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Abstract

The widespread economic damage caused by the ongoing COVID-19 pandemic poses the first major test of the bank regulatory reforms put in place following the global financial crisis. This study assesses this framework, with an emphasis on capital and liquidity requirements. Leading up to the COVID-19 crisis, banks were well-capitalized and held ample liquid assets, reflecting in part heightened requirements. Capital requirements were comparable across major jurisdictions, despite differences in the implementation of the international Basel standards. The overall robust capital and liquidity levels resulted in a resilient banking system, which maintained lending through the early stages of the pandemic. Furthermore, trading activity was a source of strength for banks, reflecting in part a prudent regulatory approach. Areas for potential improvement include addressing the cyclicality of requirements.

1 – Introduction

Following the 2007-09 financial crisis, the Congress enacted the Dodd-Frank Act to reform the financial system and reduce the likelihood of a financial crisis. At the same time, U.S. regulators worked through the Basel Committee on Banking Supervision and the Financial Stability Board to coordinate international reforms to build a more resilient financial system. Through these efforts, U.S. regulators designed and implemented reforms to address the weaknesses identified during the financial crisis. The widespread economic damage caused by the ongoing COVID-19 pandemic provides the first major test of the post-crisis regulatory regime. This study assesses the domestic bank regulatory framework in light of the COVID-19 crisis, with an emphasis on capital and liquidity requirements.

We find that large, internationally active banks entered the crisis with robust capital positions. This enabled the banks to weather the initial shock, and continue to support economic activity. The capital positions reflect strong capital requirements globally. Indeed, one striking finding we obtain is that capital requirements for global systemically important banks (G-SIBs) heading into the crisis were generally comparable across major jurisdictions. This reflects the fact that while various jurisdictions have chosen to enhance capital requirements for internationally active banks in different ways, these enhancements add up to similar overall requirements.

We also find that jurisdictions that had activated the countercyclical capital buffer (CCyB) lowered it quickly at the onset of the crisis. However, the overall level of the CCyB was zero in many jurisdictions and less than 1% in most others, reducing the benefit from releasing the capital buffer. While the COVID-19 crisis occurred following a period of steady expansion globally, the relatively low level of the CCyB reflects its link to financial imbalances rather than the economic cycle. In addition, most jurisdictions also released statements encouraging banks to dip into their capital conservation buffers (CCB). However, this appears to have little effect as banks were reluctant to lower their capital ratios into their buffers, possibly due to concerns about an adverse market reaction. This suggests a gap in how the capital buffers work in practice and how regulators intend them to perform.

Focusing our attention on large domestic firms, we next examine the procyclicality of capital requirements, as such procyclicality can hamper lending in economic downturns. We find that while these firms exhibited significant balance sheet growth in the early stage of the pandemic, required capital levels rose less. This reflects the fact that much of the asset growth came from drawdowns of existing lines of credit, essentially transforming an off-balance sheet commitment into an on-balance sheet asset. As the regulatory framework already accounts for such commitments, the impact of this on overall requirements was muted. That said, we found that risk-weighted assets for certain categories, namely market risk and the credit valuation adjustment (CVA) rose noticeably, reflecting the risk-sensitivity of these requirements.

Examining recent changes in the liquidity positions of large bank holding companies in the United States, we find that firms entered the crisis with solid liquidity positions—both in terms of their high quality liquid asset (HQLA) holdings and their liquidity coverage ratios (LCR). We find that the liquidity of firms further increased in the early days of the crisis, which was driven by the rapid growth of excess reserves. Additionally, banks experienced sizeable inflows of deposits, which provided a source of low-cost funding. Notably, the increase in already strong liquidity positions suggests that firms prefer larger liquid asset buffers in the face of economic and market uncertainty.

We next investigate how firm liquidity positions were affected by the liquidity facilities implemented to help the functioning of financial markets and support the flow of credit to businesses and households We find that while some facilities helped firms maintain liquidity positions, other facilities had no significant effect on balance sheet liquidity measures. Specifically, we find that using the Primary Dealer Credit Facility was associated with increases in both HQLA and the LCR; borrowing from the discount window increased HQLA, but not the LCR; and using the Money Market Liquidity Facility had no detectable effect on either liquidity measures. Our results suggest that some Federal Reserve liquidity facilities contributed to the increase in firms' already strong liquidity positions.

One natural question is whether these strong capital and liquidity positions enabled firms to continue to support economic activity. We find that banks continued to lend through the crisis, albeit with much of the loans reflecting drawdowns of existing commitments by corporate borrowers rather than new lending per se. Many large corporations drew down their existing lines of credit for precautionary purposes. Furthermore, the paycheck protection program also supported lending during this period. In contrast to the growth in corporate credit, consumer lending has been weak this year. In addition, we show that overall credit growth this year is unrelated to banks' capital, suggesting that there has 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 rapidly changing information about the nature of the pandemic. During March, 2020, dislocations appeared in financial markets, as firms withdrew from market making activity, especially in the U.S. Treasury market. This resulted in some leveraged investors closing out their positions, increasing the risk of fire sales. As volatility picked up and margins 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, helping calm markets. The elevated trading activity in the early stages of the crisis led to an increase in fees, commissions and bid-ask spreads, sustaining the profitability of large banks. In addition, firms also issued corporate bonds and equity at a rapid pace to bolster their balance sheets, leading to increases in underwriting fees. Reflecting in part the limitations on proprietary trading put in place following the financial crisis, no major bank suffered sizeable losses on their portfolios. As such, trading activity strengthened firms during this period.

Finally, we assess the performance of large banks in financial markets during this period. Overall, we find that the performance of large banks lagged that of broader markets. Comparing the performance of large banks in the financial crisis and over the COVID-19 pandemic, we find that the CAPM betas of banks were significantly elevated in the financial crisis, but less so during the COVID-19 pandemic. This indicates that the value of banks did not co-move with the overall market in a strong way during the latter period. Moreover, we find that credit default swap (CDS) spreads rose less over the pandemic period than over the financial crisis, indicating that market participants were not unduly worried about the safety and soundness of large banks. One slightly puzzling finding is that changes in CDS spreads appear unrelated to bank capital ratios, either regulatory or market-based.

Our study is part of a rapidly growing literature that identifies lessons learned from the ongoing COVID-19 crisis. Consistent with these studies we find that the post-crisis framework performed well in this crisis. Specifically, our key finding is that banks entered into the crisis with strong capital and liquidity levels, and this enabled them to support economic activity by lending to firms and intermediating financial markets. That said, we identify some targeted areas of the regulatory framework that can potentially benefit from further study and refinement, including the usage of countercyclical capital buffers and firms' apparently reluctance to draw down their capital conservation buffers.

The remainder of this study is organized as follows. Section 2 reviews the existing literature on the role of banking regulation during the COVID-19 pandemic. Section 3 presents our findings of capital requirements and levels across major jurisdictions. Section 4 investigates liquidity positions at domestic banks and how they were affected by usage of Federal Reserve facilities. Section 5 examines lending and trading activity at major banks during this period. Section 6 presents evidence from financial markets and Section 7 concludes.

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 financial crisis have put banks in a strong position to absorb potential losses following the COVID-19 shock. Lewrick et al. (2020) report that banks globally held \$5.1 trillion of capital above their regulatory requirements in aggregate, and were therefore substantially better capitalized than in the years leading up to the financial crisis. Blank et al. (2020) report that the aggregate CET1 ratio of U.S. banks increased from 5.8 percent in the first quarter of 2009 to 11.7 percent in the fourth quarter of 2019, implying a robust capitalization prior to the COVID-19 shock. Specifically investigating the draw-down of outstanding credit line commitments, Acharya and Steffen (2020) conclude that U.S. banks were adequately capitalized due to the successful implementation of the post-crisis reforms. Similarly, Li, Strahan, and Zhang (2020) find that strong capital positions contributed to the ability of banks to accommodate the large increase in corporate liquidity demands. Thus, there is a broad consensus that the regulatory capital framework, and especially the more stringent capital requirements, contributed to the safety and soundness of the financial system during the pandemic so far. However, some features of the regulatory framework have drawn criticism in the light of the COVID-19 crisis.

