text{Gov}_i + \Gamma X_{i,t-1} + \alpha_i + \mu_t + \varepsilon_{it}, \tag{5}$$

where T-bill Supply_{t-30} is the value of T-bills issuance in trillion dollars, measured in the calendar month before day t to mitigate possible endogeneity issues.[32] All other variables are as in regression (4).

Results of regression (5) are in Column (2) of Table 6; standard errors are robust to serial correlation, cross-correlation, and heteroskedasticity. Consistent with our conjecture, a monthly decrease of T-bill issuance by \$100 billion increases the portfolio share of ON RRP investment significantly more for government MMFs than for prime MMFs, by 1.5 percentage points (p-value < 0.01). Since the standard deviation of monthly T-bill issuance in our sample is \$220 billion, the effect is economically important.

In Column (3), we estimate regression (5) using another measure of T-bill supply: the value T-bills outstanding relative to total AUM of MMFs in percentages; this measure is also only available at the monthly frequency. Consistent with the results based on T-bill issuance, a decline of 10 percentage points in the ratio of T-bills outstanding to total MMF AUM leads government MMFs to increase their portfolio share at the ON RRP by an additional 4.1 percentage points relative to prime funds (p-value < 0.01); since the standard deviation of the value of T-bills outstanding as a percentage of total MMF AUM in our sample is 12

[32] Our data on T-bill issuance and T-bills outstanding are only available at the monthly frequency.

percentage points, the effect is economically important.

5.3 Putting It All Together

Since variaton in interest rate risk and T-bill supply could contaminate our estimates of the impact of bank balance-sheet costs on the ON RRP share in MMF portfolios, in this section, we rerun our analysis explicitly controlling for these potential confounding factors. Namely, we re-estimate regression (3) adding the interactions of the government-MMF dummy with our measures of T-bill supply (either T-bill issuance or T-bill outstanding over total MMF AUM) and interest rate risk (the MOVE index). Results are in Table 7.

The impact of bank balance-sheet costs on the share of MMF portfolios invested at the ON RRP remains significant and large: after the end of the SLR relief, government MMFs increased their portfolio share of ON RRP investment by 11.6 percentage points more than prime MMFs (p-value < 0.01). Interest rate uncertainty and T-bill supply also affect government-MMF portfolios in a way that is consistent with the results of the previous section: a ten-point increase in the MOVE index leads government MMFs to increase their portfolio share at the ON RRP by 3.3 percentage points more than prime MMFs (p-value $<$ 0.01); similarly, a $100-billion dollar decline in last month's T-bill issuance leads to a relative increase of 0.8 percentage points (p-value < 0.01).[33]

In other words, although both interest rate risk and T-bill supply are important determinants of the share of MMFs' portfolio invested at the ON RRP, accounting for these channels does not make the effect of banks' balance-sheet costs disappear. The impact of the increase in banks' balance-sheet costs after the end of the SLR relief remains significant and quantitatively important.

We also quantify the effect of banks' balance-sheet costs—as well as the effects of T-bill supply and interest-rate risk—on the dollar investment of MMFs at the ON RRP. In terms of dollar value, an increase in banks' balance-sheet costs affects MMFs investment at the ON RRP in two ways: it increases both MMF size (Section 4) and the ON RRP share in MMF portfolios. To capture both the size and portfolio composition channels, we run

[33] Results are similar when measuring T-bill supply as the ratio of T-bills outstanding to total MMF AUM; see Column (2) of Table 7.

	$\%ONRRP_{it}$	
	(1)	(2)
	MMF	MMF
Post SLR $\text{Relief}_t \times \text{Gov}_i$	11.639***	9.218***
	(2.152)	(2.249)
$\text{MOVE}_{t-1} \times \text{Gov}_i$	0.328***	0.352***
	(0.055)	(0.046)
T-Bills $\text{Issuance}_{t-30} \times \text{Gov}_i$	-8.250***	
	(1.693)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}} \times \text{Gov}_i$		-25.731***
		(3.794)
Fund FE	Y	Y
Date FE	Y	Y
Controls	Y	Y
R^2	0.76	0.77
Sample Period	6/20–12/21	6/20–12/21
Observations	30850	30850

Table 7: **Banks' Balance-Sheet Costs and the Share of MMF Portfolio Invested at the ON RRP: Controlling for the Effects of Interest Rate Risk and T-bill Supply.** This table shows the results of panel regressions at the fund-day level based on equations (3)–(5). The sample includes all MMFs eligible to invest in the ON RRP. The time period is June 1, 2020–December 31, 2021. $\%ONRRP_{it}$ is the percentage of fund AUM invested at the ON RRP. Post SLR Relief_t is a dummy for the period after the end of the SLR relief (March 31, 2021). Gov_i is a dummy for government MMFs. T-bill Issuance_{t-30} is the total T-bill issuance in the previous calendar month in trillions of dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, the interaction of a dummy for 2021Q1 (i.e., one quarter ahead of the end of the SLR relief) with Gov_i, and the interactions of month-end dummies (one for each month) with Gov_i. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

a specification that merges regressions (1) and (3), while also controlling for the effects of interest rate uncertainty and T-bill supply from regressions (4) and (5).

Namely, we run the following daily regression on the panel of MMFs that are eligible to invest at the ON RRP, from April 14, 2020 to December 31, 2021:

$$
\begin{aligned}
\$\text{ONRRP}_{it} = &\ \beta_1 \,\text{Post SLR Relief}_t \times \text{SLR-Bank MMF}_i \\
&+ \beta_2 \,\text{Post SLR Relief}_t \times \text{Gov}_i \\
&+ \beta_3 \,\text{MOVE}_{t-1} \times \text{Gov}_i + \beta_4 \,\text{T-bill Supply}_{t-30} \times \text{Gov}_i \\
&+ \Gamma X_{i,t-1} + \alpha_i + \mu_t + \varepsilon_{it},
\end{aligned}
\tag{6}
$$

where the set of controls $X_{i,t-1}$ includes the fund's lagged net yield, the lagged net flow, the interactions of a dummy for 2021Q1 with the dummy for MMFs affiliated to SLR banks and the dummy for government MMFs (to allow for anticipatory effects), and the interactions of month-end dummies (one for each month) with the government-MMF dummy (to allow for the differential effect of European banks' window-dressing on government and prime MMFs). All other variables are defined as in regressions (1)-(5). Results are in Table 8; standard errors are robust to heteroskedasticity, serial correlation, and cross-correlation.

