Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
COVID-19 as a stress test: Assessing the bank regulatory framework

Elizabeth Duncan a, Akos Horvath b, Diana Iercosan b, Bert Loudis b, Alice Maddrey b, Francis Martinez b, Timothy Mooney b, Ben Ranish b, Ke Wang b, Missaka Warusawitharana b,* Carlo Wix b

a Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD 21218, United States of America
b Federal Reserve Board, 20th Street and Constitution Avenue N.W., Washington, DC 20551, United States of America

A B S T R A C T

The broad economic damage of the COVID-19 pandemic poses the first major test of the bank regulatory reforms put in place after the Global Financial Crisis. Our study assesses the U.S. regulatory framework, with an emphasis on capital and liquidity requirements. Prior to the COVID-19 crisis, banks were well capitalized and held ample liquid assets, which partly reflects enhanced requirements. The overall robust capital and liquidity levels resulted in a resilient banking system, which maintained lending and market making through the early stages of the pandemic. Trading activity was a source of strength for banks, reflecting in part a prudent regulatory approach. That said, leverage requirements are associated with more repo position netting by banks, with potential implications for market making.

1. Introduction

After the 2007–09 Global Financial Crisis (GFC), the U.S. Congress enacted the Dodd–Frank Act in order to reform the financial system and reduce the likelihood of a financial crisis. U.S. regulators worked through the Basel Committee on Banking Supervision (BCBS) and the Financial Stability Board to coordinate international efforts and build a more resilient financial system. Through these efforts, U.S. regulators implemented reforms to address the weaknesses identified in the GFC. The broad economic damage of the COVID-19 pandemic poses the first major test of the post-GFC regulatory regime. We assess the bank regulatory framework in the United States during the COVID-19 crisis, with an emphasis on capital and liquidity requirements.

We find that banks entered the crisis with robust capital positions, which enabled them to withstand the shock and continue supporting the economy. The resilience of banks is partly attributable to the post-GFC enhancements to the regulatory framework, which require banks to have more and higher-quality capital. At the end of 2019, U.S. global systemically important banks (G-SIBs) faced substantially higher capital requirements than before the GFC and held capital well in excess of these requirements. Economic developments at the onset of the pandemic put downward pressure on the capital and leverage ratios of banks. Various regulatory interventions, aimed at both easing regulatory capital requirements and strengthening capital positions, ensured that banks were able to maintain their already strong levels of capital.

Examining recent changes in the liquidity positions of large bank holding companies (BHCs), we find that they entered the crisis with solid liquidity positions—both in terms of their high-quality liquid asset (HQLA) holdings and their liquidity coverage ratios (LCRs). We find that the liquidity of banks further increased in the early days of the crisis because of the rapid growth of central bank reserves. Banks also saw large inflows of deposits as investors — in their flight to safety — liquidated riskier assets and increased cash holdings. While deposit inflows provided a source of low-cost funding, they also put downward pressure on the capital and leverage ratios of banks, thereby constituting both a growth opportunity and a regulatory challenge for...
banks during the COVID-19 pandemic (Li et al., 2020; Bolton et al., 2021). Notably, we find that, despite the large deposit inflows, banks chose to retain their increased liquid asset holdings and use Federal Reserve liquidity facilities. This suggests that banks prefer larger liquidity buffers in times of economic uncertainty, which is consistent with the liquidity hoarding motive described by Acharya and Rajan (2022).

We investigate how the liquidity positions of large BHCs were affected by the Federal Reserve liquidity facilities implemented to help the functioning of financial markets and support the flow of credit to businesses and households. First, we find that BHCs with lower LCR buffers prior to the pandemic were more likely to borrow from the discount window in early 2020, which suggests that BHCs with more binding liquidity constraints needed the facilities more. Second, we find that while some facilities helped BHCs maintain liquidity positions, others had no significant effect on balance sheet liquidity. Specifically, we find the following: Using the Primary Dealer Credit Facility (PDCF) increased both HQLA and the LCR; discount window borrowing increased HQLA but not the LCR; and using the Money Market Mutual Fund Liquidity Facility (MMFLF) had no detectable effect on either liquidity measure. Overall, some Federal Reserve liquidity facilities bolstered the already strong liquidity positions of BHCs in this time period.

One natural question that follows is whether the strong capital and liquidity positions enabled banks to support the economy through lending. We find that banks continued to lend through the COVID-19 crisis, albeit some of this reflects demand-driven drawdowns of existing commitments by corporate borrowers rather than new lending. Furthermore, the Paycheck Protection Program (PPP) also supported lending during this period. In contrast to the growth in corporate credit, consumer lending was weak in 2020. We show that credit growth in 2020 was unrelated to voluntary capital buffers and discount window use, suggesting that there had not been a credit crunch.

The onset of the COVID-19 crisis was associated with increased market volatility and elevated trading as market participants shifted their portfolios and adjusted to the spreading pandemic. In March 2020, financial markets were disrupted as price volatility and bid–ask spreads rose, especially in the U.S. Treasury market. This resulted in some leveraged investors closing their positions, which increased the risk of fire sales. As volatility surged, particularly at the long end of the yield curve, the Federal Reserve stepped in with emergency purchases of U.S. Treasury securities and announced a range of facilities to ease market tensions (Schrimpf et al., 2020). The elevated trading activity in the early stages of the crisis led to an increase in fees, commissions, and bid–ask spreads, supporting the profitability of large banks. In addition, nonfinancial firms also issued corporate bonds and equity at a rapid pace to bolster their balance sheets, which led to increases in underwriting fees. Partly due to the post-GFC regulation of proprietary trading, no major bank suffered sizable losses on its portfolio. Overall, trading activity strengthened BHCs during this period.

We also examine the relationship between the repo market participation of large BHCs and their regulatory leverage constraints, focusing on the supplementary leverage ratio (SLR) requirement. Specifically, we analyze the association between the SLRs and the repo positions of U.S. G-SIBs from Q4 2016 to Q3 2021 and provide empirical evidence that smaller SLR buffers are linked to more repo book netting. This novel finding suggests that SLR constraints discourage U.S. G-SIBs from providing market liquidity through entering one-sided reverse repo positions, which can potentially constrain their market making activity. Our finding is also consistent with the observable pattern that repo book netting peaked during the market turmoil at the beginning of 2020, when SLR buffers were relatively smaller, while there was a large unmet demand for liquidity in key financial markets (Goldberg, 2020). Notably, U.S. G-SIBs maintained their repo book size during this period, which indicates that they were both able and willing to participate in the market notwithstanding diminished SLR buffers. Our results hold both before and during the COVID-19 crisis, and they are also robust to the exclusion of central bank reserves and U.S. Treasury securities from the SLR’s denominator.

The paper is organized as follows. Section 2 reviews the existing literature on the role of banking regulation during the COVID-19 crisis. Section 3 provides a detailed description of the post-GFC capital and liquidity framework as well as a discussion on the differences between the GFC and the COVID-19 crisis. Section 4 studies the capital positions of large BHCs over the course of the pandemic and how they were affected by various regulatory interventions. Section 5 studies the liquidity positions of large BHCs and how they were related to the use of Federal Reserve facilities. Section 6 examines lending activity in 2020 and investigates whether it was related to capital ratios and discount window use. Section 7 examines trading activity as well as the relationship between leverage ratios and repo market making activity. Section 8 concludes. An online appendix provides additional results, including an international comparison of the capital requirements of large banks, the reaction of international financial markets, and a discussion of the procyclicality of the U.S. regulatory framework.

2. Literature review

This section provides an overview of the recent literature on the role of banking regulation during the COVID-19 economic crisis. We discuss arguments made in previous studies on how the current regulatory framework has contributed to financial market developments since the onset of the pandemic and review the discussions on the regulatory response to the COVID-19 shock.

Most studies agree that the stricter capital regulations introduced since the GFC have put banks in a strong position to absorb potential losses following the COVID-19 shock. Lewrick et al. (2020) show that banks globally held $5.1 trillion of capital above their regulatory requirements, in aggregate, and were thus substantially more well capitalized than prior to the GFC. Blank et al. (2020) report that the aggregate common equity Tier 1 (CET1) ratio of U.S. banks increased from 5.8% in Q1 2009 to 11.7% in Q4 2019, implying robust capitalization before the COVID-19 shock. Investigating the drawdown of outstanding credit line commitments, Acharya and Steffen (2020) conclude that U.S. banks were adequately capitalized because of the successful implementation of the post-crisis reforms. Similarly, Li et al. (2020) find that strong capital positions contributed to the ability of banks to accommodate the large increase in corporate liquidity demands. Hence, there is consensus that the regulatory framework – and especially the more-stringent capital requirements – contributed to the safety and soundness of the financial system. However, some features of the regulatory framework face criticism in light of the COVID-19 crisis.

First, enhanced capital requirements may have had an adverse effect on the market making activity of banks and thus on market liquidity in the U.S. Treasury and corporate bond markets. Various studies document disruptions in the U.S. Treasury market in March 2020. Global investors started selling U.S. Treasury securities to obtain cash in mid-March, which inflated the balance sheets of banks’ broker-dealer subsidiaries. The unprecedented trading volumes temporarily overwhelmed BHCs, exceeding their capacity to intermediate the U.S. Treasury market (Duffie, 2020; Federal Reserve Board, 2020; Schrimpf et al., 2020). Similarly, amid selling pressures in the corporate bond market in mid-March, BHCs showed signs of reluctance to increase holdings lest they fall below regulatory capital requirements (Aramonte and Avalos, 2020; Kargar et al., 2021; O’Hara and Zhou, 2021). In order to ease market pressures, the Federal Reserve launched a large-scale asset purchase program of U.S. Treasury securities and mortgage-backed securities (MBS) on March 15, 2020. The Federal Reserve also intervened in the corporate bond market by introducing the PDCF on

1 See also Berger and Demirgüç-Kunt (2021) for an overview of research on banking during the COVID-19 crisis.
March 17 and the Primary and Secondary Market Corporate Credit Facilities on March 23. On April 9, these programs were further expanded to include the purchases of eligible corporate bond portfolios in the form of exchange-traded funds with exposure to U.S. high-yield corporate bonds. Corporate bond market liquidity improved significantly following these interventions (Boyarchenko et al., 2020; Haddad et al., 2021; Kargar et al., 2021).

Second, the COVID-19 crisis highlights the issue of the procyclicality of capital regulation. The procyclicality of the Basel III capital framework had been discussed before the COVID-19 crisis. Repullo and Suarez (2013) show theoretically and Behn et al. (2016) document empirically that linking capital charges to asset risk increases capital requirements during economic downturns, which may have a procyclical effect on bank lending. The main regulatory instrument to address such procyclicality is the countercyclical capital buffer (CCyB), which aims to ensure that banks accumulate capital during economic expansions so that it can then be released during economic downturns, when losses materialize. Many countries have reduced their CCyB levels since the onset of the COVID-19 pandemic to help maintain the supply of credit and dampen the financial cycle. In the United States, however, the CCyB had never been activated, and thus this macroprudential tool was not available to U.S. regulators. Therefore, the Federal Reserve resorted to various emergency rulemakings to reduce bank capital requirements (i.e., the temporary relaxation of the SLR requirement). These regulatory interventions helped inject greater countercyclicality into the current regulatory framework. Blank et al. (2020) argue that the CCyB should always be turned on by default in good times, so that U.S. policymakers have room to ease capital requirements in downturns. Hence, the COVID-19 crisis reveals that the U.S. regulatory capital framework can benefit from increased countercyclicality.

Finally, there is a discussion on banks’ ability and willingness to use their regulatory capital buffers and the role of payout restrictions. Under the current regulatory framework, banks that dip into their capital conservation buffers (CCBs) face restrictions on their dividend payouts, share buybacks, and executive bonuses. Banks might thus be reluctant to use their capital buffers because it negatively affects shareholders. Indeed, there is evidence that U.S. banks with smaller capital buffers extended relatively less credit to small and medium-sized enterprises in 2020 (Berrospide et al., 2021). In order to avoid the stigma of individual banks not paying dividends, regulators can impose restrictions on dividend payouts, share buybacks, and bonus payments for all banks, which alleviates the collective action problem (Drehmann et al., 2020). Svoronas and Vrbaski (2020) discuss that many regulatory authorities worldwide, such as the European Central Bank or the Bank of England, had imposed some form of payout restrictions by May 2020, which helped increase usable capital buffers (Altavilla et al., 2020). The United States, however, had not enacted any restrictive measures by that time. Blank et al. (2020) contested this “watchful waiting” approach and recommended that U.S. regulators require all U.S. banks to suspend both common dividends and share repurchases. Following its annual stress test in June 2020, the Federal Reserve required big banks to suspend share buybacks and limit dividend payments for a year.

3. Institutional background

3.1. Basel III reforms after the global financial crisis

After the GFC, there were various reforms to the U.S. financial regulations, including capital and liquidity standards.