First, heightened capital requirements may have had an adverse effect on banks' market-making activities and therefore on market liquidity in the Treasury and corporate bond markets. Various studies document disruptions in the U.S. Treasury market in March 2020. Global investors started selling off Treasuries to obtain cash in mid-March, which increased the inventories and thus the balance sheets of dealer banks. The unusually high trading volumes temporarily overwhelmed the capacity of dealers to intermediate the Treasury market (see Duffie 2020; Federal Reserve Board 2020; Schrimpf, Shin, and Sushko, 2020). Similarly, amidst selling pressures in the corporate bond market in mid-March, dealers may have been reluctant to accumulate inventory to avoid falling below regulatory capital requirements (see Aramonte and Avalos, 2020; Kargar et al., 2020; O'Hara and Zhou, 2020). To ease these market pressures, the Federal Reserve intervened in the corporate bond market by introducing the Primary Dealer Credit Facility (PDCF) on March 17 and the Primary and Secondary Market Corporate Credit Facilities (PMCCF and SMCCF) on March 23. On April 9, these programs were expanded in size and scope to include the purchases of eligible corporate bond portfolios in the form of ETFs with exposure to U.S. high-yield corporate bonds. Several studies document that liquidity in the corporate bond market improved significantly following these interventions (Boyarchenko, Kovner, Shachar, 2020; Haddad, Moreira, and Muir, 2020; Kargar et al., 2020).

Second, the COVID-19 economic crisis has highlighted issues related to the pro-cyclicality of capital regulation. The pro-cyclicality of the Basel III capital framework has been discussed well before the current crisis. Repullo and Suarez (2012) show theoretically and Behn, Haselmann, and Wachtel (2016) document empirically that linking capital charges to asset risk increases capital requirements during economic downturns, which has a pro-cyclical effect on bank lending. The main regulatory instrument to address such pro-cyclicality is the countercyclical capital buffer (CCyB), which aims to ensure that banks build up capital during economic expansions, which can then be released during downturns when losses materialize. Indeed, 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.[2] However, in the United States, the CCyB had never been activated in the pre-COVID period and hence this macroprudential tool was not available to U.S. regulators. Instead, the Federal Reserve resorted to a number of emergency rulemakings which aimed to reduce bank capital requirements (such as e.g. the temporary relaxation of the SLR requirements), as documented in Blank et al. (2020). These regulatory interventions helped inject greater countercyclicality into the current regulatory framework. Blank et al. (2020) therefore argue that the CCyB should always be turned on by default in good times, so that U.S. policymakers have room to cut capital requirements in a sharp downturn. Thus, the COVID-19

[2] See, for example, De Nora, O'Brien, O'Brien (2020) for an account of the Bank of Ireland's rational to lower the countercyclical capital buffer.

crisis revealed that the U.S. regulatory capital framework can benefit from increased countercyclicality.

Finally, there has been a discussion on banks' ability and willingness to use their regulatory capital buffers and the role of payout restrictions. Under the current framework, banks that dip into their capital conservation buffers face regulatory restrictions on dividend payouts, share buybacks, and executive bonuses. Banks might thus be reluctant to use their capital buffers as it negatively affects their shareholders. In fact, U.S. banks with smaller capital buffers extended relatively less credit in 2020 (Berrospide et al., 2020). To avoid the stigma associated with an individual bank 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). Svoronos and Vrbaski (2020) document that many regulatory authorities worldwide had imposed some form of payout restrictions by May 2020, such as the European Central Bank or the Bank of England, which helped to increase banks' usable capital buffers (Altavilla et al., 2020). The United States, however, had not yet enacted any restrictive measures by that time. Blank et al. (2020) criticized this "watchful waiting" approach and recommended that U.S. regulators should require all U.S. banks to suspend both common dividends and share repurchases. Following its annual stress test, the Federal Reserve followed suit and required big banks to suspend share buybacks and limit dividend payments.

3 – Capital Requirements and Capital Levels

3.1 – Capital Requirements and Capital Levels at the Onset of the COVID-19 Pandemic

The Basel III regulatory reforms introduced since the 2007-09 financial crisis significantly increased capital requirements in order to enhance banks' resilience to adverse economic shocks. Against this background, the economic fallout caused by the ongoing COVID-19 pandemic provides the first major test for the post-crisis regulatory framework. While Basel III provides a consistent global capital framework, it still allows for national discretion across jurisdictions in the implementation of the standards. In this section, we focus on Common Equity Tier 1 (CET1) capital as the core measure of banks' capitalization and study regulatory capital requirements and banks' reported capital ratios in the United States and Europe at the onset of the pandemic. The analysis sheds light on the resilience of banks and on the comparability of requirements across jurisdictions.

3.1.1 – Common Equity Tier 1 Capital Requirements

Panel A of Table 1 reports the individual components of the CET1 capital requirement as of the fourth quarter of 2019 for 8 U.S. and 13 European global systemically important banks (GSIBs), as well as for 29 U.S. and 14 European non-GSIB banks subject to the annual Federal Reserve stress test and the Supervisory Review and Evaluation Process (SREP), respectively. Basel III requires all banks to hold at least 4.5 percent of CET1 capital relative to risk-weighted assets (RWA), an additional 2.5 percent capital conservation buffer (CCB) above the regulatory minimum, as well as additional requirements based on the systemic risk profile of a bank. These requirements pertain to all internationally active banks in Basel jurisdictions. There are, however, a number of differences in the implementation of CET1 requirements between the U.S. and Europe with regard to: (i) the role of stress test requirements, (ii) the additional requirements for GSIBs and domestic systemically important banks (DSIBs), and (iii) the implementation of the countercyclical capital buffer (CCyB).

First, both U.S. and European regulators conduct annual bank stress tests, which imply additional capital charges for the tested banks. In the United States, this "Stress Capital Buffer" (SCB) replaces the CCB for banks with an SCB above 2.5 percent, while in Europe the corresponding SREP Pillar 2 requirement is added on top of the CCB for all banks. This incremental SCB (above the CCB) in the U.S. implies on average an additional 1.1 percent requirement for GSIB banks and a 0.5 percent requirement for non-GSIB banks.[3] In Europe, the SREP buffer implies on average an additional 1.9 percent requirement for GSIB banks and a 1.8 percent requirement for Non-GSIB banks.

Second, the regulatory frameworks in the U.S. and Europe differ with regard to the calculation method for the GSIB surcharge. European GSIB banks are subject to the GSIB surcharge as determined by the Financial Stability Board (Method 1 surcharge).[4] In contrast, U.S. GSIB banks are subject to an additional GSIB surcharge methodology, which accounts for a bank's level of short-term wholesale funding (Method 2 surcharge), and must comply with the higher of the two surcharges. As of the fourth quarter of 2019, this Method 2 GSIB surcharge on average yields an additional 0.9 percent requirement on top of the average 1.9 percent Method 1 requirement for U.S. GSIB banks. While GSIB surcharges are therefore generally higher in the U.S., many large European non-GSIB banks are subject to a DSIB capital surcharge that does not exist in the U.S; this yields an additional 1.1 percent CET1 requirement for European non-GSIB banks. Finally, at the end of 2019 some European countries had already activated the countercyclical capital buffer, which on average contributes an additional 0.2 percent requirement for European banks.[5] The last row of Panel A shows that, despite these differences in the implementation, U.S. and European GSIB banks were subject to comparable overall CET1 requirements at the onset of the COVID-19 pandemic, reflecting the fact that different jurisdictions have chosen to enhance different aspects of the international capital standards. Requirements for GSIB banks in the U.S. were slightly higher due to the use of the additional Method 2 GSIB surcharge methodology. For large non-GSIB banks, overall CET1 requirements were substantially

[3] The SCB requirement above was calculated using data from the 2019 stress tests. The SCB itself will come into effect in Q4 2020.