Column (1) of Table 8 shows that after the end of the SLR relief, MMFs affiliated with banks subject to the SLR—whose AUM increased on average by \$2.2 billion per fund in the quarter before the relief end—increased their daily ON RRP investment by \$1.2 billion per fund relative to other MMFs (p-value < 0.01). Similarly, after the end of the SLR relief, government MMFs—whose portfolio was more impacted by banks' reduction of repo borrowing than that of prime MMFs—increased their daily ON RRP investment by \$7.6 billion per fund relative to prime MMFs (p-value < 0.01).

Interest rate uncertainty and T-bill supply also have important effects on the dollar-value of ON RRP take-up in 2020–2021. From June 2020–March 2021 to April–December 2021, the MOVE index increased by 13 points, leading to an additional daily ON RRP investment of \$3.2 billion for the average government MMF, relative to the average prime MMF (p-value < 0.01). Similarly, one-month-lagged monthly T-bill issuance decreased by \$280 billion during the same period, leading to an additional daily investment by the average government MMF of \$1.4 billion (p-value < 0.01). In Column (2), we replicate the regression in Column (1) measuring T-bill supply as the ratio between T-bills outstanding and MMFs' total AUM in the previous month; results are qualitatively and quantitatively similar.

In Columns (3) and (4) of Table 8, we replicate Columns (1) and (2) adding the in-

	$ONRRP_{it}$			
	(1) MMF	(2) MMF	(3) MMF	(4) MMF
Post SLR Relief$_t$ × SLR-Bank MMF$_i$	1.212***	1.174***	3.067***	3.042***
	(0.183)	(0.185)	(0.323)	(0.327)
Post SLR Relief$_t$ × SLR-Bank MMF$_i$ × (SLR - SLR Req)$_{i2019Q4}$			-0.711***	-0.717***
			(0.064)	(0.063)
Post SLR Relief$_t$ × Gov$_i$	7.628***	6.342***	8.066***	6.763***
	(1.282)	(1.425)	(1.295)	(1.440)
MOVE$_{t-1}$ × Gov$_i$	0.246***	0.257***	0.246***	0.257***
	(0.037)	(0.031)	(0.037)	(0.031)
T-Bills Issuance$_{t-30}$ × Gov$_i$	-5.113***		-5.092***	
	(1.088)		(1.091)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ × Gov$_i$		-14.963***		-15.018***
		(2.586)		(2.580)
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.54	0.54	0.54	0.54
Sample Period	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21
Observations	30850	30850	30850	30850

Table 8: **Banks' Balance-Sheet Costs, Interest Rate Risk, T-bill Supply, and MMF Dollar Investment at the ON RRP.** This table shows the results of panel regressions at the fund-day level based on equation (6). The sample includes all MMFs eligible to invest in the ON RRP. The time period is June 1, 2020–December 31, 2021. $ONRRP$_{it}$ is the fund's dollar investment at the ON RRP in billions of dollars. Post SLR Relief$_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR. (SLR-SLR Req)$_{i2019Q4}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the last quarter of 2019. Gov$_i$ is a dummy for government MMFs. MOVE$_{t-1}$ is the MOVE index, lagged by one day. T-bill Issuance$_{t-30}$ is the total T-bill issuance in the previous calendar month in trillions of dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flows, the interactions of a dummy for 2021Q1 (i.e., one quarter ahead of the end of the SLR relief) with SLR-Bank MMF$_i$ and with Gov$_i$, and the interactions of month-end dummies (one for each month) with Gov$_i$. In Columns (3) and (4), the set of controls also includes the interaction of the 2021Q1 dummy with SLR-Bank MMF$_i$ × (SLR-SLR Req)$_{i2019Q4}$. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

teractions Post SLR Relief$_t$ × SLR-Bank MMF$_i$ × (SLR − SLR Req)$_{i2019Q4}$ and 2021Q1$_t$ × SLR-Bank MMF$_i$ × (SLR − SLR Req)$_{i2019Q4}$. Results are similar; after the end of the SLR relief, MMFs affiliated with SLR banks increase their daily dollar ON RRP investment relatively more, and the increase is larger if the bank's 2019Q4 SLR buffer is lower—by additional $700 million per one-percentage-point drop in the buffer (p-value < 0.01). This evidence is consistent with these funds experiencing larger inflows due to the the tightening of banks' balance-sheet costs and placing the additional cash at the ON RRP. The effects of all other channels are practically unchanged.

One could wonder whether the impact of the end of the SLR relief on MMFs' portfolio choices—and in particular on government funds' investment in the ON RRP—may be driven by the flow of SLR-bank deposits into government MMFs. This is not the case. To show that, in Table 9, we re-estimate regression (6) using the percentage of fund portfolio invested at the ON RRP ($\%\text{ONRRP}_{it}$) as dependent variable. Importantly, after controlling for the impact of affiliation to an SLR bank, government MMFs still increase their portfolio share invested at the ON RRP more than prime MMFs (by 12 percentage points, with p-value < 0.01).[34] This evidence suggests that the relative increase in the ON RRP investment of government MMFs after the end of the SLR relief was driven by the inward shift in bank supply of wholesale debt and especially of Treasury repos—and not by the increase in the relative size of government MMFs.

For robustness, in Appendix B, we replicate Tables 7– 9 starting the sample on April 14, 2020, when the SLR relief became effective for BHCs. Results are similar; see Tables B.3–B.5.

6 Conclusions

This paper finds that banks' balance-sheet costs, such as those introduced by the post-GFC regulation, have an important impact on MMFs—both the primary non-bank alternative to bank deposits and the main non-bank provider of wholesale liquidity to banks. We do that by looking at the effect of bank balance-sheet costs on both MMF size and their investment at the Federal Reserve's ON RRP facility—a facility through which MMFs can place cash with the Federal Reserve at a fixed rate.

[34] After the end of the SLR relief, MMFs affiliated with SLR banks also increase their portfolio share of ON RRP investment in relative terms (by 1.8 percentage points with p-value < 0.01), consistent with these funds using the ON RRP to invest the inflows received from affiliated banks around the end of the relief.