---

2 See, for example, De Nora et al. (2020) for an account of the Bank of Ireland’s rationale for lowering the CCyB.

3 For further details on the U.S. CCyB framework, see Part 217 of the Code of Federal Regulations.
3.1.2. Liquidity regulations

Before the GFC, banks were not subject to explicit liquidity regulation in the United States. While reserve requirements limited a bank’s ability to lend out deposits, reserves were not intended as a source of contingent liquidity in times of stress. There were no reserve requirements imposed on non-deposit liabilities, although bank supervisors would regularly assess whether a bank’s liquidity position warranted remediation. The run-like behavior seen in banks and money markets highlighted the limitations of the regulatory and supervisory frameworks with regard to bank liquidity. In the wake of multiple bank failures, domestic and international initiatives were undertaken to review and bolster the existing liquidity standards. Hence, the Basel III framework introduced two different liquidity requirements: the LCR and the Net Stable Funding Ratio (NSFR).

The LCR rule requires that banks maintain a ratio of HQLA to net cash outflows over thirty days that exceeds 100% in normal times. This requirement intends to give banks and supervisors time to remedy liquidity stress events or prepare for an orderly resolution. The calculation of HQLA takes into account both the risk profile and market characteristics of assets. Such assets must be easy to value, have lower credit and market risk, and be liquid and readily-marketable. The LCR rule distinguishes three levels of HQLA. Level 1 HQLA are not assigned a haircut and primarily consist of central bank reserves and securities issued or guaranteed by the U.S. government or another 0% risk-weight sovereign entity. Level 2A HQLA are assigned a 15% haircut and primarily consist of U.S. government-sponsored enterprise debt and MBS or securities issued or guaranteed by 20% risk-weight sovereign entities. Level 2B HQLA are assigned a 50% haircut and consist primarily of investment-grade debt or primary index (e.g., Russell 1000) equity securities. Net cash outflows, which constitute the denominator of the LCR, are defined as total expected cash outflows, minus total expected cash inflows, in the stress scenario for the subsequent thirty days specified in Part 249 of the Code of Federal Regulations.

The NSFR requires that banks maintain a ratio of available stable funding to required stable funding in excess of 100%. Available stable funding measures the relative stability of an institution’s liability profile, which depends on factors such as contractual maturities and the propensity of counterparties to withdraw funding. Capital and liabilities are weighted such that more stable funding sources receive higher weights. Capital instruments and liabilities with a residual maturity of one year or longer receive full weight, while retail and small business deposits receive nearly full weight. Required stable funding measures the liquidity characteristics of an institution’s assets and off-balance-sheet exposures, which are weighted according to their relative liquidity such that less liquid assets receive higher weights and require more stable funding. The NSFR ensures a more sustainable structure of assets and liabilities, reducing the likelihood that a bank’s liquidity erodes as market conditions deteriorate, and reduces vulnerability to a potential idiosyncratic shock. From a systemic perspective, the NSFR also lowers the probability of fire sales and reduces the contagion effect that arises from financial-sector interconnectedness.

3.2. Comparing the global financial crisis and the COVID-19 crisis

The overarching goal of the post-GFC regulatory reforms was “to improve the banking sector’s ability to absorb shocks arising from financial and economic stress, whatever the source” and ensure that the banking system is sufficiently resilient “to support the real economy and contribute positively to sustainable economic growth” (BCBS, 2017).

There are, however, marked differences between the COVID-19 crisis and the GFC. First, while the GFC arguably originated because of excessive risk-taking and high leverage in the financial system, the origins of the COVID-19 crisis were fundamentally non-economic in nature. While the GFC was endogenous, the pandemic was exogenous to financial system developments. Second, and relatedly, while the GFC was preceded by a gradual build up of financial imbalances, the COVID-19 shock came abruptly and unexpectedly. The GFC started to unfold in February 2007 – with the increase of subprime mortgage defaults – and escalated more than one year later with the failure of Lehman Brothers in September 2008 (Brunnermeier, 2009). By contrast, the COVID-19 shock hit the U.S. economy within a few weeks in March 2020, triggering a monetary, fiscal, and prudential policy response of unprecedented scope and speed (Borio, 2020b). Finally, while the GFC was triggered by and associated with a substantial increase in mortgage and consumer loan default rates, delinquencies actually decreased during the pandemic, driven by the generous forbearance programs of banks and the government (Dettling and Lambie-Hanson, 2021).

Another difference between the GFC and COVID-19 crises is the dynamics of U.S. Treasury security and investment-grade corporate bond markets (Liang, 2020). In earlier crises, these safe assets experienced buying pressures from investors’ flight to safety and flight to liquidity (Vayanos, 2004; Brunnermeier and Pedersen, 2009). By contrast, there was a sharp increase in the yields of these securities in March 2020, as is also discussed in the Financial Stability Report of the Federal Reserve Board (2020). The unprecedented market conditions were driven by selling pressures from fixed-income mutual funds (Ma et al., 2020) and limited balance sheet capacity of dealers due to regulatory constraints (Duffie, 2020; He et al., 2022).

4. Capital positions and regulatory interventions

As a result of the post-GFC regulatory reforms, banks in the United States entered the COVID-19 crisis with high levels of capital, including significant voluntary capital buffers. Panel A of Fig. 1 shows how the CET1 capital ratios and requirements of banks evolved over the period from Q1 2019 to Q3 2021. While CET1 capital ratios declined from 12.2% to 11.6% in Q1 2020, they increased to 13.0% over the remainder of 2020. During this period, CET1 capital requirements changed as stress testing was formally incorporated in capital requirements in the form of the stress capital buffer in Q4 2020. Panel B of Fig. 1 shows the evolution of SLRs and requirements. Similarly, the SLRs of banks declined from 6.4% to 6.2% during Q1 2020 and then increased to 7.2% in Q4 2020. While the decrease in capital and leverage ratios in Q1 2020 reflects economic developments at the beginning of the pandemic, the subsequent increase can be attributed to various regulatory interventions, as we discuss in the following.

Economic developments during the pandemic put downward pressure on the capital and leverage ratios of banks in several ways. Regulatory capital (in the numerator) declined as loan loss reserves doubled in the first half of 2020, partly due to an increase in credit risk and partly due to the adoption of the Current Expected Credit Loss (CECL) accounting standard. Meanwhile, exposure measures (in

---

4 In the United States, the LCR and NSFR apply to large banking organizations that constitute a greater risk to the stability of the financial system. As of mid-2018, all BHCs as well as savings and loan holding companies with total consolidated assets in excess of $250 billion or greater than $10 billion in foreign exposures were subject to the LCR rule. The NSFR rule became effective in July 2021, applicable to certain large BHCs in the country with total consolidated assets in excess of $100 billion.

5 See also Borio (2020a) and Giese and Haldane (2020) for a comparison of the GFC and the COVID-19 crisis.

6 The stress capital buffer was introduced as a proposed rulemaking in April 2018. See the Federal Reserve’s press release on April 10, 2018.

7 Additionally, Fig. A.1 of the Appendix A shows the evolution of Tier 1 capital, total capital, and Tier 1 leverage ratios and requirements over time.

8 On January 1, 2020, most large public U.S. banks adopted CECL, which is both more forward looking and more conservative than the previous Incurred Loss Method. Losses on most loans have remained low since the start of the pandemic, but loan loss reserves (especially under CECL) are responsive to expectations of future losses.
the denominator) experienced expansionary pressures. Surging financial market volatility led to a roughly 25% increase in market risk requirements. Moreover, the growth of bank balance sheets due to a record inflow of deposits – as well as due to the increase in central bank reserves and U.S. Treasury security holdings in the wake of expansionary monetary and fiscal policy measures – increased the denominators of leverage ratios.

In order to alleviate downward pressures on the capital adequacy of banks, U.S. regulators eased requirements through various interventions. First, in March 2020, regulators extended the transitional capital relief given to CECL banks to approximately neutralize the capital impact of the CECL-induced increase in loan loss reserves. Second, in response to the growth of market risk requirements, regulators provided relief from additional requirements (e.g., capping backtesting multipliers to the pre-pandemic level) stemming from the poor performance of value-at-risk models during the extreme volatility and market disruptions of spring 2020 (Abboud et al., 2021). Third, the Federal Reserve temporarily excluded central bank reserves and U.S. Treasury security holdings from the denominator of the SLR applicable to large banks.10 As Panel B of Fig. 1 shows, this exclusion increased the average SLR of U.S. G-SIBs by 92 basis points in Q2 2020. Fourth, the community bank leverage ratio requirement was relaxed from 9% to 8% in order to reduce the impact of banks’ balance sheet expansion on leverage ratio requirements.11

In a further intervention directly aimed at improving bank capital levels, the Federal Reserve imposed dividend payout and share buyback restrictions. While large banks had voluntarily halted share buybacks through Q2 2020, the Federal Reserve expanded this restriction on buybacks to all banks with $100 billion or more in assets for Q3 2020 and Q4 2020.12,13 The Federal Reserve also imposed restrictions on banks’ dividends based on their income. As Panel B of Fig. 1 shows, the restrictions significantly furthered the preservation of bank capital. Affected banks executed only $21 billion in buybacks and $51 billion in common stock dividends in 2020, as compared with $133 billion and

$54 billion in 2019, respectively.14 If capital distributions had remained at 2019 levels, the CET1 ratios of these banks would have been 106 basis points lower at the end of 2020. By contrast, if dividends and buybacks for smaller BHCs had been at 2019 levels, their capital ratios would have only been 16 basis points lower at the end of 2020.

In summary, regulatory interventions, aimed at both easing regulatory capital requirements and strengthening capital levels, ensured that banks were able to maintain the already strong levels of capital with which they entered the pandemic.

5. Liquidity positions and federal reserve facilities

In March 2020, concerned by the onset of the COVID-19 pandemic, market participants engaged in a flight to safety, divesting themselves of less-liquid assets and using proceeds to create bank deposits or purchase U.S. Treasury securities. The availability of short-term funding deteriorated in the financial system, which put liquidity pressure on some banks, raising concerns about their ability to intermediate financial markets. The Federal Reserve took prompt action to alleviate the liquidity stress on financial markets resulting from the onset of the pandemic and to promote the flow of credit to businesses and households. In particular, the Federal Reserve conducted large-scale open market operations, enhanced central bank liquidity swap lines, and modified or established lending and liquidity facilities.

In this section, we investigate how the liquidity positions of large BHCs shifted around these events, focusing on the role of Federal Reserve liquidity facilities. In particular, we conduct an empirical analysis on how borrowings from the discount window (DW), the Money Market Mutual Fund Liquidity Facility (MMLF), and the Primary Dealer Credit Facility (PDCF), as well as reducing reserve requirements to zero, influenced the HQLA holdings and the LCR of large BHCs. Since borrowing from these facilities and reducing reserve requirements to zero, could affect both HQLA holdings and short-term cash flows, the direction and strength of their influence on the LCR is not obvious and warrants deeper investigation.

Notably, while the Federal Reserve also established other facilities than the DW, PDCF, and MMLF to support the economy during the pandemic, these facilities are not directly related to our research question because of their mechanism of action. In particular, other

9 Based on Y-9C data, the extended capital transitional rule increased the CET1 capital ratios of CECL-adopting banks by approximately 40 basis points in mid-2020.
10 See the Federal Reserve’s press release on April 1, 2020.
11 See the Federal Reserve’s press release on April 6, 2020.
12 See the Financial Services Forum’s statement on share buybacks issued on March 15, 2020.
13 See the corresponding Federal Reserve’s press releases on June 25, 2020 and on September 30, 2020.
14 Calculations in this paragraph are based on Y-9C data covering U.S. BHCs with $5 billion or more in assets that are subject to risk-based capital requirements.
facilities, such as the Commercial Paper Funding Facility, Corporate Credit Facilities, Term Asset-Backed Securities Loan Facility, and Paycheck Protection Program Liquidity Facility (PPPLF), were either not structured to lend directly to banks, BHCs, or bank-affiliated dealers, or they involved the participation of banks only in a “conduit” capacity, channeling funds to nonfinancial firms in other sectors of the economy.

5.1. Overview of selected federal reserve facilities

The discount window plays an important role in supporting the liquidity and stability of the banking system and the effective implementation of monetary policy. By providing ready access to short-term funding to depository institutions, the facility assists BHCs in their liquidity management and thus forestalls actions that could have negative consequences for the real economy, such as withdrawing credit during times of market stress. In our analysis, we focus on the provision of DW primary credit, which is available to depository institutions of sound financial condition, such as those within the large BHCs in our sample. Importantly, DW primary credit was traditionally overnight, but the facility was expanded on March 15, 2020, and became effective the next day, when the Federal Reserve allowed depository institutions to borrow for maturities of up to 90 days, pre-payable and renewable on a daily basis. DW borrowings are collateralized by a wide variety of financial assets.

The PDCF was established on March 17, 2020, to foster the functioning of financial markets and to support the credit needs of businesses and households by enhancing the ability of primary dealers to access term funding. The PDCF offers primary dealers secured funding for a term of up to 90 days, which can be collateralized by a broad range of investment-grade debt and equity securities, including municipal bonds and commercial papers.