[4] The FSB methodology uses a methodology developed by the Basel Committee for Banking Supervision that weighs banks' scores on twelve high-level indicators chosen for their contribution to financial stability. Banks indicator-level scores are used to come up with a composite score that is used to determine whether a bank is considered globally significant and if so the capital surcharge.

[5] In Section 3.3, we provide a detailed discussion of the CCyB at the onset of the COVID-19 pandemic.

higher in Europe, mainly due to higher stress test requirements and the existence of an additional DSIB surcharge.

Table 1: Capital Requirements and Capital Levels on the Onset of the COVID-19 Pandemic

In Percent (as of 2019q4)	U.S. GSIB Average	European GSIB Average	U.S. Non-GSIBs Average	EU Non-GSIB Average
Number of Banks	8	13	29	14
Panel A. CET1 Capital Requirements.				
Minimum CET1 Requirement	4.5	4.5	4.5	4.5
Capital Conservation Buffer (CCB)	2.5	2.5	2.5	2.5
Incremental Stress Capital Buffer (SCB)	1.1		0.5	
SREP Pillar 2 Requirement		1.9		1.8
Method 1 G-SIB Surcharge	1.8	1.3		
Incremental Method 2 GSIB Surcharge	0.9			
DSIB Surcharge				1.1
Countercyclical Buffer (CCYB)	0.0	0.2	0.0	0.2
Overall CET 1 Requirement	**10.8**	**10.4**	**7.5**	**10.1**
Panel B. Reported Capital Ratios.				
CET1 Capital Ratio (AA)	12.6	13.6	10.1	14.4
CET1 Capital Ratio (GA)	12.1		10.0	
T1 Capital Ratio	13.8	15.6	11.4	15.6
T1 Leverage Ratio*	7.9	5.1	9.2	5.5
Panel C. RWA Density.				
Risk-Weighted Assets / Total Assets	57.7	32.5	80.8	35.4

Sources: Regulatory reports and Annual reports, Pillar 3 Disclosures and CCAR 2020 Stress Test Results

3.1.2 – Reported Capital Ratios

Panel B of Table 1 reports the average capital ratios of banks as of the fourth quarter of 2019. In the United States, large banks are required to calculate their risk-weighted assets under both the Advanced Approaches (AA) capital framework, which uses an internal ratings-based (IRB) approach, and under the Generally Applicable (GA) capital framework, which uses the standardized approach for U.S. banks to calculate risk-weighted assets. According to the Collins amendment of the Dodd-Frank act, U.S. banks must apply whichever approach yields the higher amount of risk-weighted assets (RWA) in the calculation of their risk-based capital ratios. In contrast, European banks only need to apply risk-based capital ratios as calculated under the IRB approach. This implies that, for a given portfolio, European banks may have a lower risk-weighted assets measure than US banks. The effect of this can be seen in Panel C, which reports that risk-weighted assets of U.S. banks are substantially higher relative to accounting total assets than for European banks.

Reflecting the more stringent measurement of risk-weighted assets, U.S. banks report lower risk-based CET1 capital ratios compared to their European counterparts. The average AA CET1 ratio of U.S. GSIB banks is 12.6 percent, compared to 13.6 for European GSIB banks, and the average AA CET1 ratio of U.S. non-GSIB banks is 10.1 percent, compared to 14.4 for European non-GSIB banks. Thus, in terms of their risk-based capital ratios European banks appear to be better capitalized at the onset of the pandemic. In contrast, however, U.S. banks report higher non-risk-based tier1 leverage ratios.

Overall, the results indicate that large banks in both the United States and Europe entered the ongoing COVID-19 economic crisis with robust capital levels, which are substantially higher than the capital levels at the onset of the 2007-09 financial crisis (see also Blank, Stein, Hanson, and Sunderam, 2020). These robust capital levels helped ensure that systemically important banks were resilient in the initial phase of the COVID-19 shock.

3.2 – Procyclicality of Capital Requirements

There is a long-standing view that capital regulation should be countercyclical. Ideally, banks build up capital during economic expansions, which they can then release during downturns when losses materialize. However, risk-based capital regulation faces an inherent trade-off between risk-sensitivity and pro-cyclicality (see e.g. Repullo and Suarez, 2012; Behn, Haselmann, and Wachtel, 2016). Since asset risk increases during economic downturns, risk-based capital ratios decrease and banks are brought closer to their regulatory minimum requirements. Thus, banks might have an incentive to deleverage and constrain lending when it is most needed. In this section, we analyze changes in asset exposure measures through the COVID-19 crisis to examine the extent of pro-cyclicality in the regulatory framework.

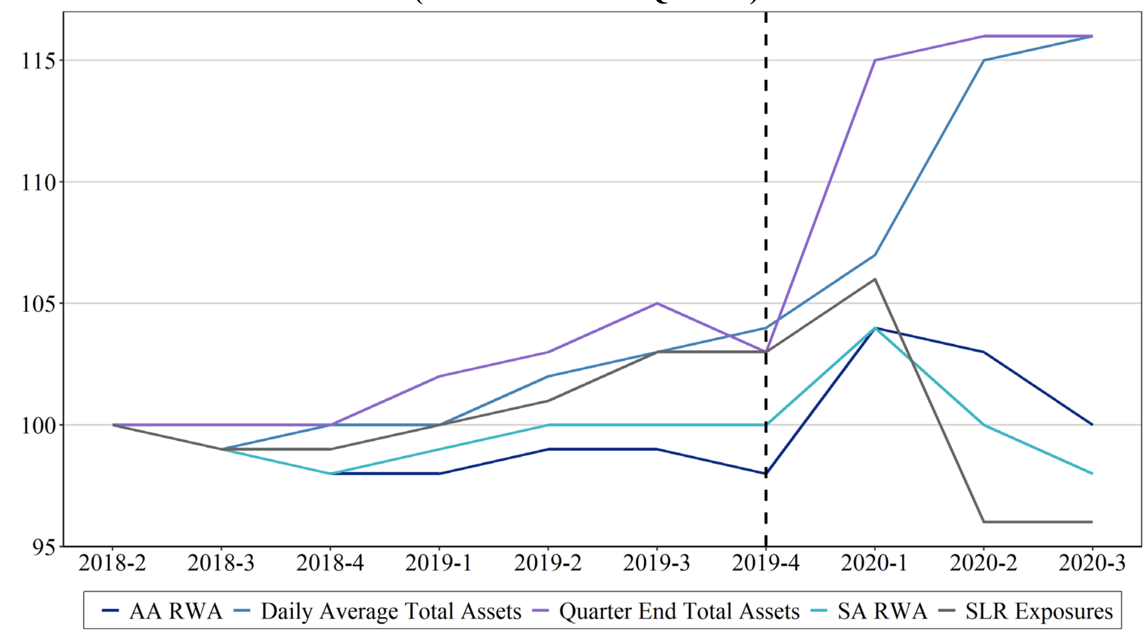
We begin by documenting changes in balance sheet measures of assets and risk. Figure 1 shows the set of asset exposure measures that are currently used in the calculation of regulatory capital ratios for large U.S. banking firms, indexed to 100 as of the beginning of the sample period in Q2 2018.[6,7] Exposure measures based on both risk-weighted assets and total assets increased materially in the first quarter of 2020, at a higher growth rate than in all other recent quarters. Quarter end total assets had the highest growth rate—at almost 12 percent—while total exposures, which include off-balance sheet items and are used to measure the supplementary leverage ratio (SLR), increased by a comparatively modest 2 percent. In the second quarter of 2020 total assets continued to grow at a more modest rate, while risk-based assets and total exposures declined. The

[6] Defined as the 11 firms supervised by the Large Institution Supervision Coordinating Committee (LISCC). This sample includes each of the firms deemed as globally systemically important by the Bank for International Settlements along with the U.S. operations of Barclays, Deutsche Bank, and Credit Suisse.