	%ONRRP$_{it}$ (%)			
	(1)	(2)	(3)	(4)
	MMF	MMF	MMF	MMF
Post SLR Relief$_t$ × SLR-Bank MMF$_i$	1.832***	1.750***	2.147***	2.087***
	(0.301)	(0.307)	(0.437)	(0.440)
Post SLR Relief$_t$ × SLR-Bank MMF$_i$ × (SLR - SLR Req)$_{i2019Q4}$			-0.121*	-0.129**
			(0.063)	(0.063)
Post SLR Relief$_t$ × Gov$_i$	11.744***	9.295***	11.818***	9.371***
	(2.150)	(2.247)	(2.143)	(2.245)
MOVE$_{t-1}$ × Gov$_i$	0.330***	0.354***	0.330***	0.354***
	(0.056)	(0.046)	(0.055)	(0.046)
T-Bills Issuance$_{t-30}$ × Gov$_i$	-8.039***		-8.036***	
	(1.681)		(1.681)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ × Gov$_i$		-25.489***		-25.499***
		(3.787)		(3.787)
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.76	0.77	0.76	0.77
Sample Period	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21
Observations	30850	30850	30850	30850

Table 9: **Banks' Balance-Sheet Costs, Interest Rate Risk, T-bill Supply, and the Share of MMF Portfolio Invested at the ON RRP.** This table shows the results of panel regressions at the fund-day level based on equation (6). The sample includes all MMFs eligible to invest in the ON RRP. The time period is June 1, 2020–December 31, 2021. %ONRRP$_{it}$ is is the percentage of fund AUM invested at the ON RRP. Post SLR Relief$_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR. (SLR-SLR Req)$_{i2019Q4}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the last quarter of 2019. Gov$_i$ is a dummy for government MMFs. MOVE$_{t-1}$ is the MOVE index, lagged by one day. T-bill Issuance$_{t-30}$ is the total T-bill issuance in the previous calendar month in trillions of dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flows, the interactions of a dummy for 2021Q1 (i.e., one quarter ahead of the end of the SLR relief) with SLR-Bank MMF$_i$ and with Gov$_i$, and the interactions of month-end dummies (one for each month) with Gov$_i$. In Columns (3) and (4), the set of controls also includes the interaction of the 2021Q1 dummy with SLR-Bank MMF$_i$ × (SLR-SLR Req)$_{i2019Q4}$. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

To identify the impact of balance-sheet costs, we use a quasi-natural experiment: the variation in banks' balance-sheet costs caused by the SLR relief of 2020–2021; this regulatory change temporarily excluded Treasuries and reserves from the calculation of banks'

SLRs, reducing the balance-sheet costs associated with the SLR requirement for almost a year. Around the end of the relief, when the balance-sheet costs of the banks subject to the SLR regulation rose, MMFs affiliated with these banks experienced significantly larger inflows, as these banks had an incentive to shed depositors and push them into their affiliated funds. Moreover, after the end of the relief, MMFs with more limited investment options—government MMFs—shifted their portfolios towards the ON RRP more, as SLR banks also reduced their repo borrowing to shrink the size of their balance sheets.

Our findings imply that central bank balance-sheet expansions—by increasing banks' balance-sheet costs—impact financial markets beyond their direct effect on the banking system. In financial systems where non-bank financial institutions (NBFIs) have access to the central bank balance sheet, NBFIs may hold a fraction of the central bank's liabilities, draining reserves from the banking system and potentially affecting the impact of QE on the economy. In contrast, if only banks have access to the central-bank balance sheet, banks' balance-sheet space becomes more limited, as banks must hold all the liquidity injected by the central bank; in this case, central-bank balance-sheet expansions are likely to increase NBFI intermediation, which may pose risks to financial stability. These are important questions that deserve further investigation.

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Appendix

A Banks' Balance-Sheet Costs and MMF Size

In this appendix, we present robustness checks of our results on the effect of banks' balance-sheet costs on MMF size (Section 4). Table A.1 replicates the results of Table 3, starting the sample on April 14, 2020, when the SLR relief became effective for bank holding companies (BHCs)—instead of June 1, when it became effective for depository institutions (DIs). The MMF flows in the earlier part of this sample were affected by the money-market turmoil of March–April 2020; to make sure that our results are not contaminated by this confounding factor, we also include the interaction of a dummy for April 2020 with the dummy for MMFs affiliated with SLR banks. Throughout the appendix, as in the paper, we use standard errors that are robust to heteroskedasticity, serial correlation, and cross-correlation.

Results are very similar to those reported in the main text. In the quarter prior to the end of the SLR relief, net flows in MMFs affiliated with a bank subject to the SLR requirement increased significantly more than those in other MMFs, by \$30 million per day when considering all MMF types (p-value = 0.044) and by \$39 million per day when restricting the sample to government MMFs (p-value = 0.062). As in Table 3, the effect in the quarter following the end of the SLR relief is positive and economically important but statistically insignificant, consistent with banks acting mostly ahead of the end of the relief. Finally, as in Table 3, we also show that the parallel trend assumption is not violated (Column (2)), that the effect is robust to controlling for MMF affiliation to any type of bank (Column (3)), and that the effect is stronger when restricting the sample to government MMFs (Column (4)).

We also replicate the results of Table 4 in the main text, starting the sample on April 14, 2020; see Table A.2. As in Table A.1, to make sure that our results are not contaminated by the investor flows caused by the money-market turmoil of March–April 2020, we also include the interactions of a dummy for April 2020 with the dummies for MMFs affiliated with non-custodial and custodial SLR banks and with the 2019Q4 SLR buffer of the bank to which the fund is affiliated. Results are quantitatively and qualitatively similar to those in the main text: MMFs affiliated with non-custodial banks subject to the SLR experience significant

	Flow$_{it}$ (\$bn)			
	(1)	(2)	(3)	(4)
	MMF	MMF	MMF	Gov MMF
2021Q1$_t$ × SLR-Bank MMF$_i$	0.030**		0.035*	0.039*
	(0.015)		(0.018)	(0.021)
2021Q2$_t$ × SLR-Bank MMF$_i$	0.017		0.017	0.023
	(0.019)		(0.021)	(0.025)
Linear Trend × SLR-Bank MMF$_i$		-0.000		
		(0.000)		
2021Q1$_t$ × Bank MMF$_i$			-0.005	
			(0.007)	
2021Q2$_t$ × Bank MMF$_i$			0.000	
			(0.007)	
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.02	0.03	0.02	0.03
Sample Period	4/20–12/21	4/20–12/20	4/20–12/21	4/20–12/21
Observations	85160	37196	85160	62865

Table A.1: **Banks' Balance-Sheet Costs and MMF Size.** This table shows the results of panel regressions at the fund-day level based on equation (1) of the main text. In Columns (1)–(3), the sample includes all MMFs; in Column (4), the sample is restricted to government MMFs. In Columns (1), (3), and (4), the time period is April 14, 2020 (when the SLR relief was established for BHCs)–December 31, 2021; in Column (2), the time period is April 14–December 31, 2020 ("pre period"). Flow$_{it}$ is the fund's daily net flow in billions of dollars. 2021Q1$_t$ and 2021Q2$_t$ are two dummies for the quarters immediately before and immediately after the end of the SLR relief (March 31, 2021). SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR. Bank MMF$_i$ is a dummy for MMFs affiliated to any bank. Linear Trend is a linear time trend in days. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, the interaction of a dummy for April 2020 with SLR-Bank MMF$_i$, and, in Column (3), also the interaction of the April-2020 dummy with Bank MMF$_i$. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

inflows around the end of the SLR relief, whereas MMFs affiliated with custodial banks subject to the SLR do not, consistent with the increase in balance-sheet costs being greater for non-custodial banks as we explain in the text (Section 2). Similarly, MMFs affiliated with SLR banks with a lower SLR buffer in 2019Q4 experience larger inflows around the end of the relief.