The MMLF was established on March 18, 2020, to enhance financial market liquidity by helping money market mutual funds meet the increased demand for redemptions by businesses and households, putting liquidity stress on these funds at the beginning of the COVID-19 crisis. MMLF loans are provided to eligible firms by the Federal Reserve Bank of Boston for a term of up to one year, secured by high-quality assets purchased from the funds.

5.2. Bank holding company balance sheet liquidity dynamics

We utilize high-frequency public and confidential information collected by the Federal Reserve. Using FR 2052a data, we calculate the LCR, defined as

\[
\text{LCR}, \% = \frac{\text{HQLA}, \%}{(\text{Net Cash Outflows over the Next 30 Days})} \times 100
\]

for firm i on day t, as described in Section 3.1.2. As per the applicable liquidity regulations, the largest U.S. domestic BHCs and intermediate holding companies of foreign banks are required to maintain their LCR above 100% on any given day.

Balancing the objectives of the analysis with data limitations, we focus on the BHCs that are required to comply with and report their LCR at a daily frequency. We conduct our empirical analysis using high-frequency reporting information on the largest, systemically important banks in the United States, which together held about two-thirds of total assets and about three-fourths of HQLA in the entire banking sector as of Q4 2019. Throughout the analysis, we use assets and liabilities consolidated at the holding company level.

In Fig. 2, we summarize balance sheet liquidity changes of large BHCs at the onset of the COVID-19 outbreak. Panel A shows that, from a liquidity requirement perspective, sample firms had solid liquidity positions. The mean LCR of daily-reporting holding companies was about 120% in early 2020—well above the 100% LCR requirement. By the second half of March 2020, the mean LCR of large BHCs had further improved and stabilized around 130%.

We decompose the LCR to gain insight into what drove the ratio's rapid increase in this time period. As Panel B shows, the mean HQLA and thirty-day net cash outflows of sample firms increased in lockstep by about 5% of total assets in March 2020. The simultaneous increase in liquid assets and net cash outflows indicates that large BHCs did not simply reallocate their asset portfolios to enhance their LCR, but they increased both their liquid asset holdings and reliance on short-term funding in this time period.

We further analyze HQLA holdings to examine changes in the liquid asset mix of large BHCs. Panel C shows that the rapid HQLA increase was almost entirely driven by an equivalent increase in excess reserves. At the same time, the mean proportion of non-excess-reserve HQLA remained stable at around 16% to 18% of total assets, with a slight decrease in April 2020. Hence, sample firms saw a significant improvement in their liquidity positions from the increase in excess reserves while keeping their other HQLA largely unchanged.

The recent behavior of large BHCs in March 2020 is informative about the effectiveness of liquidity regulation because it can indicate a reluctance to draw down liquid asset buffers in the face of economic and market uncertainty. Fig. 2 suggests that the average sample firm increased its buffer above the LCR requirement by about 10 percentage points at the onset of the COVID-19 pandemic. Notably, this increase in liquid assets comes at an opportunity cost, in the form of lower asset returns, which large BHCs chose to incur in order to both meet the LCR requirement and prepare for potential liquidity shortages in the future.

One possible source of the rapid increase in HQLA and the LCR is the extensive liquidity provision by the Federal Reserve to support smooth market functioning and facilitate the availability of credit to businesses and households. The facilities enabled large BHCs to increase their LCR by obtaining more excess reserves while preserving most of their other HQLA holdings. Fig. 3 shows an extensive utilization of the DW, PDCF, and MMLF from the second half of March 2020—concurrently with the rapid increase in HQLA and the LCR discussed above. The aggregate utilization of the three facilities peaked at about $120 billion outstanding at the beginning of April 2020, from which we aggregate data at the holding company level by summing the assets and liabilities of all entities, including depository institutions and broker-dealers, that belong to the corresponding top-holder firms.
Fig. 2. Balance sheet liquidity of large bank holding companies in early 2020. This figure shows a decomposition of the liquidity coverage ratio (LCR) of large bank holding companies (BHCs) that report daily in the United States. The panels present daily mean values calculated over the cross section of BHCs at the beginning of 2020. The LCR of a firm is the percent ratio of its high-quality liquid assets (HQLA) to its thirty-day net cash outflows. Panel A shows the LCR, and Panel B shows HQLA and net cash outflows, expressed as a percentage of Q4 2019 total assets. Panel C shows the decomposition of HQLA (blue line) into excess reserves (shaded area) and other assets (gray line), expressed as a percentage of Q4 2019 total assets. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 3. Aggregate use of selected federal reserve facilities in early 2020. This figure shows aggregate outstanding funding provided by the Federal Reserve through the discount window, the Primary Dealer Credit Facility (PDCF), and the Money Market Mutual Fund Liquidity Facility (MMLF). The chart presents weekly values at the beginning of 2020.

The connection between liquidity regulation and the Federal Reserve facility use of large BHCs is also suggested by the finding that sample firms with smaller LCR buffers used such facilities with a higher probability. This relationship is shown by the means comparison analysis in Table 1, in which we split the sample of BHCs into two groups (i.e., “low” and “high”) so that the two groups significantly differ in pre-crisis LCR buffers but are comparable in both total assets and HQLA holdings in February 2020. Comparing the two groups, we find that the BHCs with “low” LCR buffers used the DW with significantly, 40% higher probability in March 2020 than the BHCs with “high” LCR buffers. The BHCs with “low” LCR buffers also used the MMLF with slightly higher probability, while we find no significant connection between pre-crisis LCR buffers and PDCF use. Importantly, these results are robust to the particular sample split based on which we perform the means comparison.

Importantly, the liquidity provision through Federal Reserve facilities was not the only economic force that acted on the liquidity of large holding companies in this time period. For example, the Federal Reserve implemented various other measures to support market functioning and ease short-term funding strains, such as open market operations and central bank liquidity swaps, which increased the liquid

implemented since the GFC, but it may also result from the Federal Reserve’s announcements that publicly encouraged banks to use the discount window to manage liquidity risks efficiently.22

The connection between liquidity regulation and the Federal Reserve facility use of large BHCs is also suggested by the finding that sample firms with smaller LCR buffers used such facilities with a higher probability. This relationship is shown by the means comparison analysis in Table 1, in which we split the sample of BHCs into two groups (i.e., “low” and “high”) so that the two groups significantly differ in pre-crisis LCR buffers but are comparable in both total assets and HQLA holdings in February 2020. Comparing the two groups, we find that the BHCs with “low” LCR buffers used the DW with significantly, 40% higher probability in March 2020 than the BHCs with “high” LCR buffers. The BHCs with “low” LCR buffers also used the MMLF with slightly higher probability, while we find no significant connection between pre-crisis LCR buffers and PDCF use. Importantly, these results are robust to the particular sample split based on which we perform the means comparison.

Importantly, the liquidity provision through Federal Reserve facilities was not the only economic force that acted on the liquidity of large holding companies in this time period. For example, the Federal Reserve implemented various other measures to support market functioning and ease short-term funding strains, such as open market operations and central bank liquidity swaps, which increased the liquid

22 See the Federal Reserve’s announcements on March 16, 2020, and March 19, 2020.
Table 1: LCR buffer size and the use of selected federal reserve facilities.

| Number of firms | Sample Split A | Sample Split B |
|-----------------|---------------|---------------|
|                  | Low | High | Diff. | Low | High | Diff. |
| Mean Comparison  |     |      |      |     |      |      |
| Total Assets ($tr) | 1.0 | 1.2 | 0.1 | 1.1 | 1.1 | 0.1 |
| HQLA (% of assets) | 21.6 | 19.2 | -2.4 | 21.8 | 18.9 | -2.9 |
| LCR buffer (pp)   | 21.3 | 62.4 | 41.1* | 21.2 | 62.6 | 41.4 |
| Fed Facility Use  |     |      |      |     |      |      |
| Pr(DW use)        | 100% | 60% | -40%** | 100% | 60% | -40%** |
| Pr(MMLF use)      | 50% | 40% | -10% | 67% | 20% | -47% |
| Pr(PDCF use)      | 80% | 100% | 20% | 100% | 75% | -25% |

This table compares the probabilities that large U.S. bank holding companies (BHCs) with low or high liquidity coverage ratio (LCR) buffers used the discount window (DW), Primary Dealer Credit Facility (PDCF), and Money Market Mutual Fund Liquidity Facility (MMLF) in March 2020. We conduct a means comparison exercise, splitting the sample of firms into two groups (i.e., "low" and "high") so that the two groups significantly differ in pre-crisis LCR buffers but are comparable in both total assets and high-quality liquid asset (HQLA) holdings in February 2020. Additionally, for the sake of robust statistical inference, we perform two different sample splits (i.e., sample splits A and B). The sample consists of 11 BHCs that report the LCR on a daily basis. Out of the 11 BHCs, only 9 were eligible for the PDCF because 2 did not have primary dealer subsidiaries. The mean differences in Q4 2019 total assets, February 2020 HQLA holdings, and February 2020 LCR buffers between the corresponding "low" and "high" groups are tested against zero using t-tests. The differences in the probabilities (Pr) of using each facility between the corresponding "low" and "high" groups are tested against zero using z-tests of proportions. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and *** respectively.

5.3. Effect of federal reserve facilities on balance sheet liquidity

We use an econometric approach to measure the effect of discount window, PDCF, and MMLF borrowings, as well as reserve requirement changes, on the HQLA and the LCR of large BHCs in the time period from January 2020 to May 2020. Specifically, we take advantage of the high-frequency regulatory and supervisory information in our panel dataset and use a regression model to estimate how the balance sheet liquidity of a BHC changes in the five business days after it uses either of these facilities or faces a change in mandatory reserve requirements. We interpret the results by expressing all quantities as a percentage of total assets, except for the LCR, which is already a ratio. We provide the specification and diagnostics of our dynamic regression model, which includes lagged dependent and explanatory variables. We provide the specification and diagnostics of our dynamic regression model in Appendix A.2 of Appendix A.24 Based on the model coefficients, we estimate how the HQLA and the LCR of large holding companies respond in the short run to DW, PDCF, and MMLF borrowings as well as changes in reserves requirements. In the rest of this section, we present and interpret the estimation results.25

5.3.1. Discount window borrowing

From a liquidity regulation perspective, we would expect that discount window use increases the LCR of BHCs. Regarding the LCR numerator, DW loans cause an immediate increase in cash equivalents, which fully count toward HQLA.26 Regarding the LCR denominator, the effect of discount window use on thirty-day net cash outflows depends on loan maturity. Before the COVID-19 crisis, DW loans typically had an overnight maturity and would thus increase net cash outflows by 0% to 25% of the loan amount, depending on the type of collateral pledged. On March 15, 2020, the maximum term of primary credit DW loans was increased to 90 days. As Fig. 3 shows, these changes were followed by a rapid increase in discount window use, suggesting that they played a key role in satisfying the need for longer-term DW loans. Since such loans are not considered in thirty-day net cash outflow calculations, we expect that DW borrowings in this time period had little effect on net cash outflows and thus—because of their positive impact on HQLA—to led to an increase in the LCR of BHCs.

The model estimates in Fig. 4 are in line with our expectations: Both the HQLA and the LCR of BHCS increase in the days after DW borrowings, although the latter effect is statistically insignificant. There are two notable patterns in the estimates. First, the estimated increase in HQLA happens over three days: Borrowing $1 from the discount window is typically followed by an HQLA increase of $2 the next day and an HQLA increase of $6 after three days and later. This suggests that, after borrowing from the discount window, BHCs also take other measures, such as borrowing through other channels or selling non-HQLA assets, to improve their liquidity positions. Second, the positive liquidity changes that follow DW borrowings appear to be lasting in the sense that BHCs tend to preserve the newly obtained HQLA rather than use it for extending loans, purchasing non-HQLA securities, or paying off debt.

Overall, our estimates show that the discount window served as an effective tool for helping banks enhance their liquidity positions in early 2020. The estimates also suggest that, in this time period, banks used the discount window as part of a process that aimed to increase their liquid asset buffers in this time of uncertainty.

5.3.2. Primary dealer credit facility borrowing

From a liquidity regulation perspective, we expect that BHCS increase their LCR through PDCF use. Regarding the LCR numerator, PDCF loans cause an immediate increase in cash equivalents, which in turn increases HQLA, to the extent that the assets pledged as collateral have a less than 100% weight in HQLA. Regarding the LCR denominator, thirty-day net cash outflows also increase if the term of the PDCF loan is shorter than thirty days—in this case, net cash outflows increase by 0% to 25% of the loan amount, depending on the type of collateral pledged. However, about half of the PDCF loan amounts borrowed by

23 Concerns about omitted variable bias arise because there are several, potentially latent, macro- and microeconomic factors that plausibly influence HQLA and the LCR. Error autocorrelation concerns arise because both HQLA and the LCR exhibit strong autocorrelation themselves, as visible in Fig. 2. Since autocorrelation in the dependent variable is typically inherited by model error terms, the uncorrelated error term assumption is violated, which leads to biased standard error estimates and invalidates the significance tests of the estimated effects.

24 As we discuss in A.2 of the Appendix A, our estimates are robust to model specification and are similar to the estimates that we obtain using the local projection approach proposed by Jordi (2005).