[7] The historical analysis covers eight quarters of data because of intermediate holding company data availability. These firms finalized their new structures and reporting starting in the second quarter of 2018.

material decline of second quarter total exposures is, in part, due to the temporary exclusion of U.S. Treasury securities and deposits at Federal Reserve Banks from the measure.[8] Large banks reported around $2.1 trillion in these deductions and, in the absence of this temporary exclusion, leverage exposures would have risen by about $0.7 trillion. Balance sheet measures of assets and risk were little changed in the third quarter of 2020.

Figure 1: Regulatory Capital Denominator Comparison, Aggregate of Large Firms (Indexed to 100 in Q2 2018)



Sources: FFIEC 101 and FR Y9C
Notes: AA RWA = Advanced Approaches Risk-Weighted Assets. SA RWA = Standardized Approach Risk-Weighted Assets.

Table 2 below summarizes the differences in the calculation of these exposure measures, which explains their divergent growth rates in the first quarter of 2020. Leverage exposures grow far less than total assets, primarily as the large asset growth in the first quarter came largely from drawdowns of off-balance sheet commercial lines of credit (Acharya and Steffen, 2020). This shift from off- to on-balance sheet amounts increased total and risk-weighted assets, but left total exposures unaffected as it already accounts for off-balance sheet commitments. Furthermore, since the growth of bank balance sheets did not accelerate until the middle of March, daily average assets, which is used in the denominator of the leverage ratio, grew far less than quarter end assets. The two asset measures should ultimately catch up to each other. These results indicate that the treatment of off-balance sheet commitments in the SLR and the daily averaging of assets in the leverage ratio helped mitigate pro-cyclicality.

[8] 85 FR 32980

Table 2: Exposure Measure Calculation Comparison by Q1 2020 Percent Growth

Exposure measure	Q1 2020 growth	Applicable regulatory capital requirements	Daily averages	Includes OBS	Risk-based
Quarter end total assets	+11.5%	None			
AA risk-weighted assets	+5.9%	AA risk-weighted ratios			
SA risk-weighted assets	+4.4%	SA risk-weighted ratios			
Daily average total assets	+3.4%	Leverage ratio			
Total exposures	+2.7%	Supplementary leverage ratio			

Note: Grey shading indicates that the exposure measure uses the methodology indicated. OBS denotes off-balance sheet items.

Turning to risk-weighted assets, we find that the two (quarter-end) risk-based asset exposure measures (AA and SA risk-weighted assets) grow less than quarter-end total assets. In part, this reflects the fact that the risk-based measures apply some—but not full—weight to off-balance sheet exposures, whereas the SLR exposure applies full weight and total assets apply no weight. In addition, while credit quality deteriorated—and is reflected in higher risk exposure for some loans—bank balance sheets shifted towards lower risk assets overall, in particular cash and sovereign exposures.[9]

The banks in this sample are subject to two different risk-based asset measures. The standardized approach (SA) measure assesses risk in a relatively static way driven by the characteristics of the exposure at the time of origination. In contrast, the advanced approaches (AA) measure relies heavily on models that may capture fluctuations in risk related to the business cycle. The slightly larger increase in the AA exposure measure as compared to the SA measure suggests that the model-based capital regulation is—as expected—slightly more pro-cyclical.

Decomposition of exposures by risk type helps shed additional light on divergences in the measurements. Table 3 shows exposures broken down by the major types of risk they capture: credit risk, market risk, credit valuation adjustments (CVA), and operational risk. In the first quarter of 2020, large banks reported material increases in market risk and CVA. The risk-based market risk measures increased by over 20 percent, while their underlying exposure of trading assets only increased by 11.8 percent. Since market risk RWA are partially based on Value-at-Risk (VaR) models, the pro-cyclical increase in RWA reflects increased market volatility.[10] To avoid additional capital procyclicality owed to increased market risk capital, banking regulators offered temporary capital relief and allowed banks to cap their back-testing multiplier to the year end 2019

[9] For example, sovereign and bank exposures increased by 24% and 19% respectively in Q1 2020, while having low average risk weights (5% and 28% as of Q4 2019).

[10] The market risk capital of a bank is adjusted to reflect the bank's VaR model performance to ensure that the bank is not undercapitalized for the inventory risk it holds. This is achieved by scaling the VaR and stressed VaR capital by a multiplier determined by the number of backtesting exceptions— the number of business days for which the daily net trading loss, if any, exceeds the corresponding daily VaR—that occurred over the preceding year. In times of high market volatility, such as during the March COVID 19 market shock, banks experience an excess of backtesting exceptions, since VaR models are mostly calibrated to history and are slow to respond to a regime shift.

value.[11] Similarly, CVA increased by over 50 percent since they are measured through a VaR model of counterparty credit spreads, which had high volatility during the pandemic period. Thus, market volatility during the COVID-19 shock drove increases in each of these risk measures. Credit and operational risk were considerably less volatile. Credit risk-weighted assets increased by 3.2 percent and 5.2 percent under the SA and AA frameworks, respectively, and operational risk decreased by only 0.3 percent.

Table 3: Q4 2019 to Q1 2020 Asset Growth by Risk Stripe, Aggregate LISCC Firms (percent)

	Risk-Weighted Assets		Quarter End Assets
	SA	AA	
Credit	3.2%	5.2%	12.0%
Market	23.0%	26.4%	11.8%*
CVA		50.1%	
Operational		-0.3%	
Total	**4.4%**	**5.9%**	**11.5%**

Sources: FFIEC 101 and FR Y9C
*Trading assets

Overall, our analysis indicates that the current regulatory framework entails a modest degree of pro-cyclicality during the COVID-19 crisis. While certain elements, such as market RWA and CVA, saw material increases due to heightened market volatility, model-based RWA increased overall only slightly more than standardized RWA. The most pronounced aggregate volatility occurred in the non-risk-based measure of total assets, which increased in Q1 due to credit line drawdowns.

3.3 – Changes in the Countercyclical Capital Buffer in Response to COVD-19

The main regulatory instrument to curb the pro-cyclicality of the risk-based capital framework is the countercyclical capital buffer (CCyB), which regulators can increase as financial vulnerabilities rise and reduce during downturns. This section studies how regulators across major jurisdictions utilized the CCyB in response to the COVID-19 shock.

Before the outbreak of the pandemic, there were fifteen jurisdictions worldwide, which had either already activated a non-zero CCyB or had announced an activation of the buffer within the next 12 months (Edge and Liang, 2020). Table 4 tracks the changes in CCyB regulation across these fifteen jurisdictions in response to the COVID-19 shock. The first two columns in Table 4 list the effective CCyB rates for these fifteen jurisdictions as of March 1, 2020 and the dates when these rates became effective. Within these jurisdictions, there was substantial variation in the levels of the CCyB, ranging from 0.25 percent in France to 2.5 percent in Sweden. The next two columns show the scheduled increases in the CCyB, before these plans were revoked in the wake of the

[11] See https://www.occ.gov/topics/supervision-and-examination/capital/market-risk-faq.pdf.

COVID-19 shock. The final column reports the prevailing CCyB rates after the COVID-19 induced policy responses. Beyond these fifteen jurisdictions, there were 60 jurisdictions—including the United States—with a CCyB framework in place, which had however not activated the buffer as of end of 2019.