	Flow$_{it}$ ($bn)			
	(1)	(2)	(3)	(4)
	MMF	Gov MMF	MMF	Gov MMF
$2021Q1_t$ × Non-Custodial SLR-Bank MMF$_i$	0.044**	0.058**		
	(0.020)	(0.029)		
$2021Q2_t$ × Non-Custodial SLR-Bank MMF$_i$	0.024	0.032		
	(0.026)	(0.035)		
$2021Q1_t$ × Custodial SLR-Bank MMF$_i$	0.009	0.011		
	(0.017)	(0.022)		
$2021Q2_t$ × Custodial SLR-Bank MMF$_i$	0.006	0.010		
	(0.021)	(0.027)		
$2021Q1_t$ × (SLR - SLR Req)$_{i2019Q4}$			-0.010**	-0.008
			(0.005)	(0.007)
$2021Q2_t$ × (SLR - SLR Req)$_{i2019Q4}$			-0.004	-0.001
			(0.006)	(0.009)
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.02	0.03	0.05	0.06
Sample Period	4/20–12/21	4/20–12/21	4/20–12/21	4/20–12/21
Observations	85160	62865	27344	19942

Table A.2: **Banks' Balance-Sheet Costs and MMF Size: Identification through Custodial Banks and Banks' SLR Buffers.** This table shows the results of panel regressions at the fund-day level based on equations (1) and (2) of the main text. In Columns (1) and (3), the sample includes all MMFs; in Columns (2) and (4), the sample is restricted to government MMFs. The time period is April 14, 2020 (when the SLR relief was established for BHCs)–December 31, 2021. Flow$_{it}$ is the fund's daily net flow in billions of dollars. $2021Q1_t$ and $2021Q2_t$ are two dummies for the quarters immediately before and immediately after the end of the SLR relief (March 31, 2021). Non-custodial SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR that are not custodial banks. Custodial SLR-Bank MMF$_i$ is a dummy for MMFs affiliated to custodial banks subject to the SLR. (SLR-SLR Req)$_{i2019Q4}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the last quarter of 2019. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, and the interactions of a dummy for April 2020 with Non-custodial SLR-Bank MMF$_i$ and Custodial SLR-Bank MMF$_i$ in Columns (1) and (2) and with (SLR-SLR Req)$_{i2019Q4}$ in Columns (3) and (4). Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table A.3 replicates the results of regression (2) of the main text (see Columns (3) and (4) of Table 4), using the three-month lagged difference between the SLR of the bank to which the fund is affiliated and the regulatory requirement, $(\text{SLR}-\text{SLR Req})_{i,t-60}$, as the treatment variable. Similarly to the 2019Q4 SLR buffer used in regression (2), this variable aims to measure the tightness of the bank's balance-sheet constraints and therefore the exposure of its affiliated MMFs to the bank's balance-sheet costs; in contrast to the 2029Q4 SLR buffer, however, this proxy can capture time variation in the tightness of the bank's balance-sheet constraints. As in Table 4, the regression is run on the sample of MMFs affiliated to banks subject to the SLR. In Column (1), we include both prime and government MMFs; in Column (2), we restrict the sample to government MMFs.

Results are in Table A.3 and are very similar to those in Columns (3) and (4) of Table 4. A 10-percentage-point reduction in a bank's SLR buffer leads to inflows into the affiliated MMFs of \$70 million per day per fund in the quarter ahead of the end of the SLR relief (p-value = 0.015), for a total increase in AUM of \$4.3 billion per fund over 2021Q1; the effect is the same when restricting the sample to government MMFs (\$70 million per day per fund, with p-value = 0.052).

For robustness, we also replicate our analysis using fund AUM as dependent variable, instead of fund flows; that is, we run our analysis in levels rather than in changes. Namely, we estimate the following regression:

$$\text{AUM}_{it} = \beta \text{Post SLR}_t \times \text{SLR-Bank MMF}_i + \Gamma X_{i,t-1} + \alpha_i + \mu_t + \varepsilon_{it}, \tag{A.1}$$

where AUM_{it} is fund i's AUM in billions of dollars on day t, Post SLR_t is a dummy for the period after the end of the SLR relief (March 31, 2021), SLR-Bank MMF_i is a dummy for MMFs affiliated to SLR banks, and $X_{i,t-1}$ is a set of controls that includes the fund's lagged net yield, the lagged net flow, and the interaction of a dummy for 2021Q1 with the dummy for MMFs affiliated to SLR banks to allow for anticipatory effects. α_i and μ_t are fund and day fixed effects.

Results of regression (A.1) are in Table A.4 and are qualitatively and quantitatively consistent with those in the main text (see Table 3). After the SLR relief ended, the AUM of MMFs affiliated with SLR banks increased by \$3 billion per fund relative to those of

	Flow$_{it}$ (\$bn)	
	(1)	(2)
	MMF	Gov MMF
$2021Q1_t \times (\text{SLR - SLR Req})_{it-60}$	-0.007**	-0.007*
	(0.003)	(0.003)
$2021Q2_t \times (\text{SLR - SLR Req})_{it-60}$	-0.002	-0.002
	(0.002)	(0.003)
Fund FE	Y	Y
Date FE	Y	Y
Controls	Y	Y
R^2	0.05	0.06
Sample Period	6/20–12/21	6/20–12/21
Observations	24924	18226

Table A.3: **Banks' Balance-Sheet Costs and MMF Size: Identification through Banks' Lagged SLR Buffers.** This table shows the results pf panel regressions at the fund-day level based on equation (2) of the main text. In Column (1) , the sample includes all MMFs; in Columns (2), the sample is restricted to government MMFs. The sample period is from June 1, 2020–December 31, 2021. Flow$_{it}$ is the fund's daily net flow in billions of dollars. $2021Q1_t$ and $2021Q2_t$ are two dummies for the quarters immediately before and immediately after the end of the SLR relief (March 31, 2021). $(\text{SLR} - \text{SLR Req})_{it-60}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the previous calendar quarter. All regressions include fund and day fixed effects, as well as the fund's lagged net yield and net flow as controls. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

other MMFs (p-value < 0.01); see Column (1). Consistent with the results in the main text, Column (2) shows that the AUM of MMFs affiliated with SLR banks were not increasing relative to those of other MMFs during June–December 2020 ("pre period"); if anything, they were mildly decreasing. Finally, as in our results on fund flows, the effect is robust to controlling for MMF affiliation to any type of bank (Column (3)) and is even stronger when restricting the sample to government MMFs (Column (4)).