25 The estimated effects of changes in reserves requirements on the balance sheet liquidity of large BHCS are presented in Appendix A.3 of Appendix A.

26 In principle, the positive effect of DW loans on HQLA could be neutralized if HQLA securities are used as collateral, which would thus become encumbered and cease to count as HQLA. In practice, however, most of the assets pledged as collateral for DW loans are not HQLA.
The firms in our sample had a seven-day term, and the other half had a ninety-day term. Therefore, as the effect on net cash outflows is both weaker than the effect on HQLA and diluted by ninety-day PDCF loans, we expect that PDCF use leads to an overall increase in the LCR of BHCs.

The model estimates shown in Fig. 5 confirm our expectations: Both the HQLA and the LCR of BHCs increase the day after PDCF borrowings, indicating that BHCs pledged assets that had low or no weight in HQLA calculations as collateral (e.g., investment-grade debt or equity securities) in return for the cash equivalents received. Interestingly, however, more than one day after PDCF borrowings, we find that both HQLA and the LCR revert to levels that are not significantly different from the initial state. This finding suggests that BHCs used the liquid assets obtained through the facility for repaying obligations that had low or no weight in the net cash outflow calculations—such as repurchase agreements secured by Level 1 or Level 2 A HQLA or debt obligations of more than thirty days maturity. Overall, our estimates suggest that the PDCF helped mitigate the liquidity pressure and funding difficulties of primary dealers and may have enhanced the stability of securities markets during the early days of the COVID-19 crisis.

5.3.3. Money market mutual fund liquidity facility borrowing

From a liquidity regulation perspective, we expect that the MMLF had little to no impact on the LCR. Regarding the LCR numerator, using the facility causes a sequence of offsetting changes in HQLA: A firm uses cash to purchase mutual fund assets, which are then pledged as collateral for the MMLF loan, which in turn generates a cash inflow, thus restoring the initial level of HQLA. Regarding the LCR denominator, thirty-day net cash outflows increase if the term of the MMLF loan is shorter than thirty days—in this case, net cash outflows increase by 0% to 25% of the loan amount, depending on the collateral pledged. However, the data show that about 80% and 50% of the MMLF loan amount borrowed by the firms in our sample had a term that was longer than thirty and seventy days, respectively. Therefore, we expect that the use of this facility had no effect on the HQLA and the LCR.
Fig. 5. Estimated changes in liquidity metrics after PDCF borrowing. This figure shows estimates of cumulative changes in the high-quality liquid assets (HQLA, Panel A) and the liquidity coverage ratio (LCR, Panel B) of large bank holding companies (BHCs) in the United States after obtaining funding from the Primary Dealer Credit Facility (PDCF) of the Federal Reserve. The set of large holding companies consists of the U.S. BHCs and the intermediate holding companies of foreign banks that report the LCR on a daily basis. The estimates are based on the dynamic regression model specified in Eq. (A.1) of the Appendix A, which is estimated in the time period from January 1, 2020, to April 30, 2020. The statistically significant estimates (i.e., those with p-values less than 0.1) are shaded gray, whereas the insignificant ones are shaded light blue. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of BHCs in the time period of our analysis. The model estimates are consistent with our expectations: We find that MMLF borrowings have no significant effect on short-term HQLA or LCR dynamics.

5.4. Effect of liquidity facilities on bank leverage ratios

We now assess the impact of Federal Reserve liquidity facilities on capital ratios. While the cash and cash equivalents obtained by using these facilities have a risk weight of zero and thus do not affect risk-based capital ratios, they could affect leverage ratios, which are sensitive to bank balance sheet growth. Therefore, borrowings from certain temporary liquidity facilities were exempted from leverage ratio requirements in order to facilitate their usage by banks. In particular, borrowings from the MMLF and the PPPLF were excluded from the denominators of leverage ratios. In the following, we quantify the exemption effect and measure the increase in leverage ratios as a result of using these liquidity facilities.

We present the effect of MMLF use on the SLRs of large BHCs in Table 2. In the first two quarters of 2020, outstanding borrowings from this liquidity facility were small relative to the total leverage exposures of the BHCs that used it. Consequently, the effect of MMLF use on their SLRs is also small: The mean SLR of these BHCs increased by about 11 basis points as a result of the exemption received for MMLF use.

We present the effect of PPPLF use on the leverage ratios of banks in Table 3. The PPPLF use of the largest banks was negligible, and both their SLRs and their leverage ratios were practically unaffected. Meanwhile, smaller banks used the facility more, in both a relative and an absolute sense, generating more than 90% of PPPLF dollar borrowings. The size of PPPLF borrowings of the average community bank that used the facility was about 9% of its total assets. Hence, as a result of their PPPLF use, the mean leverage ratio of such community banks was boosted by about 77 basis points, which was a significant relief of their potentially binding leverage ratio requirement. Indeed, our data show that while only about 0.2% of community bank PPPLF users fell short of the leverage ratio requirement at the end of Q2 2020,

27 See the respective interim final rules excluding MMLF and PPPLF borrowings from capital ratio denominators effective March 23, 2020, and April 13, 2020.
this fraction would have been about 3.2% if we remove the effect of leverage ratio exemption received for their PPPFLF use.\footnote{We analyze leverage ratio bindingness taking into account that the leverage ratio requirement is 4% of total assets for all banks in the United States, except for those community banks that opted to be subject to the community bank leverage ratio requirement, which was at 8% of total assets in 2020.}

Overall, we find that the effect of MMLF use on the SLRs of large BHCs was small, while the effect of PPPFLF use on the leverage ratios of large banks was negligible.\footnote{Notably, our analysis provides an upper bound for the causal effect of these liquidity facilities on bank leverage ratios because they neglect incentive and substitution effects. That is, in the absence of favorable regulatory treatment, some of the balance sheet growth associated with MMLF and PPPFLF borrowings might not have occurred. Furthermore, banks might have allocated their resources to activities with lower leverage ratio impact, such as off-balance-sheet activities or activities that decrease total leverage exposures through the increase in netted items.} Large banks made little use of the PPPFLF, which we attribute to two main factors. One, these banks experienced a large inflow of deposits during the first half of 2020, which provided ample low-cost funding for their lending activity. Two, large U.S. banks held sizable voluntary buffers above their SLR and leverage ratio requirements at the beginning of 2020, which likely reduced their incentives to use these facilities for leverage ratio relief purposes. Meanwhile, our calculations suggest that some of the more leverage-constrained community banks were major users and beneficiaries of the PPPFLF and the associated leverage ratio exemption.

6. Lending activity

In this section, we show that modest changes in total bank credit obscure significant fluctuations within loan portfolios during the pandemic. Bank size and business model explain a significant part of the cross-sectional variation in credit growth across banks. By contrast, we find only a weak association between credit growth and either the tightness of regulatory capital constraints or measures of bank health. Therefore, we find little empirical evidence for a “credit crunch” in the sense of Bernanke and Lown (1991). These results suggest that extraordinary macroeconomic conditions affecting credit demand are the primary drivers of aggregate credit fluctuations and the evidence in the Senior Loan Officer Opinion Survey on Bank Lending Practices (SLOOS) on tighter credit availability.

6.1. Aggregate lending

Table 4 compares total credit exposure growth (Panel A) and lending growth (Panel B) in each quarter of 2020 to mean quarterly growth in the previous two years. Panel A shows that the overall growth of lending commitments, which include undrawn (off-balance-sheet) credit lines, was quite stable, if a bit slow later in 2020. At the same time, a breakdown shows that second-quarter growth differed between larger and smaller banks, with slightly negative growth at U.S. G-SIBs. This divergence reflects Paycheck Protection Program (PPP) loans, most of which were extended by smaller banks.\footnote{In the second quarter, U.S. G-SIBs account for only about 13% of the $486 billion on-balance-sheet PPP loans.} If we exclude PPP loans from our measure of credit exposure, second-quarter growth falls to –1.0% at U.S. G-SIBs and just +0.2% at other banks.

Panel B focuses on loan growth, which is affected by borrowers’ use of credit lines. Compared to total credit exposure, overall loan growth was higher in the first quarter – driven by U.S. G-SIBs – and lower in the second and third quarters. This difference reflects a sharp rise in commercial credit line utilization during the financial market turmoil in March 2020. Much of this credit demand appears to have been precautionary in nature because these credit lines were mostly repaid as market conditions eased in the second and third quarters of 2020, which generated a sharp reversal in loan growth. Since commercial credit lines are issued almost entirely by large banks, credit exposure and loan growth trends are more similar at smaller banks.

Table 4

| Panel A | Panel B |
|--------|--------|
| Q1 2020 | Q2 2020 |
| C&I loans | 7.3% | 5.7% |
| Commercial real estate loans | 6.4% | 4.8% |
| Residential real estate loans | 3.2% | 2.8% |
| Consumer loans | 5.1% | 3.9% |
| Total credit exposure | 6.1% | 4.3% |

6.2. Lending by loan types

Table 5 breaks down the total credit exposure growth (Panel A) and loan growth (Panel B) in 2020 by type. Panels A and B show that commercial real estate lending grew at a similar pace to past years, while total exposure growth slightly lagged. Residential real estate lending growth continued to be slow, consistent with the steady migration of mortgage origination to the nonbank financial sector. Overall, lending growth in these two segments was consistent with banks continuing to provide credit to real estate borrowers in the COVID-19 crisis.

Meanwhile, there were sharp fluctuations in the growth of commercial and industrial (C&I) loans and significantly lower growth in consumer loans. Although commercial credit exposure growth was especially strong in Q2 2020, this is mostly due to PPP loans. Excluding PPP loans, C&I loan portfolios shrunk by almost 10% and commercial credit exposure fell by 0.6%. However, to the extent that PPP loans substituted for conventional bank credit, credit exposure growth in the absence of PPP loans would have exceeded –0.6%. The sharp decline in second-quarter C&I loan balances and the preceding increase were primarily driven by the above discussed draws on and repayment of commercial credit lines; total commercial credit exposure growth was modest.

Comparing Panels A and B, we find that consumers paid down a significant share of their personal credit lines in the first two quarters of 2020, while consumer loan balances resumed growth from the third quarter. Horvath et al. (2021) show that this reduction in credit was concentrated among the most creditworthy borrowers, which is likely related to pandemic-induced reductions in travel and leisure spending and stimulus-related increases in the personal savings rate. In addition, total consumer credit commitments fell by almost 1% in the second and third quarters. This is consistent with news reports of credit card issuers reducing credit card lines in order to lower credit risk exposure as well as the empirical evidence on the flight to safety in the credit card market documented by Horvath et al. (2021).

6.3. Evidence of changes in credit supply

Notwithstanding the sharp movements in C&I and consumer loans presented above, overall loan balances did not change sharply in 2020. However, this observation is of limited use in assessing whether the credit supply tightened. The small change in the quantity of bank credit could be due to a reduction in credit supply alongside an increase in credit demand or due to an increase in credit supply alongside a reduction in credit demand, and either is conceivable. Acknowledging

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
| Q1 2020 | Q2 2020 |
\hline
Total leverage exposures ($ billion) & 8230 & 7397 \\
MMLF use ($ billion) & 48.73 & 19.91 \\
MMLF use (% of Total leverage exposures) & 2.12 & 1.36 \\
Mean SLR (%) & 5.79 & 7.31 \\
Mean SLR without MMLF exemption (%) & 5.68 & 7.20 \\
\hline
\end{tabular}
\caption{Effect of MMLF use on the SLRs of large bank holding companies.}
\end{table}
supply during a downturn is typically considered harmful to social welfare. This difficulty, we examine the available evidence, as reduced credit supply during a downturn is typically considered harmful to social welfare.

### Table 3
Effect of PPPFLF Use on Bank Leverage Ratios in Q2 2020.

| Total assets ($ billion) | PPPFLF use ($ billion) | PPPFLF use (% of Assets) | Mean LR (%) | Mean LR w/o Ex. |
|-------------------------|------------------------|--------------------------|-------------|-----------------|
| U.S. G-SIBs             | 1644                   | 3.1                      | 0.19        | 8.49            | 8.48           |
| Large banks             | 164                    | 1.7                      | 0.92        | 8.77            | 8.68           |
| Regional banks          | 695                    | 15.5                     | 2.15        | 9.24            | 9.07           |
| Community banks         | 521                    | 43.4                     | 8.59        | 9.85            | 9.18           |

This table shows the total assets, total Paycheck Protection Program Liquidity Facility (PPPFLF) borrowings, and mean leverage ratios (LRs) of the banks that used the PPPFLF. The statistics are presented for Q2 2020 when the PPPFLF borrowings of banks peaked. The statistics are broken down for different bank size categories. Large banks, regional banks, and community banks are banks with total assets above $100 billion, between $10 and $100 billion, and below $10 billion, respectively. The last column shows how much the mean leverage ratio of these companies would have been without the exemption received for their PPPFLF use.