In response to the COVID-19 shock, in March and early April, thirteen out of these fifteen jurisdictions with an active CCyB either reduced the buffer requirement to zero or revoked plans to increase the buffer. As of July 2020, only Luxembourg has not taken any action in reducing its CCyB, while five other jurisdictions (Bulgaria, Czech Republic, Hong Kong, Norway, and Slovakia) had made downward adjustments while retaining a positive CCyB. The remaining nine jurisdictions all have set CCyB to zero. These reductions in the CCyB provided immediate capital relief for banks in those jurisdictions.

More broadly, the analysis indicates that the ability to provide capital relief was limited by the fact that most jurisdictions, including several with large banking systems, had not activated the CCyB. This may be due to the emphasis of the Basel CCyB standard on the role of financial vulnerabilities, and the credit-to-GDP gap in particular (see Borio and Lowe, 2002). These findings indicate that incorporating broader measures of real economic activity into setting the CCyB may help ensure that it can play a more active role in combating future downturns.

Table 4: Countercyclical Capital Buffer (CCyB) Changes across Jurisdictions

Country	Effective CCyB rate before March 1st (percent)	Effective since	Future planned CCyB rate before COVID (percent)	Planned effective date	Post-COVID CCyB rate
Belgium	0.00	Jan-2016	0.50	Jul-2020	0.00
Bulgaria	0.50	Oct-2019	1.00	Apr-2020	0.50
			1.50	Jan-2021	
Czech Republic	1.75	Jan-2020	2.00	Jul-2020	0.50
Denmark	1.00	Sep-2019	1.50	Jun-2020	0.00
			2.00	Dec-2020	
France	0.25	Jul-2019	0.50	Apr-2020	0.00
Germany	0.00	Jan-2016	0.25	Jul-2020	0.00
Hong Kong	2.00	Oct-2019			1.00
Iceland	2.00	Feb-2020			0.00
Ireland	1.00	Jul-2019			0.00
Lithuania	1.00	Jun-2019			0.00
Luxembourg	0.25	Jan-2020	0.50	Jan-2021	No Change
Norway	2.50	Dec-2019			1.00
Slovakia	1.50	Aug-2019	2.00	Aug-2020	1.00
Sweden	2.50	Sep-2019			0.00
United Kingdom	1.00	Oct-2019	2.00	Dec-2020	0.00

Note: All data as of July 20, 2020. Switzerland has implemented a sectoral CCyB on residential mortgages, which has been set at 2 percent since January 2014. Source: BIS, ESRB, Hong Kong Monetary Authority, FRB IF report on March 11th and updated by FRB S&R

3.4 – Usability of Capital Buffers

The post-crisis regulatory regime involves a number of capital buffers that are intended to allow banks to build up capital in good times and draw it down in bad times. These buffers include the capital conservation buffer, the G-SIB surcharge and the stress capital buffer. The regulatory consequences of firms dipping into their buffers consists of limits to payouts by banks and discretionary bonuses to executives. One feature of the ongoing economic crisis is that large banks, both domestic and foreign, have shown considerable reluctance to lower their capital levels below these buffers, in spite of repeated encouragement by regulators to do so (Berrospide et al., 2020). For example, on March 17, 2020 The Board of Governors of the Federal Reserve System, Federal Deposit Insurance Corporation, and Office of the Comptroller of the Currency issued a joint statement that supported the usage of capital buffers to lend in a safe and sound manner.[12] Furthermore, the agencies also amended the way the buffer restrictions apply to help facilitate their use.[13]

As-of Q3 2020, no large banks have dipped into their capital buffers. In aggregate, these firms have materially more excess capital[14] in Q3 2020 ($288 billion) than they did in Q4 2019 ($211 billion). 30 out of 34 of these firms have a greater capital cushion now than they did pre-COVID-19 crisis. These conclusions hold if supplementary leverage ratio (SLR) relief is included or excluded from the analysis.[15]

The apparent lack of willingness of banks to utilize their capital and dip into their buffers indicates that the broad goal of capital buffers is not functioning as intended. One potential reason for this is that banks may be quite concerned about the response of investors and other market participants to their capital level falling below their buffer requirement, reflecting the vulnerability of banks to changes in investor sentiment (see He and Xiong, 2012). The reluctance of banks to use their capital buffers suggests that refinement of this aspect of the post-crisis regulatory regime may be warranted.

4 – Liquidity Positions and Federal Reserve Facilities

In March 2020, concerned by the onset of the COVID-19 pandemic, market participants fled 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 a liquidity squeeze on some firms and raised concerns about their ability to intermediate on financial markets. The Federal Reserve took prompt action to alleviate the liquidity stress on financial markets resulting from the onset of the pandemic and promote the flow of credit to businesses and households.

The Federal Reserve conducted large-scale open market operations, enhanced central bank liquidity swap lines, and modified or established lending and liquidity facilities. Notably, Duffie (2020) argues that the large-scale purchases of U.S. Treasury securities did not effectively alleviate dealer balance sheet constraints because these actions merely swapped U.S. Treasury securities for central bank reserves. On April 1, the Federal Reserve temporarily excluded both U.S. Treasury securities and reserves from the SLR denominator, which Duffie (2020) notes may have eased the stress on the U.S. Treasury market.

In this section, we examine the liquidity positions of large banks leading up to these events. We conduct an empirical analysis of the changes in liquidity positions of large bank holding

[12] Board of Governors of the Federal Reserve System (2020) *Statement on the Use of Capital and Liquidity Buffers*

[13] 85 FR 15909

[14] Calculated as capital holdings minus required capital. The most binding ratio of each reference bank is used in the aggregate calculation.

[15] In the absence of SLR relief, Q3 2020 excess capital would have been $282 billion.

companies in the United States due to Federal Reserve liquidity facilities. In particular, we examine how borrowings from the discount window (DW) lending facility, 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 LCR of large bank holding companies.[16] Since borrowing from these facilities and reducing reserve requirements to zero could potentially affect both HQLA holdings and short-term cash flows, the direction and strength of their influence on the LCR is not immediately apparent, warranting deeper investigation.

4.1 – Overview of Selected Federal Reserve Facilities

The DW 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 firms 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.[17] 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 bank holding companies in our sample. Importantly, DW primary credit was traditionally overnight, but the facility was expanded on March 15, 2020, when the Federal Reserve allowed depository institutions to borrow for maturities 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.[18] 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.[19] 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.[20]

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[16] In line with the Basel III international standards, the LCR measures the short-term resilience and liquidity risk of a firm by comparing its unencumbered HQLA holdings to its liquidity needs in a thirty-day liquidity stress scenario.

[17] On the economic stabilization role of the Federal Reserve's discount window, see Gorton and Metrick (2013).

[18] Primary dealers are firms that function as counterparties of the Federal Reserve Bank of New York in its implementation of Federal Reserve monetary policy. See the term sheet of the PDCF for additional information.

[19] For a detailed analysis of the investor run on money market mutual funds in March 2020, see Li et al. (2020).

[20] Eligible financial institutions that can borrow from the MMLF include all U.S. depository institutions, U.S. bank holding companies (parent companies incorporated in the United States or their U.S. broker-dealer subsidiaries), or U.S. branches and agencies of foreign banks. See the term sheet of the MMLF for additional information.

4.2 – Data Description and Summary of Changes in Firm Balance Sheet Liquidity

The analysis utilizes high-frequency public and confidential information collected by the Federal Reserve.[21] Using FR 2052a data, we calculate the liquidity coverage ratio, defined as

$$\mathrm{LCR}_{\mathrm{i,t}}(\%) = \frac{\mathrm{HQLA}_{\mathrm{i,t}}}{(\mathrm{NOF\ over\ 30\ days})_{\mathrm{i,t}}} \times 100 \tag{1}$$

for firm i on day t, where HQLA and NOF stand for high-quality liquid assets and net outflows, defined in Part 249 of the Code of Federal Regulations. As per the applicable liquidity regulations, the largest U.S. domestic bank holding companies and intermediate holding companies of foreign banking organizations are expected to maintain their LCR above 100% on any given day.