In Table A.5, we replicate Table 4 using fund AUM as dependent variable. Results are similar to those in the main text. After the end of the relief, the AUM of MMFs affiliated with non-custodial SLR banks increase by \$3.2 billion per fund (p-value < 0.01) and significantly more than those of MMFs affiliated with custodial SLR banks (by \$661

	AUM$_{it}$ (\$bn)			
	(1)	(2)	(3)	(4)
	MMF	MMF	MMF	Gov MMF
Post SLR Relief$_t$ × SLR-Bank MMF$_i$	3.013***		2.658***	3.694***
	(0.211)		(0.213)	(0.284)
Linear Trend × SLR-Bank MMF$_i$		-0.020***		
		(0.002)		
Post SLR Relief$_t$ × Bank MMF$_i$			0.396***	
			(0.062)	
Post SLR Relief$_t$ × (SLR-Bank MMF$_i$ - Bank MMF$_i$)			2.262***	
(F-statistic)			95.792	
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.99	0.99	0.99	0.99
Sample Period	6/20–12/21	6/20–12/20	6/20–12/21	6/20–12/21
Observations	78219	30255	78219	57890

Table A.4: **Banks' Balance-Sheet Costs and MMF Size, Using Fund AUM as Dependent Variable.** This table shows the results of panel regressions at the fund-day level based on equation (A.1). In Columns (1)–(3) the sample includes all MMFs; in Column (4), the sample is restricted to government MMFs. In Columns (1), (3), and (4) the time period is June 1, 2020–December 31, 2021; in Column (2), the time period is June 1–December 31, 2020 ("pre period"). AUM$_{it}$ is the fund's daily AUM in billions of dollars. Post SLR Relief$_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR. Bank MMF$_i$ is a dummy for MMFs affiliated to any bank. Linear Trend is a linear time trend in days. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, the interaction of a dummy for 2021Q1 (i.e., one quarter ahead of the end of the SLR relief) with SLR-Bank MMF$_i$ in Columns (1), (3), and (4), and also the interaction of the 2021Q1 dummy with Bank MMF$_i$ in Column (3). Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

million with p-value < 0.01); the effect is even stronger when restricting the sample to government MMFs (Column (2)). Similarly, the size of MMFs affiliated with SLR banks that had a lower SLR buffer in 2019Q4 (i.e., before the introduction of the SLR relief) increases more after the end of the relief: a 10-percentage-point reduction in the buffer leads to an increase in size of \$198 million per fund (p-value < 0.01) when considering all MMFs and of \$218 million when considering only government MMFs.

	AUM$_{it}$ ($bn)			
	(1)	(2)	(3)	(4)
	MMF	Gov MMF	MMF	Gov MMF
Post SLR Relief$_t$ × Non-Custodial SLR-Bank MMF$_i$	3.243***	4.534***		
	(0.208)	(0.299)		
Post SLR Relief$_t$ × Custodial SLR-Bank MMF$_i$	2.583***	2.299***		
	(0.237)	(0.282)		
Post SLR Relief$_t$ × (SLR - SLR Req)$_{i2019Q4}$			-0.198***	-0.218***
			(0.026)	(0.033)
Post SLR Relief$_t$ × (Non-Custodial SLR-Bank MMF$_i$ - Custodial SLR-Bank MMF$_i$)	0.661***	2.234***		
(F-statistic)	27.956	205.204		
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.99	0.99	0.98	0.98
Sample Period	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21
Observations	78219	57890	25100	18358

Table A.5: **Banks' Balance-Sheet Costs and MMF Size: Identification through Custodial Banks and Banks' SLR Buffers, Using Fund AUM as Dependent Variable**. This table shows the results of panel regressions at the fund-day level based on equation (A.1). In Columns (1) and (3), the sample includes all MMFs; in Columns (2) and (4), the sample is restricted to government MMFs. The time period is June 1, 2020–December 31, 2021. AUM$_{it}$ is the fund's daily net AUM in billions of dollars. Post SLR Relief$_t$ is a dummy for the period immediately after the end of the SLR relief (March 31, 2021). Non-custodial SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR that are not custodial banks. Custodial SLR-Bank MMF$_i$ is a dummy for MMFs affiliated to custodial banks subject to the SLR. (SLR-SLR Req)$_{i2019Q4}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the last quarter of 2019. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, and the interactions of a dummy for 2021Q1 (i.e., one quarter ahead of the end of the SLR relief) with Non-custodial SLR-Bank MMF$_i$ and Custodial SLR-Bank MMF$_i$ in Columns (1) and (2) and with (SLR-SLR Req)$_{i2019Q4}$ in Columns (3) and (4). Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

B Banks' Balance-sheet Costs and MMF Portfolios

In this appendix, we present robustness checks of our results on the effect of banks' balance-sheet costs on the share MMF portfolios invested at the ON RRP (Section 5).

Figure B.1 replicates Panel (b) of Figure 5 in the main text, extending the sample until August 31, 2022. This figure shows that total private repos held by MMFs declined by $408 billion from the end of the SLR relief to the end of August 2022, whereas the amount of sponsored repos in MMF portfolios remained roughly constant, around $90 billion. Since sponsored repos cleared by FICC are nettable, which means that they take less space on banks' balance sheets than other repos, this evidence suggests that the decline in MMFs' holdings of private repos after the end of the SLR relief was due to the sudden increase in banks' balance-sheet costs, rather than to a negative demand shock on MMFs.

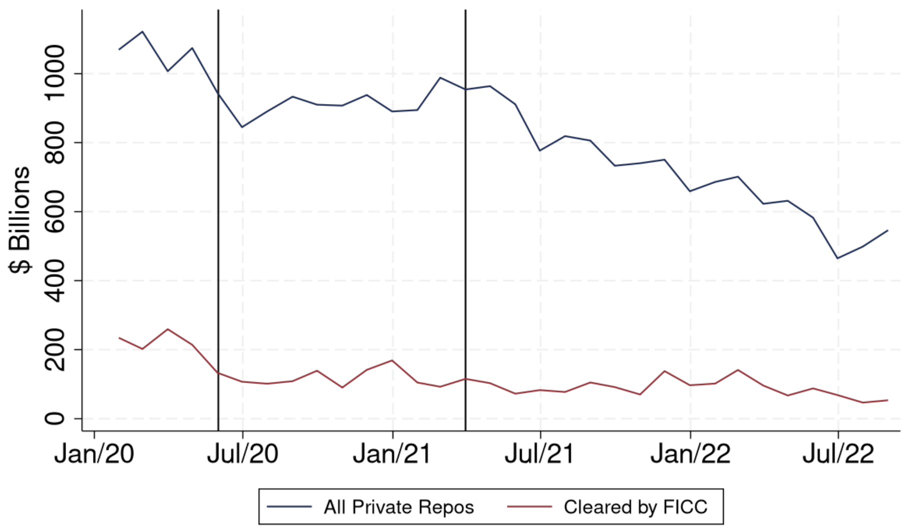

Figure B.1: **Private Repos and Sponsored Repos Held by MMFs from January 2020 to August 2022.** This figure shows the total amount of private repos held by MMFs (blue line) and the amount of private repos held by MMFs that are cleared by the Fixed Income Clearing Corporation (FICC) in its sponsored repo platform (red line), at the end of each month. MMF holdings are in billions of dollars; data are from the Office of Financial Research (OFR) US Short-term Funding Monitor. The vertical lines represent the start-date and end-date of the SLR relief for depository institutions: June 1, 2020, and March 31, 2021.