### Table 4
Growth of U.S. bank credit in 2020.

### Panel A. Quarterly total credit exposure growth (in %)

|                      | 2018-2019 | 2020 | Q1 | Q2 | Q3 | Q4 |
|----------------------|-----------|------|----|----|----|----|
| All banks            | 1.2       | 1.0  | 2.0 | 0.4 | 0.1 | **
| U.S. G-SIBs          | 1.0       | 1.3  | -0.3 | 0.2 | 0.1 | 
| Others               | 1.3       | 0.8  | 3.8** | 0.5** | 0.0*** |

This table reports the growth of total credit exposures (Panel A) and loans (Panel B) of all banks in the United States. The first column shows mean quarterly growth rates in 2018 and 2019, and the last four columns show mean quarterly growth rates in each quarter of 2020. Panel A includes both loans and undrawn credit commitments, while Panel B excludes undrawn credit commitments. The data are from the FR Y-9C form and the FFIEC call reports. Statistically significant deviations from the 2018–2019 means at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

### Panel B. Quarterly loan growth (in %)

|                      | 2018-2019 | 2020 | Q1 | Q2 | Q3 | Q4 |
|----------------------|-----------|------|----|----|----|----|
| All banks            | 1.0       | 3.6*** | 0.2 | -0.2* | 0.4 |
| U.S. G-SIBs          | 0.5       | 5.5*** | -5.3*** | -0.8 | 1.7 |
| Others               | 1.2       | 2.4**  | 3.5*** | 0.1*  | -0.3*** |

This table shows the total assets, total Paycheck Protection Program Liquidity Facility (PPPFLF) borrowings, and mean leverage ratios (LRs) of the banks that used the PPPFLF. The statistics are presented for Q2 2020 when the PPPFLF borrowings of banks peaked. The statistics are broken down for different bank size categories. Large banks, regional banks, and community banks are banks with total assets above $100 billion, between $10 and $100 billion, and below $10 billion, respectively. The last column shows how much the mean leverage ratio of these companies would have been without the exemption received for their PPPFLF use.

We conduct a cross-sectional regression analysis and investigate how capital constraints and the reliance on the Federal Reserve’s discount window relate to bank-level credit growth from Q4 2019 to Q4 2020. To the extent that capital constraints can explain credit growth, changes to their tightness might have hampered the extension of credit during the COVID-19 pandemic. Similarly, if discount window use is related to credit growth, it would suggest that monetary policy interventions played a role in stabilizing credit supply.

In our analysis, we use the growth in total credit exposure from Q4 2019 through Q4 2020 as our main credit growth measure. Importantly, this measure is unaffected by credit line usage, over which the banks have relatively little control, and it also excludes PPP loans because these loans do not affect a bank’s credit risk or constrain its capital. In addition to our main measure, we also use two alternative lending growth measures: one that includes PPP loans and one that measures loan growth instead of exposure growth and thus reflects credit line use.

We consider two types of capital constraints: regulatory capital constraints and economic capital constraints. Our first measure of regulatory capital constraints is the CET1 risk-based capital requirement at the end of 2019. We split each bank’s CET1 capital ratio into the CET1 requirement, which includes the CCB and the G-SIB surcharge, and its voluntary capital buffer, held in excess of the requirement. If banks make lending decisions so as to maintain a specific buffer amount, then voluntary buffers should predict credit growth, while capital requirements need not be related to credit growth. Our second measure of regulatory capital constraints is commercial credit line draws. The unexpectedly large draws in March 2020 constitute a shock to regulatory capital requirements and should be associated with lower credit exposure growth if capital constraints affect lending decisions. While the credit line draws were transitory in nature, banks may not have fully anticipated their short duration at the time. Finally, we enhance the identification of the effect of regulatory capital constraints by controlling for two market-based measures of capital. These are (i) the market leverage ratio, defined as market capitalization to total assets as of the end of 2019, and (ii) the percentage change in market capitalization in Q1 2020.

Furthermore, we examine whether discount window use is associated with lending growth. To this end, we use a dummy variable that

31. Regulatory actions taken in April 2020 clarify the CARES Act intent that PPP loans should bear zero regulatory capital cost. See the interim final rule on PPP loans effective April 13, 2020.

32. In of the Appendix A, we examine the impact of leverage constraints and find similar results.

33. When drawn, credit lines represent an increase in a bank’s risk-weighted assets but do not affect our measure of credit exposure. Credit line draws also likely represent a shock to a bank’s economic risk exposure, which might also generate an association between credit line exposure and credit growth.

34. Market capitalization data are from the CRSP 1925 U.S. stock database, which are linked to FR Y-9C data using the Federal Reserve Bank of New York CRSP-FRB Link.
takes the value 1 if a bank borrowed from the discount window from March 16, 2020, to June 30, 2020, and the value 0 otherwise.\textsuperscript{35} The literature documents a positive effect of DW borrowing on bank lending during the GFC (Berger et al., 2017). We test if this effect is stronger for capital-constrained banks by interacting the DW usage dummy with the voluntary CET1 capital buffer variable. Hence, we use the following regression specification:

\[
\begin{align*}
\gamma_i &= \alpha + \beta_1 \text{CET1 Requirement}_i + \beta_2 \text{CET1 Voluntary Buffer}_i \\
&+ \beta_3 \text{Credit Lines/CET1}_i \\
&+ \gamma_1 \text{DW Usage}_i + \gamma_2 ( \text{DW Usage}_i \times \text{CET1 Voluntary Buffer}_i ) \\
&+ \theta_1 \text{Q1 Market Cap Decline}_i + \theta_2 \text{Market Leverage}_i + \zeta \times x_i + \epsilon_i 
\end{align*}
\]

where dependent variable \( \gamma \) represents our different measures of credit growth and control variable vector \( x \) stands for the following bank characteristics at the end of 2019: total credit exposure growth in 2019, bank size, the share of interest income, and the distribution of bank loan portfolios across seven lending categories.\textsuperscript{36} We restrict the regression analysis to banks with $1 billion or more in total assets, with CET1 ratios between 0% and 25% and with Tier 1 leverage ratios between 0% and 15%, all as of Q4 2019.

Table 6 shows our regression results. The weak model fit in Column A suggests that the variation in capital constraints, exposure to credit line draws, and DW use explain little of the variation in credit growth. The relationship between credit growth and capital constraint intensity, commitment growth, and DW use is insignificant across all columns.\textsuperscript{37} This is not what we would expect if the banking system had been in a “credit crunch”, with banks limiting lending because of insufficient capital or liquidity (Peek and Rosengren, 1997). As we discuss in Section 4, banks entered the pandemic with strong capital and liquidity positions and were thus likely unconstrained. These results are consistent with Li et al. (2020), showing that banks’ pre-crisis financial positions did not constrain borrower access to credit. The results are also in line with the findings in Carlson et al. (2013) of no significant relationship between capital ratios and credit growth when the banking sector is unconstrained. On the other hand, Berrospide et al. (2021) find that buffer-constrained banks reduced their credit supply in the form of loan commitments and lending relationships. Unlike our analysis, which examines total lending across a broad set of banks, Berrospide et al. (2021) focus only on the largest banks that are subject to stress tests and specifically investigate small business lending. We also detect a weak relationship between our economic capital measures and credit growth in 2020. One interpretation is that banks entered 2020 in such a robust condition that, even though some banks were hit harder than others, few had been weakened so much as to have lower risk appetite or funding liquidity constraints.

In contrast, differences in bank size and business models do explain some of the variation in growth. Credit commitments grew faster at smaller banks (+2% per standard deviation decrease) and at banks with a smaller interest income share of revenue (+2% per standard deviation decrease). The association between credit commitment growth and size is twice as large when including PPP lending (Column D) because PPP lending is more concentrated at smaller banks. This highlights the important role of smaller banks in facilitating the flow of credit during the pandemic.

\textsuperscript{35} In of the Appendix A, we use an alternative measure of DW use, defined as the peak dollar use during this period scaled by total assets. Our results are robust to this alternative specification.

\textsuperscript{36} The seven lending categories are C&I loans, loans to financial institutions, commercial real estate, other wholesale lending, residential real estate, revolving retail lending, and other consumer lending.

\textsuperscript{37} However, for DW users, the statistical confidence interval is large enough that we cannot rule out increases in 2020 lending of several percentage points for each standard deviation increase in the CET1 voluntary buffer.

Table 6

|                  | Total credit exposure growth | Loan growth |
|------------------|-----------------------------|------------|
|                  | Excl. PPP Loans             | Excl. PPP Loans |
|                  | [A] | [B] | [C] | [D] | [E] |
| CET1 requirement | -1.33 | -0.69 | 0.17 | 1.28 | 1.61 |
| CET1 voluntary buffer | -0.25 | -0.11 | 0.05 | 0.40 | 0.33 |
| Credit Lines/CET1 | 0.00 | 0.01 | 0.03 | 0.04** | 0.03** |
| DW usage dummy | -1.28 | -0.89 | -4.05 | -0.84 | -8.15 |
| DW Usage × CET1 Vol. Buf. | -0.03 | -0.07 | 0.48 | -0.10 | -1.22 |
| Q1 market cap decline | 0.13 | 0.16 | 0.16 | 0.22 |
| Market leverage | -0.09 | -0.05 | 0.04 | -0.30 |
| Lagged growth | 0.08*** | 0.01 | 0.07 | 0.03 |
| Size | -2.01*** | -1.76*** | -3.40*** | -1.93*** |
| Interest income share | -0.18** | -0.08 | -0.06 | -0.06 |
| Loan portfolio shares | Yes | Yes | Yes | Yes |
| Asset-weighted | Yes | Yes | Yes | Yes |
| R² | 0.00 | 0.08 | 0.20 | 0.16 | 0.27 |
| Observations | 655 | 655 | 655 | 655 | 655 |

This table shows the estimation results for the regression specified in Eq. (2). The sample consists of 655 banks with $1 billion or more in total assets, with common equity Tier 1 (CET1) ratios between 0% and 25% and with Tier 1 leverage ratios between 0% and 15%, all as of Q4 2019. The data are obtained from the FR Y-9C form and the FFIEC call reports as well as the Federal Reserve’s confidential discount window (DW) borrowing records. Columns A to C measure credit growth by credit exposure growth, excluding Paycheck Protection Program (PPP) loans. Column A includes our measures of regulatory capital constraints (in terms of CET1 capital ratios) and the DW usage dummy. Column B adds our measures of economic capital constraints and control variables for bank business models, while Column C weights each bank in the regression according to its Q4 2019 total assets. Column D adds PPP lending to our outcome variable. Column E measures loan growth instead of total credit exposure growth. The statistical significance of regression estimates at the 10%, 5%, and 1% levels, calculated based on heteroskedasticity-robust standard errors, is denoted by *, **, and ***, respectively.

While our analysis does not find evidence of binding capital constraints, a few caveats are in order. First, we assume that CET1 ratios and credit line exposures are good proxies for banks’ concerns about capital requirements. Second, we assume that our control variables can explain any differences in commitment growth attributable to variation in either (i) other unrelated shocks affecting credit supply or (ii) bank-specific credit demand. In particular, banks with relatively more credit line exposure tend to look different (larger, less retail lending focus), so it is likely that the COVID-19 crisis has affected them differently, in ways other than through credit line draws.

Notably, Kapan and Minoiu (2021) also study the impact of exposure to commercial credit lines on credit availability subsequent to the large drawdowns in Q1 2020. In their empirical approach, the authors address concerns that banks may face different credit demand drivers of the contraction in credit supply. In addition, the SLOOS provides only qualitative evidence regarding the specific drivers. The survey suggests that the change in economic conditions and industry risks are the primary drivers of the contraction in credit supply. While this is suggestive evidence of a reduction in credit supply, the SLOOS provides only qualitative evidence regarding the specific drivers. The survey suggests that the change in economic conditions and industry risks are the primary drivers of the contraction in credit supply. In addition, the SLOOS reports lower demand for every form of credit except for residential credit in Q1 2020.

More generally, the SLOOS indicates tightening underwriting standards for almost every loan type in the first two quarters of 2020 by almost the same margins as in the GFC.\textsuperscript{38} While this is suggestive evidence of a reduction in credit supply, the SLOOS provides only qualitative evidence regarding the specific drivers. The survey suggests that the change in economic conditions and industry risks are the primary drivers of the contraction in credit supply. In addition, the SLOOS reports lower demand for every form of credit except for residential

\textsuperscript{38} See the SLOOS of bank lending practices on July 2020.
mortgages. The somewhat weak bank credit growth in the absence of PPP is in line with these survey responses.

Taken together, our analysis finds little indication that a “credit crunch” contributed meaningfully to the economic challenges posed by the COVID-19 crisis.

7. Trading revenues and repo market making

7.1. Trading revenues

Large banks play an important role in intermediating U.S. financial markets. This activity can pose certain risks. Indeed, during the financial crisis of 2007–09, investment banks suffered large losses, with Lehman Brothers failing and several others acquired by commercial banks. In response, the post-GFC regulatory regime significantly curtailed bank risk-taking. This section examines the trading activity of banks to shed light on the efficacy of these changes.