Balancing the objectives of the analysis with data limitations, we focus on bank holding companies that are required to comply with and report their LCR at a daily frequency. This way, we conduct our empirical analysis using high-frequency reporting information on the largest, systemically important banking organizations in the United States, which together held about two-thirds of total assets and about three-quarters of HQLA in the entire banking sector as of the fourth quarter of 2019. Throughout the analysis, we use assets and liabilities consolidated at the holding company level.[22]

In Figure 2, we summarize the changes in the balance sheet liquidity of large bank holding companies in the United States at the onset of the COVID-19 outbreak. Panel A shows that, from a liquidity requirement perspective, large bank holding companies 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 holding companies had further improved and stabilized around 130%.

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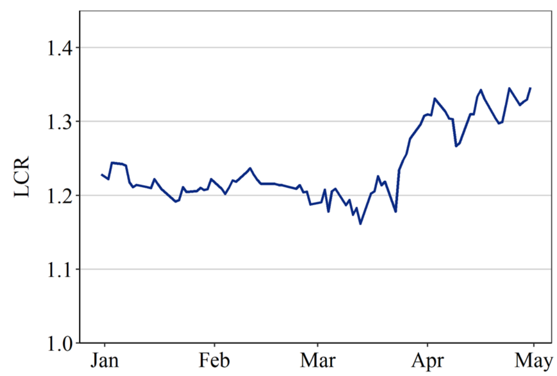
[21] We use the following publicly available datasets in our analysis: Federal Reserve data publications H.3 (Aggregate Reserves of Depository Institutions and the Monetary Base), H.4.1 (Factors Affecting Reserve Balances), and H.6 (Money Stock Measures), which contain aggregate weekly data on firm reserve balances, discount window and emergency liquidity facility borrowings, and deposits, respectively. We use confidential, daily data at the firm level on reserve balances, discount window and emergency liquidity facility borrowings, unsecured borrowing reported on the FR 2420, and deposits reported on the FR 2900. We also use confidential, daily data at the firm level from the FR 2052a report on HQLA and the thirty-day net cash outflows.

[22] 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.

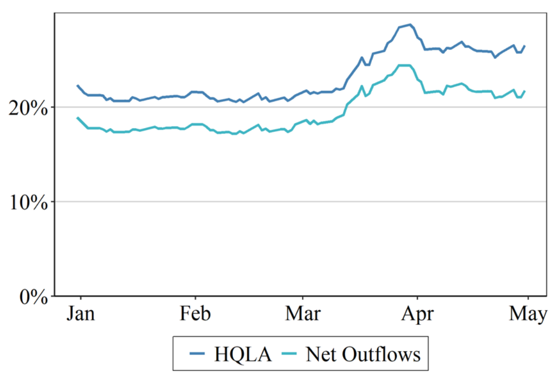
Figure 2: Balance Sheet Liquidity of Large Bank Holding Companies in the United States in 2020

This figure shows a decomposition of the LCR of U.S. bank holding companies and intermediate holding companies of foreign banking organizations that report LCR on a daily basis. The chart presents mean values calculated daily over the cross section of these firms at the beginning of 2020. As defined in Equation (1), the LCR of a firm is the ratio of its HQLA to its thirty-day net cash outflows. Panel A shows the mean of the LCR, Panel B shows the mean of the HQLA and NOF, and Panel C shows the mean of excess reserves, which constitute a part of HQLA.

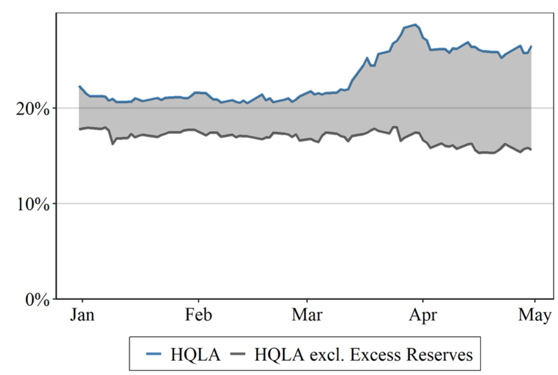
Panel A



Panel B



Panel C



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 large holding companies increased in lockstep by about five percent of total assets in March 2020. The simultaneous increase in liquid assets and net outflows indicates that large holding companies did not simply reallocate their asset portfolios to enhance their LCR, but they increased both liquid asset holdings and their reliance on short-term funding in this time period.

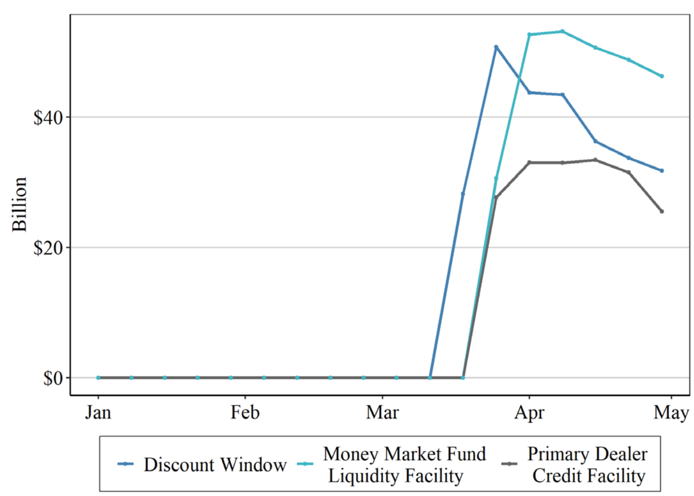
We further analyze HQLA holdings to examine changes in the liquid asset mix of large holding companies. Panel C shows that the rapid HQLA increase was almost entirely driven by an equivalent increase in excess reserves. At the same time, the mean proportion of non-excess-reserve HQLA remained stable around 16 to 18 percent of total assets—with a slight decrease in April 2020. Hence, large bank holding companies enhanced their liquidity positions by increasing excess reserves, while keeping their other HQLA largely unchanged.

The recent behavior of large bank holding companies has important implications for 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. Indeed, Figure 2 suggests that the average 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, which large bank holding companies 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 LCR and HQLA is the extensive liquidity provision by the Federal Reserve to support smooth market functioning and facilitate the availability of credit to businesses and households.[23] The facilities enabled large bank holding companies to increase their LCR by obtaining more excess reserves, while preserving most of their other HQLA holdings. Figure 3 shows an extensive utilization of the DW, PDCF, and MMLF from the second half of March 2020—concurrently with the rapid increase in LCR and HQLA discussed above. The aggregate utilization of the three liquidity facilities peaked at about $120 billion outstanding at the beginning of April 2020, from which time it gradually diminished. The extensive utilization of Federal Reserve liquidity facilities suggests that the stigma historically associated with lender-of-last-resort facilities (Armantier et al. (2011), Acharya et al. (2017), Anbil (2018)) has recently become weaker than financial firms' preference for liquidity in the face of uncertainty. This marked change in firm behavior could be partly attributable to the liquidity regulation implemented since the global financial crisis, but it may also result from the Federal Reserve's announcements.[24]

Figure 3: Aggregate Use of Selected Federal Reserve Liquidity Facilities in 2020

This figure shows the aggregate outstanding funding provided by the Federal Reserve through the DW, the PDCF, and the MMLF. The chart presents weekly values from the beginning of 2020.



[23] See the Federal Reserve's announcement on March 23, 2020. As a result of the various actions taken by the Federal Reserve in March through April 2020, aggregate excess reserves increased by about $1 trillion in the banking sector.

[24] See the Federal Reserve's announcements on March 16, 2020 and March 19, 2020.