Figure B.2 shows that, in contrast to the share of bank repos, the share of non-repo bank debt in MMF portfolios remained roughly constant around the end of the SLR relief. The share of financial commercial paper, certificates of deposits, and non-negotiable deposits in MMF portfolios declined in the first half of 2020, likely because of the money-market turmoil triggered by the Covid-19 crisis; it, however, stabilized in the second half of that year and stayed around $400 billion throughout the end of 2021, i.e., after the end of the relief.

Table B.1 replicates the results of Table 5 of the main text, starting the sample on April 14, 2020, when the SLR relief became effective at the BHC level.[35] Results are almost

[35] As in Appendix A, to control for the money-market turmoil of March–April 2020, our regressions include

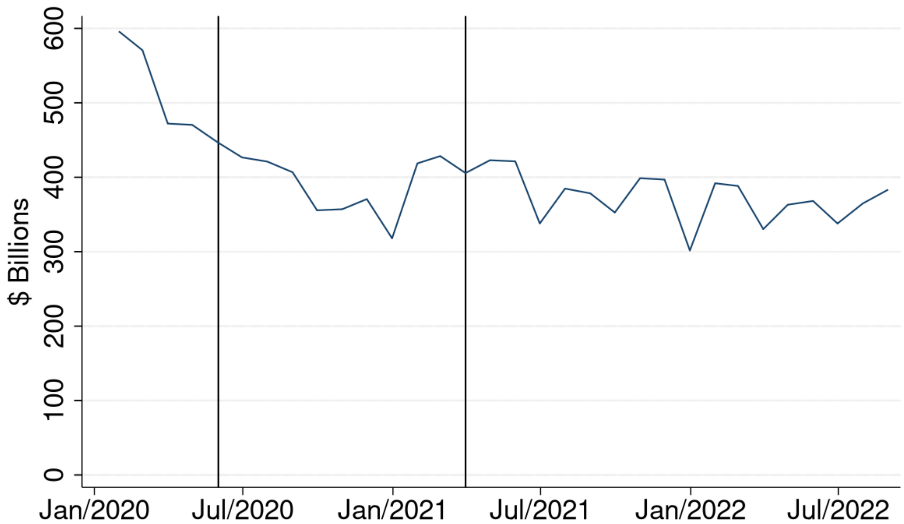

Figure B.2: **Non-repo Bank Debt Held by MMFs from January 2020 to August 2022.** This figure shows the total amount of financial commercial paper, certificates of deposits, and non-negotiable time deposits held by MMFs at the end of each month. MMF holdings are in billions of dollars; data are from the Office of Financial Research (OFR) US Short-term Funding Monitor. The vertical lines represent the start-date and end-date of the SLR relief for depository institutions: June 1, 2020, and March 31, 2021.

identical. After the end of the relief, government MMFs increased the portfolio share invested in the ON RRP by 19 percentage points more than prime MMFs (p-value < 0.01). This evidence is consistent with government MMFs being more exposed to the negative shock to bank supply of wholesale debt caused by the surge in balance-sheet costs triggered by the end of the SLR relief. Column (2) also shows that while the interaction of a linear time trend with the government-MMF dummy is statistically significantly positive in April–December 2020 ("pre period"), its magnitude is negligible, amounting to a total difference in the ON RRP portfolio shares of government and prime MMFs of only 0.09 percentage points from the end of the SLR relief to the end of the sample. The validity of the parallel trend assumption is also visible in Figure 6 and confirmed by Column (2) of Table 5. Finally, Column (3) shows that within government MMFs, funds that invested more in private repos in 2019Q4 (i.e., they rely more on bank debt to manage their portfolios) increased their portfolio share

the interaction of a dummy for April 2020 with the relevant treatment variable, i.e., the government-MMF dummy in Columns (1) and (2) and the 2019Q4 share of private repos in fund portfolios in Column (3).

at the ON RRP more after the end of the SLR relief, consistent with Column (3) of Table 5.

	%ONRRP$_{it}$		
	(1)	(2)	(3)
	MMF	MMF	Gov MMF
Post SLR Relief$_t$ × Gov$_i$	19.364***		
	(1.668)		
Linear Trend × Gov$_i$		0.000***	
		(0.000)	
Post SLR Relief$_t$ × Private Repo Share$_{i2019Q4}$			0.236***
			(0.023)
Fund FE	Y	Y	Y
Date FE	Y	Y	Y
Controls	Y	Y	Y
R^2	0.75	0.17	0.81
Sample Period	4/20–12/21	4/20–12/20	4/20–12/21
Observations	33589	14412	24278

Table B.1: **Banks' Balance-Sheet Costs and the Share of MMF Portfolio Invested at the ON RRP.** This table shows the results of panel regressions at the fund-day level based on equation (3) of the main text. In Columns (1) and (2), the sample includes all MMFs eligible to invest in the ON RRP; in Column (3), the sample is restricted to eligible government MMFs. In Columns (1) and (3), the time period is April 14, 2020 (when the SLR relief was established for BHCs)–December 31, 2021; in Column (2), the time period is April 14, 2020–December 2020 ("pre period"). %ONRRP$_{it}$ is the percentage of fund AUM invested at the ON RRP. Post SLR Relief$_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). Gov$_i$ is a dummy for government MMFs; Private Repo Share$_{i,2019Q4}$ is the percentage of private repo investment in the fund portfolio in 2019Q4. Linear Trend is a linear time trend in days. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, the interactions of month-end dummies (one for each month) with Gov$_i$ in Columns (1) and (2) and with Private Repo Share$_{i,2019Q4}$ in Column (3), and the interaction of a dummy for April 2020 with Gov$_i$ in Columns (1) and (2) and with Private Repo Share$_{i,2019Q4}$ in Column (3). Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table B.2 replicates Table 6, starting the sample on April 14, 2020, when the SLR relief became effective at the BHC level. Results are very similar: a 10-point increase in the MOVE index leads government MMFs to increase their portfolio share of ON RRP investment by 5.3 percentage points more than prime MMFs (p-value < 0.01); a \$100-billion decline in monthly T-bill supply leads to a relative increase of 1.2 percentage points (p-value < 0.01). Results are similar when measuring the T-bill supply in terms of T-bills outstanding relative to the total AUM of the MMF industry (see Column (3)).