Trading activity at the largest U.S. banks is a source of revenue when volatility in capital markets increases as a result of repricing events, generating increased client activity. Trading revenues include fees, commissions, and bid-ask spreads arising from new transactions, as well as cash flows and mark-to-market profits and losses from banks’ trading inventory positions. Falato et al. (2019) show that banks reduced their trading inventories and exposures to potential future losses following the post-GFC reforms. The reduction in trading inventories from the pre-GFC levels is due to a combination of a reduction in risk appetite, an increase in market risk capital charges with the introduction of Basel 2.5 in the early 2010s, and a ban on proprietary trading from the Volcker rule in the mid-2010s.

Fig. 6 shows quarterly trading revenues for the largest U.S. trading banks that report Volcker rule metrics. In Panel A, we show the time series of trading profits and losses aggregated across the nine large U.S. banks, including six U.S. G-SIBs and three intermediate holding companies, indicating that 2020 was particularly profitable. Indeed, the first three quarters were the most profitable in the last four years, consistent with the view that banks are limiting their trading inventory risk and focusing on riskless principal transactions, which increased sharply during this period.

Figs. 6 and 7 imply that while quarterly revenue increased respectively by 66%, 113%, 54%, and 34% in 2020, relative to Q4 2019, the size of trading portfolios remained stable as net trading assets only increased by 3%, 7%, 8%, and 4% in the respective quarters, relative to Q4 2019. Moreover, Fig. 7 suggests that high transaction volume was a major driver of the increase in revenues as quarterly transaction counts went up respectively by 33%, 17%, 9%, and 9% in 2020, relative to Q4 2019. We remove potential seasonality in Panel B of Fig. 6 by comparing trading revenues in each quarter of 2020 with the means of corresponding quarters in the preceding years. These findings indicate that the Volcker rule and other regulatory reforms helped limit the exposure of banks to trading losses. Furthermore, the gains in trading revenue helped offset significant increases in loan loss provisions due to the adverse economic circumstances.

The trading books of banks are subject to regular stress testing under a hypothetical global market shock with steep asset price declines and associated increases in credit spreads. While such a market shock implies rapid trading losses, our findings show that banks earned significant trading revenue during the COVID-19 crisis, which suggests that the increase in trading revenue earned in a stress scenario can offset some of the losses incurred from the financial market shock. One important caveat is that financial markets were buoyed by a number of actions by fiscal and monetary authorities, and we are not able to observe the counterfactual of what would have happened to financial markets and trading revenues without such policy interventions.

7.2. Repo market making

In this section, we assess the impact of regulation on repo-style transactions. Besides making capital markets, banks are also involved in making money markets, which includes engaging in repo-style transactions to provide secured short-term financing to market participants. While these transactions are generally considered low-risk because of their collateralization and short maturity, which is reflected by their low risk-based capital charges, repo-style transactions are required to be capitalized the same way as other assets by the SLR.

In theory, binding SLR requirements can incentivize banks to conserve capital and reduce their participation in repo markets. SLR constraints can limit the repo market making activity of BHCs by creating incentives for entering fewer one-sided and more nettable reverse repo positions, since nettable positions do not increase total leverage exposures. Such preferences for repo position netting limit the extent to which BHCs are able or willing to supply liquidity in repo markets. While there exists some empirical evidence that confirms the link between leverage constraints and repo market participation, the effect of SLR buffers on matched-book preference is not yet established.41 We present novel empirical evidence that large BHCs with smaller SLR buffers prefer to hold a greater share of nettable positions in their repo books in order to reduce total leverage exposures.

We study the repo-style transactions of U.S. G-SIBs, which we consider the relevant population of BHCs in our analysis for two main reasons. First, U.S. G-SIBs conduct by orders of magnitude more repo-style transactions than other BHCs—in both absolute and relative terms.42 Second, as Fig. 8 shows, U.S. G-SIBs are relatively more SLR-constrained, partly because they are subject to the 5% enhanced SLR requirement. Hence, U.S. G-SIBs are both more active in the U.S. repo market and more affected by binding SLR constraints. Throughout this analysis, we use quarterly data from Q3 2016 to Q3 2021, reported on the FFIEC 101 form.

In Fig. 9, we examine how the repo books of U.S. G-SIBs developed over time. Panel A shows that the balance sheet share of gross repo positions gradually increased from about 20% to about 30% in the last three years before the pandemic. Importantly, the share of gross repo positions remained relatively high in the first half of 2020, which indicates that U.S. G-SIBs did not curtail their repo books but maintained their repo market making activity during the financial market turmoil at the beginning of 2020. Panel B shows that the gradual repo book growth was paralleled by an increasing use of netting, which resulted in a gradually lower share of non-nettable repo positions over time. Notably, in Q1 2020, relatively low SLR buffers (see Fig. 8) coincided with the lowest mean share of non-nettable repo positions in the past five years, suggesting that U.S. G-SIBs might have used more repo book netting to increase their SLR buffers.

Inspired by these time-series patterns, we carry out a panel regression analysis to determine the lagged SLR’s impact on quarterly...

39 Repo-style transactions consist of repos and reverse repos. A repo transaction is an agreement to repurchase back an asset at a pre-determined future date and pre-agreed price, while a reverse repo transaction is an agreement to sell the asset back in the future by lending out cash.

40 In the calculation of total leverage exposures, which constitute the denominator of the SLR ratio, repo and reverse repo positions can be netted against each other if they match in both counterparty and maturity.

41 See Allah rakha et al. (2018) and Kotidis and van Horen (2018) for analyses of the repo market making activity of U.S. and U.K. broker-dealers, respectively.

42 According to data reported on the FFIEC 101 form, U.S. G-SIBs constitute 99% of the total gross repo-style assets reported. For the average U.S. G-SIB, gross repo-style assets amount to 24% of total assets, while for the average non-G-SIB, repo-style assets have a minimal share of 1% of total assets.
changes in the net-to-gross ratio of repo-style positions. We employ various regression specifications, controlling for quarter and bank fixed effects, as well as the lagged level of the net-to-gross ratio of repo-style positions. Additionally, we test if the pandemic changed the relationship between the SLR and repo book netting by interacting the lagged SLR variable with an indicator dummy for the COVID-19 period, which takes the value 0 in quarters before 2020 and the value 1 afterwards.

Table 7 presents our regression estimates, confirming that more SLR-constrained U.S. G-SIBs use more repo position netting, which suggests that they adjust their repo books so as to increase netting and thereby reduce total leverage exposures. In particular, we estimate that the average U.S. G-SIB increases netting in its repo book and thus reduces its net-to-gross ratio by 60 to 80 basis points for each standard deviation (i.e., about 40 basis points) reduction of its SLR buffer in the preceding quarter. This finding is also robust to the inclusion of

...
Fig. 9. Gross and non-nettable repo-style assets of U.S. G-SIBs. This figure shows the evolution of repo-style assets of U.S. global systemically important banks (G-SIBs), based on quarterly data from Q3 2016 to Q3 2021, reported on the FFIEC 101 form. Panel A shows the mean share of gross repo-style assets as a percentage of pre-crisis total assets. Panel B shows the mean share of net repo-style assets as a percentage of gross repo-style assets. In the calculation of total leverage exposures, banks can net repo positions against reverse repo positions if they match in both counterparty and maturity.

Table 7
Relationship between lagged SLR and non-nettable repo positions.

|                         | Net-to-gross repo-style assets |  
|-------------------------|-------------------------------|
|                         | $\Delta$                      |
|                         | $\text{SLR}_{t-1}$           |
|                         | $\times \text{ COVID Period}_{t}$ |
|                         | $\text{Net-to-Gross Ratio}_{t-1}$ |
|                         | $\text{T1 Capital Ratio}_{t-1}$ |
|                         | $R^2$                         |
|                         | Observations                  |
|                         | Fixed effects                 |
|                         | Time                         |
|                         | Time + Bank                   |
|                         | Time + Bank                   |
|                         | 160                           |
|                         | 160                           |
|                         | 160                           |
|                         | 160                           |
|                         | 160                           |

This table shows our regression estimates on how quarterly changes in the net-to-gross repo ratio are related to the one-quarter lagged values of the supplementary leverage ratio (SLR) and the Tier 1 capital ratio, controlling for the lagged levels of the net-to-gross repo ratio as well as quarter and bank fixed effects. The net-to-gross ratio is defined as the percentage ratio of a firm’s repo-style positions after netting divided by its repo-style positions before netting. The regressions are estimated over the cross section of the eight U.S. global systemically important banks, using quarterly data from Q4 2016 to Q3 2021, reported on FFIEC 101 and FR Y-9C forms. The dummy for the COVID-19 period takes the value 0 in quarters before 2020 and the value 1 afterwards. The statistical significance of regression estimates is indicated by $^*$, $^{**}$, and $^{***}$, respectively.

The relationship we find between the SLR and repo book netting is also robust to the exemption of central bank reserves and U.S. Treasury securities from total leverage exposures implemented by the Federal Reserve in 2020.\textsuperscript{44,45} Fig. 10 shows that these exemptions were substantive: Central bank reserves (Panel A) and U.S. Treasury security holdings (Panel B) respectively constituted about 11% and 8.5% of the average U.S. G-SIB’s total leverage exposures from Q2 2020 to Q1 2021. We examine if this important regulatory change altered the relationship between the SLR and repo book netting by interacting the lag of the percent exemption amounts with the lagged SLR variable in our regressions. In unreported regressions, we find that the interaction term is insignificant, indicating that the relationship between the SLR and repo book netting has not changed during the pandemic.

Crucially, even though the strength of the relationship between the SLR and repo book netting of U.S. G-SIBs did not change because of the SLR exemptions implemented in 2020, their repo market making activity was directly enhanced by boosted SLR levels. Our finding that higher SLR levels are followed by increases in net-to-gross ratios suggests that the exemptions encouraged repo market making by increasing the SLR levels of U.S. G-SIBs and thus weakening their incentives to avoid entering non-nettable repo positions. A simple calculation

\textsuperscript{44} The central bank reserves of custodian BHCs subject to the SLR were permanently excluded from total leverage exposures effective April 1, 2020.

\textsuperscript{45} In order to ease financial market strains and promote lending to businesses and households, both the central bank reserves and the U.S. Treasury security holdings of BHCs subject to the SLR were temporarily excluded from total leverage exposures effective April 14, 2020. The exemption expired on March 31, 2021.
Fig. 10. Distribution of U.S. G-SIB leverage exposures exempted in 2020. This figure shows histograms of the central bank reserves of U.S. global systemically important banks (G-SIBs) (Panel A) and their U.S. Treasury security holdings (Panel B), exempted from total leverage exposures (i.e., the supplementary leverage ratio’s denominator) in 2020. The exclusion amounts are expressed as a percentage of total leverage exposures at the firm level, and they are calculated using quarterly data reported on the FFIEC 101 and Y-9C forms from Q2 2020 to Q1 2021. The vertical red lines denote the mean values of the corresponding exclusion amounts.

Fig. A.1. Mean capital and leverage ratios and requirements. This figure shows the weighted means of the Tier 1 (T1) capital ratios and requirements (Panel A), the total capital ratios and requirements (Panel B), and the Tier 1 leverage ratios and requirements (Panel C) of the eight U.S. G-SIBs from Q1 2019 to Q3 2021. In each panel, the vertical line marks Q4 2019, the last quarter before the onset of the pandemic.
Fig. A.2. Comparison of baseline and robust estimates. This figure compares impulse response functions estimated using the baseline model specification in Eq. (A.1) and using a linear local projection ("robust") method, described by Jordà (2005). Panels A and B respectively show estimates for the dynamic effect of the discount window (DW) on the high-quality liquid assets (HQLA) and the liquidity coverage ratio (LCR) of sample firms. Panels C and D respectively show estimates for the dynamic effect of the Primary Dealer Credit Facility (PDCF) on the HQLA and the LCR of sample firms. The sample consists of the U.S. bank holding companies and the intermediate holding companies of foreign banks that report the LCR on a daily basis. The models are estimated using daily data in the time period from January 1 to April 30, 2020. The statistically significant (i.e., those with p-values less than 0.1) are shaded gray (for baseline) or blue (for robust), while the insignificant ones are denoted by white bars. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

This table shows diagnostics for the dynamic regression model specified in Eq. (A.1), which we apply to dependent variables HQLA and LCR, using different lags (p). At the top of the table, \( a_k \) denote coefficient estimates for the dependent variable’s \( k \)th lag. At the bottom of the table, we provide autocorrelation estimates for the model residuals. The statistical significance of coefficient estimates at the 1%, 5%, and 10% levels is denoted by *, **, and ***, respectively.

|        | \( y = \text{HQLA} \) (% of total assets) | \( y = \text{LCR} \) (% of net outflows) |
|--------|------------------------------------------|------------------------------------------|
|        | \( p = 1 \) | \( p = 2 \) | \( p = 3 \) | \( p = 1 \) | \( p = 2 \) | \( p = 3 \) |
| \( a_1 \) | 0.99*** | 0.92** | 0.93*** | 0.97*** | 0.78*** | 0.75*** |
| \( a_2 \) | 0.07 | 0.12 | 0.20** | 0.09 | &nbsp; | &nbsp; |
| \( a_3 \) | &nbsp; | &nbsp; | &nbsp; | &nbsp; | &nbsp; | &nbsp; |
| Adjusted \( R^2 \) | 0.99 | 0.99 | 0.99 | 0.96 | 0.96 | 0.96 |
| Observations | 891 | 891 | 891 | 891 | 891 | 891 |
| corr(\( \epsilon_1, L1(\epsilon) \)) | −0.06 | 0.01 | 0.01 | −0.19** | −0.03 | −0.00 |
| corr(\( \epsilon_2, L2(\epsilon) \)) | 0.02 | 0.02 | −0.04 | 0.08 | −0.12 | −0.03 |
| corr(\( \epsilon_3, L3(\epsilon) \)) | −0.01 | −0.00 | −0.00 | 0.09 | 0.03 | −0.00 |

This table shows diagnostics for the dynamic regression model specified in Eq. (A.1), which we apply to dependent variables HQLA and LCR, using different lags (p). At the top of the table, \( a_k \) denote coefficient estimates for the dependent variable’s \( k \)th lag. At the bottom of the table, we provide autocorrelation estimates for the model residuals. The statistical significance of coefficient estimates at the 1%, 5%, and 10% levels is denoted by *, **, and ***, respectively.