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 asset holdings of the financial sector. Meanwhile, banks faced an inflow of about $1.5 trillion of deposits in March and April 2020, which also contributed to the growth in their liquid assets. The unprecedented deposit inflow was a result of multiple factors. It was partly due to the flight-to-safety by non-financial firms and investors, which sold riskier assets and increased bank deposits in response to the economic uncertainty and short-term funding market turmoil caused by the unfolding pandemic (Duffie (2020), He et al. (2020), Kargar et al. (2020), Li and Zhang (2020)). Furthermore, as we describe in Section 5, many non-financial firms drew down their credit lines in Q1 2020 and increased their bank deposits to prepare for potential liquidity shortages in the future—a link also examined by Glancy et al. (2020). In our empirical analysis, we isolate the effect of Federal Reserve facilities from such extraneous factors.

4.3 – The Effect of Federal Reserve Facilities on Firm Balance Sheet Liquidity

We use an econometric approach to measure the effect of DW, PDCF, and MMLF borrowings, as well as reserve requirement changes, on the HQLA and LCR of large bank holding companies 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 firm 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 percentage ratio.

Modeling the HQLA and LCR of firms and isolating the effect of specific Federal Reserve facilities and measures is challenging because it raises omitted variable and error autocorrelation concerns.[25] We overcome these econometric challenges by using a dynamic regression model, which includes lagged dependent and explanatory variables. We provide the specification and diagnostics of our dynamic regression model in Appendix A. Based on the model coefficients, we estimate how the HQLA and 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.[26]

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[25] Concerns about omitted variable bias arise because there are several, potentially latent, macro- and microeconomic factors that plausibly influence HQLA and LCR. Error autocorrelation concerns arise because both HQLA and LCR exhibit strong autocorrelation themselves, as visible in Figure 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.

[26] The estimated effects of changes in reserve requirements on the balance sheet liquidity of large bank holding companies is presented in Appendix B.

4.3.1 – Borrowing from the DW

From a liquidity regulation perspective, we would expect that discount window use increases the LCR of firms. Regarding the LCR numerator, DW loans cause an immediate increase in cash equivalents, which fully count toward HQLA.[27] 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 term and would thus increase net 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 Figure 3 above 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 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—led to an increase in the LCR of firms.

The model estimates in Figure 4 are in line with our expectations: both the HQLA and LCR of firms 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, firms 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 firms tend to preserve the newly obtained HQLA rather than use it for extending loans, purchasing non-HQLA securities, or paying off debt.

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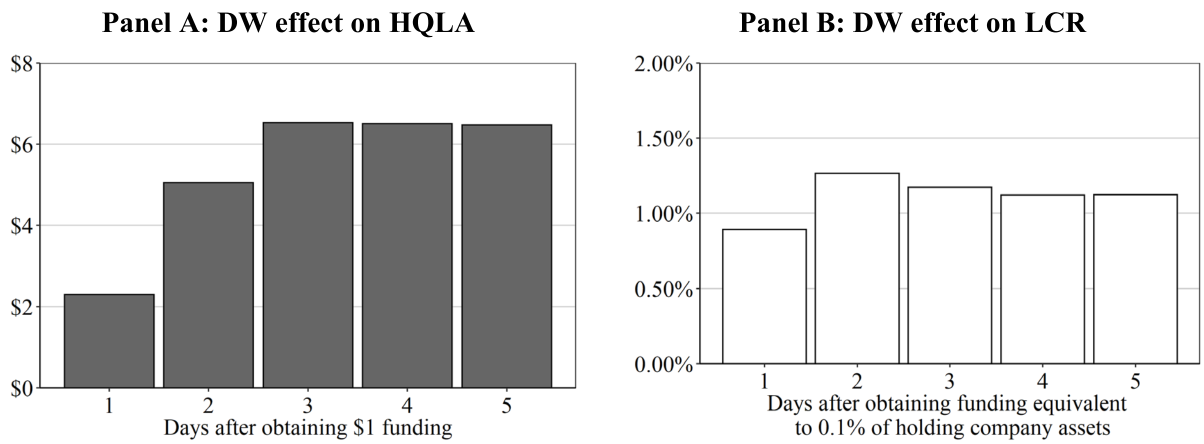
[27] In principle, the positive effect of DW loans on HQLA could be neutralized if HQLA securities are used as collateral, which would thus become encumbered and cease to count as HQLA. In practice, however, most of the assets pledged as collateral for DW loans are not HQLA.

Figure 4: Estimated Changes in Firm Liquidity after Borrowing from the DW

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 in the United States after obtaining funding from the DW of the Federal Reserve. The set of large holding companies consists of the U.S. bank holding companies and the intermediate holding companies of foreign banking organizations that report the LCR on a daily basis. The estimates are based on the dynamic regression model specified in Equation (2) of Appendix A, which is estimated in the time period from January 1 through 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 left unshaded.



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

4.3.2 – Borrowing from the PDCF

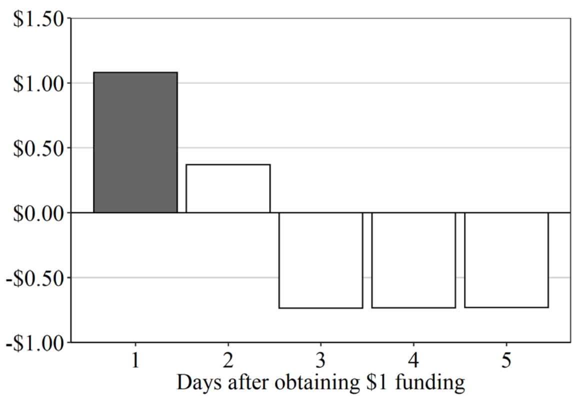
From a liquidity regulation perspective, we expect that firms increase their LCR through PDCF use. Regarding the LCR numerator, PDCF loans cause an immediate increase in cash equivalents, which in turn increases HQLA, to the extent that the assets pledged as collateral have a less than 100% weight in 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 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 the banks in our sample had a seven-day term, and the other half had a ninety-day term. Therefore, as the effect on net 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 firms.

The model estimates shown in Figure 5 confirm our expectations: both the HQLA and LCR of firms increase the day after PDCF borrowings, indicating that firms 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 LCR revert to levels that are not significantly different from the initial state. This finding suggests that firms used the liquid assets obtained through the facility for repaying obligations that had low or no weight in net outflow calculations—such as repurchase agreements secured by Level 1 or Level 2A 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.

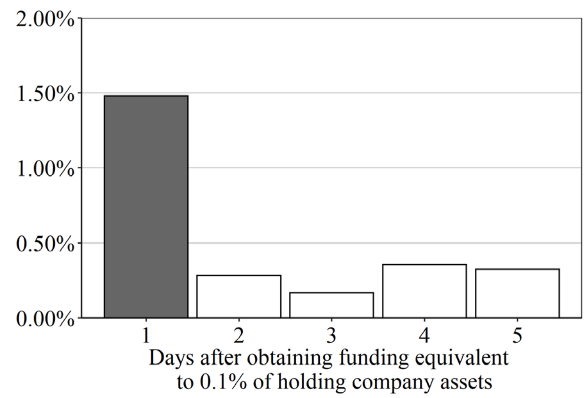
Figure 5: Estimated Changes in Firm Liquidity after Borrowing from the PDCF

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 in the United States after obtaining funding from the PDCF of the Federal Reserve. The set of large holding companies consists of the U.S. bank holding companies and the intermediate holding companies of foreign banking organizations that report the LCR on a daily basis. The estimates are based on the dynamic regression model specified in Equation (2) of Appendix A, which is estimated in the time period from January 1 through 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 unshaded.