	$\%ONRRP_{it}$		
	(1)	(2)	(3)
	MMF	MMF	MMF
$MOVE_{t-1} \times Gov_i$	0.532***		
	(0.053)		
$\text{T-Bills Issuance}_{t-30} \times Gov_i$		-12.326***	
		(1.871)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}} \times Gov_i$			-30.842***
			(3.996)
Fund FE	Y	Y	Y
Date FE	Y	Y	Y
Controls	Y	Y	Y
R^2	0.72	0.69	0.71
Sample Period	4/20–12/21	4/20–12/21	4/20–12/21
Observations	33589	33589	33589

Table B.2: **Interest Rate Risk, T-bill Supply, and the Share of MMF Portfolio Invested at the ON RRP.** This table shows the results of panel regressions at the fund-day level based on equations (4) and (5) of the main text. The sample includes all MMFs eligible to invest in the ON RRP. The time period is April 14, 2020 (when the SLR relief was established for BHCs)–December 31, 2021. $\%ONRRP_{it}$ is the percentage of fund AUM invested at the ON RRP. Gov_i is a dummy for government MMFs. $MOVE_{t-1}$ is the MOVE index, lagged by one day. $\text{T-bill Issuance}_{t-30}$ is the total T-bill issuance in the previous calendar month in trillion dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, and the interactions of Gov_i with month-end dummies (one for each month) and with a dummy for April 2020. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Table B.3 replicates Table 7 of the main text, which confirms that our results on the effect of balance-sheet costs on MMF investment at the ON RRP are not driven by variation in interest rate risk or T-bill supply, starting the sample on April 14, 2020, instead of June 1. Results are again very similar. Even after controlling for the effects of interest rate risk and T-bill supply, the end of the SLR relief led government MMFs to increase the portfolio share invested at the ON RRP more than prime MMFs, by 12 percentage points (p-value < 0.01). Also consistent with the results in the paper and those in Table B.2, higher interest rate risk (as measured by the MOVE index) and lower T-bill supply lead government MMFs to increase the portfolio share of ON RRP investment more than prime MMFs.

	$\%ONRRP_{it}$	
	(1)	(2)
	MMF	MMF
Post SLR $Relief_t$ × Gov_i	11.897***	11.705***
	(2.127)	(2.100)
$MOVE_{t-1}$ × Gov_i	0.317***	0.307***
	(0.054)	(0.043)
T-Bills $Issuance_{t-30}$ × Gov_i	-7.575***	
	(1.417)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ × Gov_i		-19.065***
		(3.057)
Fund FE	Y	Y
Date FE	Y	Y
Controls	Y	Y
R^2	0.76	0.76
Sample Period	4/20–12/21	4/20–12/21
Observations	33589	33589

Table B.3: **Banks' Balance-Sheet Costs and the Share of MMF Portfolio Invested at the ON RRP: Controlling for the Effects of Interest Rate Risk and T-bill Supply.** This table shows the results of panel regressions at the fund-day level based on equations (3)–(5) of the main text. The sample includes all MMFs eligible to invest in the ON RRP. The time period is April 14, 2020 (when the SLR relief was established for BHCs)–December 31, 2021. $\%ONRRP_{it}$ is the percentage of fund AUM invested at the ON RRP. Post SLR $Relief_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). Gov_i is a dummy for government MMFs. T-bill $Issuance_{t-30}$ is the total T-bill issuance in the previous calendar month in trillions of dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, and the interactions of Gov_i with month-end dummies (one for each month) and with a dummy for April 2020. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

Finally, Tables B.4 and B.5 replicates the results of Tables 8 and 9 on MMF investment at the ON RRP, both in dollar terms and in terms of portfolio share, starting the sample on April 14, 2020. Results are qualitatively and quantitatively similar to those in the main text.

	$\$ONRRP_{it}$			
	(1)	(2)	(3)	(4)
	MMF	MMF	MMF	MMF
Post SLR Relief$_t$ × SLR-Bank MMF$_i$	1.192***	1.267***	4.039***	4.125***
	(0.183)	(0.189)	(0.345)	(0.354)
Post SLR Relief$_t$ × SLR-Bank MMF$_i$ × (SLR - SLR Req)$_{i2019Q4}$			-1.155***	-1.160***
			(0.080)	(0.080)
Post SLR Relief$_t$ × Gov$_i$	7.817***	8.105***	8.097***	8.370***
	(1.263)	(1.330)	(1.270)	(1.340)
MOVE$_{t-1}$ × Gov$_i$	0.239***	0.225***	0.239***	0.225***
	(0.036)	(0.030)	(0.036)	(0.030)
T-Bills Issuance$_{t-30}$ × Gov$_i$	-4.992***		-4.975***	
	(0.924)		(0.925)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ × Gov$_i$		-10.438***		-10.478***
		(2.098)		(2.097)
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.52	0.53	0.53	0.53
Sample Period	4/20–12/21	4/20–12/21	4/20–12/21	4/20–12/21
Observations	33589	33589	33589	33589

Table B.4: **Banks' Balance-Sheet Costs, Interest Rate Risk, T-bill Supply, and MMF Dollar Investment at the ON RRP.** This table shows the results of panel regressions at the fund-day level based on equation (6) of the main text. The sample includes all MMFs eligible to invest in the ON RRP. The sample period is April 14, 2020 (when the SLR relief was established for BHCs)–December 31, 2021. $\$ONRRP_{it}$ is the fund's dollar investment at the ON RRP in billions of dollars. Post SLR Relief$_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR. (SLR-SLR Req)$_{i2019Q4}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the last quarter of 2019. Gov$_i$ is a dummy for government MMFs. MOVE$_{t-1}$ is the MOVE index, lagged by one day. T-bill Issuance$_{t-30}$ is the total T-bill issuance in the previous calendar month in trillions of dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, the interactions of month-end dummies (one for each month) with Gov$_i$, and the interactions of a dummy for April 2020 with Gov$_i$, SLR-Bank MMF$_i$, and, in Columns (3) and (4), also SLR-Bank MMF$_i$ × (SLR-SLR Req)$_{i2019Q4}$. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