8. Conclusion

We assess the bank regulatory framework during the COVID-19 shock. We find that the banking system withstood the shock and continued supporting the economy by lending to firms and making financial markets. This is partly due to the fact that banks entered the

combining the SLR increase from the exemptions and our regression estimates from Table 7 shows that this effect is substantive. The SLRs of individual U.S G-SIBs were by 65 to 245 basis points higher, while their mean SLR was about 125 basis points higher because of the exemptions from Q2 2020 to Q1 2021. Based on the regression model, such an SLR boost translates to an about 100 to 500 basis point increase in the net-to-gross ratios of individual U.S. G-SIBs and an about 190 to 250 basis point increase in their mean net-to-gross ratio. The magnitude of these model-implied estimates is in line with the observable increase in the mean net-to-gross ratio in this time period (see Fig. 9).

Finally, we perform a placebo test on our main results by examining if SLR constraints are associated with increased netting of derivative positions, which are also included (and can be netted against one another) in total leverage exposure calculations. Using the same regression specifications as in Table 7, we find no significant relationship between the SLR buffer and the netting of derivative positions. This result is consistent with contingent assets having relatively larger risk-based capital charges than leverage charges. Even though banks can net offsetting derivatives positions in their leverage exposures, it is primarily the risk-based capital requirements that determine capital charges for derivatives. This explains the lack of incentives for banks to adjust derivative netting out of SLR considerations.
crisis with robust capital and liquidity levels. Regulatory interventions aimed at both easing regulatory capital requirements and strengthening capital levels ensured that banks were able to maintain their already strong levels of capital adequacy. In addition, Federal Reserve facilities helped banks to further strengthen their liquidity positions and the financial system to weather the initial bout of uncertainty.

Appendix A

A.1. Further capital and leverage ratios and requirements

See Fig. A.1.

A.2. Dynamic regression model specification and diagnostics

Model Specification

In our analysis, we use the following regression specification

\[ y_{it} = \sum_{k=0}^{p} a_k y_{i,t-k} + \sum_{k=1}^{3} \beta_k x_{i,t-k} + \sum_{k=1}^{3} \gamma_k z_{i,t-k} + c + \epsilon_{it} \]  

(A.1)

where \( y_{it} \), \( x_{it} \), and \( z_{it} \) denote the dependent, (the vector of) pre-determined explanatory, and (the vector of) co-determined explanatory variables for firm \( i \) on day \( t \). The dependent variable is either HQLA, expressed as a percentage of Q4 2019 total assets, or the LCR, expressed as a percentage of thirty-day net cash outflows, as defined in Eq. (1).

We include \( p \) lags of the dependent variable in the model to capture the variable’s strong autocorrelation and to control for the influence of pre-determined latent factors. We use three lags of the explanatory variables, which we found sufficient to avoid omitted variable concerns, and we also include pre-determined explanatory variables contemporaneously (i.e., for \( k = 0 \)). We express all explanatory variables as a percentage of Q4 2019 total assets, which are unaffected by the pandemic.

- The vector of pre-determined explanatory variables (i.e., \( x \)) consists of
  - required reserves (% of total assets)
  - deposits (% of total assets)

- The vector of co-determined explanatory variables (i.e., \( z \)) consists of
  - DW borrowing (% of total assets)
  - DW repayment (% of total assets)
  - MMLF borrowing (% of total assets)
  - MMLF repayment (% of total assets)
  - PDCF borrowing (% of total assets)
  - PDCF repayment (% of total assets)
  - net change in Federal Reserve overnight repo funding (% of total assets)
  - net overnight unsecured funding (% of total assets)

We consider required reserves and deposits as pre-determined explanatory variables and thus include them contemporaneously in the model because reverse causality is arguably not a concern with these variables. Since required reserves are based on the two-week moving average of reservable liabilities, it is unlikely that the current HQLA or LCR has an immediate influence on this variable. Similarly, it is unlikely that the current HQLA or LCR has an immediate influence on the deposits of a BHC, which are based on customer decisions in the past.

We consider the use of DW, MMLF, PDCF funding, Federal Reserve overnight repo funding, and overnight unsecured funding as co-determined explanatory variables and thus include them only with a lag in the model because we cannot exclude contemporaneous reverse causality with these variables. Since a BHC may borrow from these sources to alleviate liquidity shortages, it is plausible that the BHC’s current liquidity position, also measured by its HQLA and LCR, has an immediate influence on its decision about using these facilities or unsecured funding on the same day. Regarding the facilities, we separate net borrowings (i.e., daily outstanding amount increases) and net repayments (i.e., daily outstanding amount decreases) because it is likely that borrowings and repayments have an asymmetric impact on firm asset holdings and funding structure. This way, we can identify the effect of borrowing from these facilities with greater accuracy.

Model Selection and Diagnostics

We try using different numbers of lags of variables in our model specified in Eq. (A.1). For the explanatory variables, we use three lags because their regression coefficients beyond three lags are insignificant in all model variants. For the dependent variables, we try one, two, and three lags and conclude that a lag of

- \( p = 1 \) yields the best model properties for HQLA,
- \( p = 3 \) yields the best model properties for LCR.

The diagnostics in Table A.1 highlight three important model properties. (i) All model variants detect a very strong (i.e., close-to-unity) autocorrelation in the dependent variables, which is in line with our expectations and observations of the daily HQLA and LCR of BHCs. (ii) As a result of the strong autocorrelation, the models fit the observed data exceptionally well and thus constitute a reliable tool for accurately measuring the effect of other factors, such as Federal Reserve facility use, on BHC liquidity position. (iii) Residual autocorrelation only vanishes when \( p \geq 1 \) and \( p \geq 3 \) for HQLA and the LCR, respectively. For smaller values of \( p \), residual autocorrelation violates the exogeneity assumption and renders the estimated coefficients inconsistent in the statistical sense. Therefore, in our analysis, we use the most parsimonious model specifications with no residual autocorrelation, including one lag of HQLA and three lags of the LCR in the model.

Robustness Test

We verify the robustness of our findings presented in Figs. 4 and 5 of Section 5 by using an alternative, semi-parametric estimation approach. To this end, we apply the local projection method of Jordà (2005) in a linear setting. As shown in Fig. A.2, we find that the impulse response functions calculated based on local projections match the estimates.
wake of the COVID-19 crisis. and promote the flow of credit to businesses and households in the
would be eliminated effective March 26 to stabilize financial markets
March 15, 2020, the Federal Reserve Board further announced that RR
administered rates.
interest rates is exercised primarily through the setting of the Federal Reserve’s
not required, since the control of the federal funds rate and other short-term
excess reserves—and thus on HQLA and the LCR.
and liability maturity structures to offset the impact of RR changes on
in this time period, large BHCs had sufficient flexibility in their asset
due to RR changes, they can schedule the maturity of their assets and
know in advance precisely when and how their excess reserves change
denominator would be unchanged. Therefore, in
principle, reducing RR would increase the LCR of BHCs, and increasing
RR would have the opposite effect. In practice, however, since BHCs
know in advance precisely when and how their excess reserves change
due to RR changes, they can schedule the maturity of their assets and liabilities so as to neutralize the effect on excess reserves and thus
smooth their LCR.
Using the regression model specified in Eq. (A.1), we estimate the effect of RR changes on the HQLA and the LCR of large BHCs in the time
period from January 2020 to May 2020. We find that RR changes have no significant effect on HQLA or the LCR. This finding is consistent with the
time series in Panel B of Fig. 2, which indicates no change in HQLA
at the elimination of the RR on March 26. The result also suggests that,
in this time period, large BHCs had sufficient flexibility in their asset
and liability maturity structures to offset the impact of RR changes on excess reserves—and thus on HQLA and the LCR.
A.3. Effect of reserves requirements on balance sheet liquidity

Required reserves (RR) are the amounts of vault cash and balances
held at the Federal Reserve that depository institutions were required to
maintain at a level exceeding a certain fraction of their deposits. Histor-
ically, in the “scarce reserves” regime, RR played a key role in monetary
policy implementation by creating stable and predictable demand for
reserves. In January 2019, the Federal Open Market Committee of the
Federal Reserve stated its intention to implement monetary policy in an
“ample reserves” regime, allowing the reduction of RR to zero. On
March 15, 2020, the Federal Reserve Board further announced that RR
would be eliminated effective March 26 to stabilize financial markets
and promote the flow of credit to businesses and households in the
wake of the COVID-19 crisis.

Appendix B. Supplementary data
Supplementary material related to this article can be found online
at https://doi.org/10.1016/j.jfs.2022.101016.

---

Table A.3
Regressions of total credit exposure and loan growth (Q1–Q4 2020).

| Total credit exposure growth | Loan growth |
|-----------------------------|-------------|
| Excl. PPP Loans             | Excl. PPP Loans |
| [A]            | [B] | [C] | [D] | [E] |
| CET1 requirement    | −1.53 | −0.68 | −0.13 | 1.35 | 0.87 |
| CET1 voluntary buffer | −0.18 | −0.11 | 0.40 | 0.52 | 1.00* |
| Credit lines/CET1     | 0.00  | 0.01  | 0.03  | 0.04  | 0.03  |
| DW peak usage         | 104.70 | 37.60 | 298.65 | 312.89* | 220.85 |
| Peak DW/TA × CET1 Vol. Buf. | −15.83 | −5.55 | −44.02 | −55.44* | −32.67 |
| Q1 market cap decline  | 0.13  | 0.15  | 0.13  | 0.24  |
| Market leverage        | −0.09 | −0.03 | 0.04  | −0.26 |
| Lagged growth          | 0.08*** | 0.02  | 0.07  | 0.04  |
| Size                   | −2.05*** | −1.76*** | −3.34*** | −1.97*** |
| Interest income share  | −0.18*** | −0.09 | −0.07 | −0.07 |
| Loan portfolio shares  | Yes   | Yes   | Yes   | Yes   |
| Asset-weighted         | Yes   | Yes   | Yes   | Yes   |
| Market leverage        | −0.09 | −0.03 | 0.04  | −0.26 |
| Lagged growth          | 0.08*** | 0.02  | 0.07  | 0.04  |
| Size                   | −2.05*** | −1.76*** | −3.34*** | −1.97*** |
| Interest income share  | −0.18*** | −0.09 | −0.07 | −0.07 |
| Loan portfolio shares  | Yes   | Yes   | Yes   | Yes   |
| Asset-weighted         | Yes   | Yes   | Yes   | Yes   |
| Peak DW/TA × CET1 Vol. Buf. | −15.83 | −5.55 | −44.02 | −55.44* | −32.67 |
| Q1 market cap decline  | 0.13  | 0.15  | 0.13  | 0.24  |
| Market leverage        | −0.09 | −0.03 | 0.04  | −0.26 |
| Lagged growth          | 0.08*** | 0.02  | 0.07  | 0.04  |
| Size                   | −2.05*** | −1.76*** | −3.34*** | −1.97*** |
| Interest income share  | −0.18*** | −0.09 | −0.07 | −0.07 |
| Loan portfolio shares  | Yes   | Yes   | Yes   | Yes   |
| Asset-weighted         | Yes   | Yes   | Yes   | Yes   |
| R²                      | 0.00  | 0.07  | 0.20  | 0.17  | 0.26  |
| Observations           | 655   | 655   | 655   | 655   |

This table shows a robustness check of the results presented in Table 6 of Section 6, using a continuous discount window (DW) usage variable instead of a binary dummy. The continuous DW variable is defined as the peak dollar DW usage during the period from March 16 to June 30, 2020, divided by Q4 2019 total assets. The sample consists of 655 banks with $1 billion or more in total assets, with CET1 ratios between 0% and 25%, and with Tier 1 leverage ratios between 0% and 15%, all as of Q4 2019. The data is obtained from the FR Y-9C form, the FFIEC call reports, and the Federal Reserve’s confidential discount window borrowing records. The statistical significance of regression estimates at the 10%, 5%, and 1% levels, calculated based on heteroskedasticity-robust standard errors, is denoted by *, **, and *** respectively.