	%ONRRP$_{it}$ (%)			
	(1)	(2)	(3)	(4)
	MMF	MMF	MMF	MMF
Post SLR Relief$_t$ × SLR-Bank MMF$_i$	1.871***	1.948***	1.536***	1.636***
	(0.302)	(0.313)	(0.412)	(0.425)
Post SLR Relief$_t$ × SLR-Bank MMF$_i$ × (SLR - SLR Req)$_{i2019Q4}$			0.136	0.127
			(0.096)	(0.097)
Post SLR Relief$_t$ × Gov$_i$	12.004***	11.734***	11.971***	11.705***
	(2.125)	(2.095)	(2.112)	(2.083)
MOVE$_{t-1}$ × Gov$_i$	0.318***	0.311***	0.318***	0.311***
	(0.054)	(0.043)	(0.054)	(0.043)
T-Bills Issuance$_{t-30}$ × Gov$_i$	-7.336***		-7.339***	
	(1.400)		(1.400)	
$\frac{\text{T-Bills Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ × Gov$_i$		-18.893***		-18.889***
		(3.036)		(3.037)
Fund FE	Y	Y	Y	Y
Date FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
R^2	0.76	0.77	0.76	0.77
Sample Period	4/20–12/21	4/20–12/21	4/20–12/21	4/20–12/21
Observations	33589	33589	33589	33589

Table B.5: **Banks' Balance-Sheet Costs, Interest Rate Risk, T-bill Supply, and the Share of MMF Portfolio Invested at the ON RRP.** This table shows the results of panel regressions at the fund-day level based on equation (6) of the main text. The sample includes all MMFs eligible to invest in the ON RRP. The sample period is April 14, 2020 (when the SLR relief was established for BHCs)–December 31, 2021. %ONRRP$_{it}$ is the percentage of fund AUM invested at the ON RRP. Post SLR Relief$_t$ is a dummy for the period after the end of the SLR relief (March 31, 2021). SLR-Bank MMF$_i$ is a dummy for MMFs affiliated with banks subject to the SLR. (SLR-SLR Req)$_{i2019Q4}$ is the difference between the SLR of the bank to which MMF i is affiliated and its minimum SLR requirement in the last quarter of 2019. Gov$_i$ is a dummy for government MMFs. MOVE$_{t-1}$ is the MOVE index, lagged by one day. T-bill Issuance$_{t-30}$ is the total T-bill issuance in the previous calendar month in trillions of dollars. $\frac{\text{T-bill Outstanding}_{t-30}}{\text{Avg Total AUM}_{t-30}}$ is the ratio between T-bills outstanding and the average total AUM of MMFs in the previous calendar month. All regressions include fund and day fixed effects, as well as the following set of controls: the fund's lagged net yield, the lagged net flow, the interactions of month-end dummies (one for each month) with Gov$_i$, and the interactions of a dummy for April 2020 with Gov$_i$, SLR-Bank MMF$_i$, and, in Columns (3) and (4), also SLR-Bank MMF$_i$ × (SLR-SLR Req)$_{i2019Q4}$. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.

C Bank Affiliation

In this appendix, we replicate our results using a manual identification of MMFs affiliated to SLR banks, rather than relying on the identifier available through iMoneyNet. iMoneyNet data include a dummy variable indicating whether a MMF is affiliated to a bank, as well as the name of the bank if the dummy is equal to one. Our baseline analysis in the paper uses these variables to identify MMFs affiliated with SLR banks. In our sample, however, there are seven MMFs whose names suggest that they are affiliated to a bank subject to the SLR, but for which iMoneyNet's bank-affiliation dummy is equal to zero.

As a robustness test, we replicate all our results dropping these funds from our sample. Results are in Table C.1: Column (1) replicates Column (1) of Table 3; Column (2) replicates Column (1) of Table 4; Column (3) replicates Column (1) of Table 5; Column (4) replicates Column (1) of Table 7; Columns (5) and (6) replicate Columns (1) and (3) of Table 9; and Columns (7) and (8) replicate Columns (1) and (3) of Table 8. Results are very similar.

	Flow$_{it}$ (\$bn)		%ONRRP$_{it}$				\$ONRRP$_{it}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	MMF	MMF	MMF	MMF	MMF	MMF	MMF	MMF
2021Q1$_t$ × SLR-Bank MMF$_i$	0.033**							
	(0.015)							
2021Q2$_t$ × SLR-Bank MMF$_i$	0.022							
	(0.019)							
2021Q1$_t$ × Non-Custodial SLR-Bank MMF$_i$		0.049**						
		(0.020)						
2021Q2$_t$ × Non-Custodial SLR-Bank MMF$_i$		0.030						
		(0.025)						
2021Q1$_t$ × Custodial SLR-Bank MMF$_i$		0.009						
		(0.018)						
Post SLR Relief$_t$ × Custodial SLR-Bank MMF$_i$		0.008						
		(0.021)						
Post SLR Relief$_t$ × Gov$_{it}$			19.269***	11.653***	11.742***	11.816***	7.755***	8.198***
			(1.681)	(2.149)	(2.146)	(2.140)	(1.302)	(1.315)
MOVE$_{t-1}$ × Gov$_i$				0.328***	0.330***	0.330***	0.249***	0.249***
				(0.056)	(0.056)	(0.056)	(0.038)	(0.038)
T-Bills Issuance$_{t-30}$ × Gov$_i$				-8.256***	-8.040***	-8.037***	-5.308***	-5.288***
				(1.690)	(1.678)	(1.678)	(1.107)	(1.109)
Post SLR Relief$_t$ × SLR-Bank MMF$_i$					1.831***	2.145***	0.928***	2.793***
					(0.297)	(0.434)	(0.176)	(0.310)
Post SLR Relief$_t$ × SLR-Bank MMF$_i$ × (SLR - SLR Req)$_{i2019Q4}$						-0.121*		-0.717***
						(0.064)		(0.064)
Fund FE	Y	Y	Y	Y	Y	Y	Y	Y
Date FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.02	0.02	0.75	0.76	0.76	0.76	0.54	0.54
Sample Period	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21	6/20–12/21
Observations	75797	75797	30452	30452	30452	30452	30452	30452

Table C.1: **Main Results, Dropping MMFs with Uncertain SLR-Bank Affiliation Data in iMoneyNet.** This table replicates the main results of the paper, while dropping the seven funds whose fund names conflict with their bank affiliation dummy from iMoneyNet. Column (1) replicates Column (1) of Table 3; Column (2) replicates Column (1) of Table 4; Column (3) replicates Column (1) of Table 5; Column (4) replicates Column (1) of Table 7; Columns (5) and (6) replicate Columns (1) and (3) of Table 9; and Columns (7) and (8) replicate Columns (1) and (3) of Table 8. Driscoll-Kraay standard errors are in parentheses. ***, **, and * represent 1%, 5%, and 10% statistical significance, respectively.