Table A.4
Sample composition by section.

| Sections                          | Sample institutions |
|-----------------------------------|---------------------|
| 4 Capital positions and interventions | 8 U.S. G-SIBs       |
| 5 Liquidity positions and facilities | 8 U.S. G-SIBs and 3 BHCs subject to the daily LCR |
|                                   | All PPPFL-user banks in the United States |
| 6 Lending activity                | 555 large banks in the United States |
| 7.1 Trading revenues              | Regression: 655 large banks in the United States |
| 7.2 Repo market making            | 6 U.S. G-SIBs and 3 BHCs subject to the Volcker Rule |

Sections Sample institutions
4 Capital positions and interventions 8 U.S. G-SIBs
5 Liquidity positions and facilities 8 U.S. G-SIBs and 3 BHCs subject to the daily LCR
All PPPFL-user banks in the United States
6 Lending activity Statistics: All banks in the United States
Regression: 655 large banks in the United States
7.1 Trading revenues 6 U.S. G-SIBs and 3 BHCs subject to the Volcker Rule
7.2 Repo market making 8 U.S. G-SIBs

This table shows a robustness check of the results presented in Table 6 of Section 6, using a continuous discount window (DW) usage variable instead of a binary dummy. The continuous DW variable is defined as the peak dollar DW usage during the period from March 16 to June 30, 2020, divided by Q4 2019 total assets. The sample consists of 655 banks with $1 billion or more in total assets, with CET1 ratios between 0% and 25%, and with Tier 1 leverage ratios between 0% and 15%, all as of Q4 2019. The data is obtained from the FR Y-9C form, the FFIEC call reports, and the Federal Reserve’s confidential discount window borrowing records. The statistical significance of regression estimates at the 10%, 5%, and 1% levels, calculated based on heteroskedasticity-robust standard errors, is denoted by *, **, and *** respectively.

A.4. Robustness: Lending growth and T1 leverage constraints

See Table A.2.

A.5. Robustness: Lending growth and peak DW usage

See Table A.3.

A.6. Sample composition

See Table A.4.

---

Footnote: See the Federal Reserve statement regarding monetary policy implement-
tion and balance sheet normalization issued on January 30, 2019. In an
“ample reserves” regime, the active management of the supply of reserves is not
required, since the control of the federal funds rate and other short-term
interest rates is exercised primarily through the setting of the Federal Reserve’s
administered rates.

---

"ample reserves” regime, allowing the reduction of RR to zero. On
March 15, 2020, the Federal Reserve Board further announced that RR
would be eliminated effective March 26 to stabilize financial markets
and promote the flow of credit to businesses and households in the
wake of the COVID-19 crisis.

---

from our baseline specification in Eq. (A.1) in both their magnitude
and significance. This suggests that our findings are robust to potential
model specification errors.

---

46 See the Federal Reserve statement regarding monetary policy implement-
tion and balance sheet normalization issued on January 30, 2019. In an
“ample reserves” regime, the active management of the supply of reserves is not
required, since the control of the federal funds rate and other short-term
interest rates is exercised primarily through the setting of the Federal Reserve’s
administered rates.

---

E. Duncan et al.
Journal of Financial Stability 61 (2022) 101016
References

Aboud, Alice, Anderson, Chris, Game, Aaron, Iercosan, Diana, Inanoglu, Hulusi, Lynch, David, 2021. Banks’ Backtesting Exceptions during the COVID-19 Crash: Causes and Consequences. In: FDFS Notes, Board of Governors of the Federal Reserve System, Washington, http://dx.doi.org/10.17016/2380-7172.2939.

Acharya, Viral V., Fleming, Michael J., Hrng, Warren B., Sarkar, Asani, 2017. Dealer financial conditions and lender-of-last-resort facilities. J. Financ. Econ. 123 (1), 81–107.

Acharya, Viral V., Rajan, Raghuram, 2022. Liquidity, Liquidity Everywhere, Not a Drop to Use: Why Flooding Banks with Central Bank Reserves May Not Expand Liquidity. NBER Working Paper Series 29680.

Acharya, Viral V., Steffen, Sascha, 2020. The risk of being a fallen angel and the corporate dash for cash in the midst of COVID. Rev. Corp. Finance Stud. 9 (3), 430–471.

Aiken, David, Kiley, Michael, Lee, Seung Jung, Palumbo, Michael G, Warusawitharana, Missaka, 2017. Mapping heat in the U.S. financial system. J. Bank. Financ. 81, 36–64.

Allahkhata, Meraj, Cotina, Jill, Munyan, Benjamin, 2018. Do higher capital standards always reduce bank risk? The impact of the Basel leverage ratio on the U.S. triparty repo market. J. Financ. Intermediat. 34, 3–16.

Altvilla, Carlo, Barbiero, Francesca, Boucinha, Miguel, Burlon, Lorenzo, 2020. The Great Lockdown: Pandemic Response Policies and Bank Lending Conditions. ECB Working Paper Series 2465.

Anbil, Sireja, 2018. Managing stigma during a financial crisis. J. Financ. Econ. 130 (1), 166–181.

Aramonte, Sirio, Avilos, Fernando, 2020. The recent distress in corporate bond markets: Cues from ETFs. BIS Bull. 6 (14 April 2020).

Armanier, Olivier, Gyshels, Eric, Sarkar, Asani, Shadrar, Jeffrey, 2011. Discount Window Stigma during the 2007–2008 Financial Crisis. Federal Reserve Bank of New York Staff Reports 483.

Basel Committee on Banking Supervision (BCBS), 2017. Basel III: Finalising Post-Crisis Reforms. Bank for International Settlements, Basel, Switzerland, December 2017.

Bein, Markus, Haselmann, Rainer, Wachtl, Paul, 2016. Procylical capital regulation and lending. J. Finance 71 (2), 919–956.

Berger, Allen N., Black, Lamont K., Bouwman, Christa H.S., Dlugosz, Jennifer, 2017. Capital Regulation. Bank of England Staff Working Paper 63.

 Bolton, Patrick, Li, Ye, Wang, Neng, Yang, Jioping, 2021. Dynamic Banking and the Value of Deposits. NBER Working Paper Series 28298.

Borio, Claudio, 2020a. The Covid-19 economic crisis: Dangerously unique. Bus. Econ. 55, 181–190.

Borio, Claudio, 2020b. The prudential response to the Covid-19 crisis. In: Speech By Claudio Borio on the Occasion of the Bank’s Annual General Meeting in Basel on 30 June.

Boyarchenko, Nina, Kovner, Anna, Shachar, Or, 2020. It’s What You Say and What You Buy: A Holistic Evaluation of the Corporate Credit Facilities. CEPR Discussion Paper DP15432.

Brunnermeier, Markus K., 2009. Deciphering the liquidity and credit crunch 2007–2008. J. Econ. Perspect. 19 (1), 77–100.

Brunnermeier, Markus K., Pedersen, Lasse Heje, 2009. Market liquidity and funding liquidity. Rev. Financ. Stud. 22 (6), 2201–2238.

Carlson, Mark, Shan, Hui, Warusawitharana, Missaka, 2013. Capital ratios and bank lending: A matched bank approach. J. Financ. Intermediat. 22, 663–687.

De Nora, Giorgia, O’Brien, Eoin, O’Brien, Martin, 2020. Releasing the CCyB to Support the Economy in a Time of Stress. In: Financial Stability Notes, Vol. 2020 No. 1, Central Bank of Ireland.

Dertling, Lisa, Lambie-Hanson, Lauren, 2021. Why is the Default Rate So Low? How Economic Conditions and Public Policies Have Shaped Mortgage and Auto Delinquencies During the COVID-19 Pandemic. In: FDFS Notes, March 4.

Drehmann, Mathias, Farag, Marc, Tarashev, Nikolा, Tsatsaronis, Kostas, 2020. Buffering Covid-19 losses: The role of prudential policy. BIS Bull. 9 (24 April 2020).

Duffie, Darrell, 2020. Still the World’s Safe Haven? Redesigning the U.S. Treasury Market After the COVID-19 Crisis. Hutchins Center Working Paper 62.

Falato, Antonio, Iercosan, Diana, Zikes, Filip, 2019. Banks as Regulated Traders. Finance and Economics Discussion Series 2019–005, Board of Governors of the Federal Reserve System, Washington, http://dx.doi.org/10.17016/FEDS.2019.005r1.

Federal Reserve Board, 2020. Financial stability report, may.

Giese, Julia, Haldane, Andy, 2020. COVID-19 and the financial system: A tale of two crises. Oxford Rev. Econ. Policy 36 (SI), 200–214.

Glancy, David, Gross, Maxwell, Ionescu, Anamaria Felicia, 2020. How Did Banks Fund C&I Drawdowns at the Onset of the COVID-19 Crisis? In: FDFS Notes, Board of Governors of the Federal Reserve System, Washington, http://dx.doi.org/10.17016/2380-7172.2601.

Goldberg, Jonathan, 2020. Dealer Inventory Constraints during the COVID-19 Pandemic: Evidence from the Treasury Market and Broader Implications. In: FDFS Notes, Board of Governors of the Federal Reserve System, http://dx.doi.org/10.17016/2380-7172.2581.

Gorton, Gary, Metrick, Andrew, 2013. The federal reserve and panic prevention: The roles of financial regulation and lender of last resort. J. Econ. Perspect. 27 (4), 45–64.

Haddad, Valentin, Moreira, Alan, Mair, Tyler, 2021. When selling becomes viral: Disruptions in debt markets in the COVID-19 crisis and the Fed’s role. Rev. Financ. Stud. 34 (11), 5309–5351.

He, Zhiqiu, Nagel, Stefan, Song, Zhaogang, 2022. Treasury inconvenience yields during the COVID-19 crisis. J. Financ. Econ. 143 (1), 57–79.

Horvath, Akos, Kay, Benjamin, Wix, Carlo, 2021. The COVID-19 Shock and Consumer Credit: Evidence from Credit Card Data. Finance and Economics Discussion Series 2021–008, Board of Governors of the Federal Reserve System, Washington, http://dx.doi.org/10.17016/FEDS.2021.008.

Jordà, Òscar, 2005. Estimation and inference of impulse responses by local projections. Amer. Econ. Rev. 95 (1), 161–182.

Kaplan, Tamer, Minoiu, Camelia, 2021. Liquidity Insurance vs. Credit Provision: Evidence from the COVID-19 Crisis. Working Paper.

Kargar, Mahyar, Lester, Benjamin, Lindsay, David, Liu, Shuo, Weill, Pierre-Olivier, Zúñiga, Diego, 2021. Corporate bond liquidity during the COVID-19 crisis. Rev. Financ. Stud. 34 (11), 5352–5401.

Kositidis, Antonis, van Horen, Neeltje, 2018. Repo Market Functioning: The Role of Capital Regulation. Bank of England Staff Working Paper 746.

Lewrick, Ulf, Schmieder, Christian, Sobrun, Jhuvesh, Takáts, Előd, 2020. Releasing bank buffers to cushion the crisis a quantitative assessment. BIS Bull. 11 (5 May 2020).

Li, Lei, Strahan, Philip E., Zhang, Song, 2020. Banks as lenders of first resort: Evidence from the COVID-19 crisis. Rev. Corp. Finance Stud. 9 (3), 472–500.

Liang, J. Nellie, 2020. Corporate Bond Market Dysfunction During COVID-19 and Reverse Flight to Liquidity. Working Paper.

Lowe, Philip E., 2019. The Covid-19 crisis: An overview. In: FEDS Notes, Board of Governors of the Federal Reserve System, Washington, http://dx.doi.org/10.17016/2380-7172.2616.

Ma, Yiming, Xiao, Kairong, Zeng, Yao, 2020. Mutual Fund Liquidity Transformation and Reverse Flight to Liquidity. Working Paper.

Ma, Yiming, Xiao, Kairong, Zeng, Yao, 2020. Mutual Fund Liquidity Transformation and Reverse Flight to Liquidity. Working Paper.

O’Hara, Maureen, Zhou, Xing (Alex), 2021. Anatomy of a liquidity crisis: Corporate bond markets in the COVID-19 crisis. J. Financ. Econ. 143 (1), 57–79.

Peek, Joe, Rosengren, Eric S., 1997. The international transmission of financial shocks: The case of Japan. Amer. Econ. Rev. 87 (4), 495–505.

Repullo, Rafael, Suarez, Javier, 2013. The procyclical effects of bank capital regulation. Rev. Financ. Stud. 26 (2), 452–490.

Schrömpf, Andreas, Shin, Hyun Song, Sushko, Vladyslav, 2020. Leverage and margin spirals in fixed income markets during the Covid-19 crisis. BIS Bull. 2 (2 April 2020).

Svensson, Jean-Philippe, Vrbaski, Rastko, 2020. Banks’ dividends in Covid-19 times. FSI Briefs 6.

Vayanos, Dimitri, 2004. Flight to Quality, Flight to Liquidity, and the Pricing of Risk. NBER Working Paper 10327.