Panel A: PDCF effect on HQLA



Panel B: PDCF effect on LCRs



4.3.3 – Borrowing from the MMLF

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 three 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 outflows increase by 0% to 25% of the loan amount, depending on the collateral pledged. However, the data shows 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 LCR of firms 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 – Lending and Trading

5.1 – Lending During the Crisis

Total bank credit exposure, which includes both loans and undrawn credit commitments, grew at a roughly average pace in 2020, with higher growth in the second quarter and lower growth in the third quarter. However, when we disaggregate credit growth into its components, the effect of substantial economic disruptions due to the pandemic become apparent, and more consistent with survey evidence of generally tighter credit availability. In this section, we illustrate the impacts of the pandemic on various forms of bank credit. In addition, we show that while bank size and business models were significantly associated with credit growth in 2020, we find little association between credit growth and either the tightness of regulatory capital constraints or measures of bank health. In other words, we find little evidence of a "credit crunch" (Bernanke and Lown, 1991), suggesting that extraordinary macroeconomic conditions affecting credit demand are the primary explanation for significant fluctuations in aggregate credit.

5.1.1 – Aggregate Lending

Table 5 compares total credit exposure growth (panel A) and lending growth (panel B) in the first three quarters of 2020 with the average quarterly growth over the previous two years. Differences that are statistically significant from this historical average are indicated by * and **.

The first row of panel A shows that the overall growth of total lending commitments—which includes undrawn (off-balance sheet) credit lines—was quite stable, a bit stronger than average in the second quarter and a bit weaker than average in the third. However, the further breakdown shows second quarter growth diverged between larger and smaller banks, with slightly negative growth at G-SIBs. This divergence reflected the issuance of Paycheck Protection Program (PPP) loans under the CARES' Act—the bulk of which were issued by smaller banks.[28] If we exclude PPP loans from our measure of credit exposure, second quarter growth falls to -1.0% at G-SIBs and just +0.2% at other U.S. banks (-0.4% overall). This is consistent with reports and survey evidence that credit conditions tightened in the wake of the pandemic.

[28] In the second quarter, G-SIBs account for only about 13% of the $486 billion in PPP loans held on balance sheets in our sample.

Table 5: Growth of Bank Credit (2020)

Panel A: Quarterly Total Credit Exposure Growth (%)[29]

	2018-2019	2020		
	Average	**Q1**	**Q2**	**Q3**
U.S. Banks	1.2	1.0	2.0	0.4
of which, G-SIBs	1.0	1.3	-0.3	0.2
of which, others	1.3	0.8	3.8**	0.5**

Panel B: Quarterly Loan Growth (%)

	2018-2019	2020		
	Average	**Q1**	**Q2**	**Q3**
U.S. Banks	1.0	3.6**	0.2	-0.2
of which, G-SIBs	0.5	5.5**	-5.2**	-0.8
of which, others	1.2	2.4*	3.5**	0.1
International G-SIBs	0.2	4.0	1.6	5.8*

Indicates significance at the 95% level, ** at the 99% level. Data source: FR Y9-C and FFIEC CALL reports (US banks), S&P Global Market Intelligence (Foreign G-SIBs).[30]

Panel B focuses on loan growth, which is affected by borrowers' use of credit lines. In contrast to total credit exposure, overall loan growth was higher in the first quarter—driven by G-SIBs, and lower in the second and third quarters. This difference reflects a sharp rise in the utilization of commercial credit lines during difficult bond market conditions in March. Much of this credit demand appears to have been precautionary since these credit lines were mostly repaid as market conditions eased in the second and third quarters, generating a sharp reversal in loan growth. Since commercial credit lines are issued almost entirely by large banks (especially G-SIBs), credit exposure and loan growth trends are more similar at smaller banks. The final row of panel B shows that fluctuations in loan growth were not just a U.S. phenomenon.[31]

5.1.2 – Lending by Loan Type

[29] Credit exposure includes both loans and undrawn credit commitments.

[30] We filter out firms whose financials are consolidated within other regulatory report filers to avoid double-counting.

[31] Strong loan growth from international G-SIBs in the third quarter is mostly attributable to high loan growth at large Chinese banks.

Table 6 compares total credit exposure (panel A) and loan growth (panel B) in 2020 by loan type. As before, * and ** denote statistically significant differences from the historical average.

Table 6: Growth of Bank Credit (2020), by Loan Type

Panel A: Quarterly Total Credit Exposure Growth (U.S. Banks)				
	2018-2019		**2020**	
	Average	**Q1**	**Q2**	**Q3**
Commercial Loans	1.6	2.6	5.5**	1.1
" ", excl. Paycheck Protection Program Loans (PPP)	-	-	-0.6	1.0
Commercial Real Estate	1.3	0.3	1.0	1.0
Residential Real Estate	0.3	-0.1	0.1	0.3
Consumer Loans	1.0	0.0	-0.9**	-0.8**

Panel B: Quarterly Loan Growth (%) (U.S. Banks)				
Commercial Loans	1.2	11.2**	1.4	-1.8**
" ", excl. Paycheck Protection Program Loans (PPP)	-	-	-9.5**	-2.0**
Commercial Real Estate	1.2	1.5	1.1	0.8
Residential Real Estate	0.3	-0.1	-0.1	0.5
Consumer Loans	1.1	-4.3*	-3.5*	0.6

Indicates significance at the 95% level, ** at the 99% level. Data source: FR Y9-C and FFIEC CALL reports.

Panels A and B show that commercial real estate lending grew at a similar pace to past years, with total exposure growth lagging somewhat. Residential real estate lending growth continued to be slow, consistent with steady migration of mortgage origination to the non-bank financial sector. Overall, lending growth in these two segments was consistent with banks continuing to provide credit to real estate borrowers through the crisis.

In contrast, we see sharp fluctuations in the growth of commercial and industrial (C&I) loans and significantly lower growth in consumer loans over this period. While commercial credit exposure growth was especially strong in Q2, this is mostly due to the PPP loans. Excluding PPP loans, C&I loan portfolios shrunk by almost 10% in the second quarter and commercial credit exposure fell by 0.6%. Of course, to the extent that PPP substituted for conventional bank credit, credit exposure growth absent PPP would have exceeded -0.6%. This sharp decline in second quarter C&I loan balances and the sharp increase that preceded it was primarily due to previously discussed draws on and repayment of commercial credit lines; total commercial credit exposure growth was comparatively modest.

In addition, a comparison of panels A and B shows that consumers paid down a significant share of their personal credit lines in the first two quarters of 2020, with consumer loan balances resuming modest growth in the third quarter. Horvath, Kay and Wix (2020) show that this reduction in credit was concentrated in the most creditworthy consumers, and is therefore 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 reduce their risk exposure as well as additional evidence of "flight-to-safety" in the card market documented by Horvath, Kay and Wix (2020).[32]

5.1.3 – Evidence of Changes in Credit Supply

Notwithstanding the sharp movements in C&I and consumer loans documented above, overall loan balances did not change sharply through Q3 2020. However, this observation is of limited use in assessing whether the credit supply tightened. Bank credit might have changed little in response to tighter credit but increased credit demand, or looser credit but with decreased credit demand—and either is conceivable. Acknowledging this difficulty, we discuss the available evidence, as tight constraints in a downturn are typically considered harmful to social welfare.

First, we use cross-sectional least squares regressions to relate bank-level credit growth (Q4 2019 through Q3 2020) to two types of constraints as well as measures of bank size and business model, which largely serve as proxies for differences in credit demand. If these constraints help explain credit growth, changes to their tightness in the pandemic may be holding back credit growth.

As our primary credit growth measure, we use the growth in total credit exposure from Q4 2019 through Q3 2020. This measure is unaffected by credit line usage—which the banks have relatively little control over. Our primary growth measure excludes PPP loans, as these loans do not present the bank with either credit risk or constrain capital.[33]

The two types of constraints we consider are regulatory capital constraints and economic capital (i.e. wealth) constraints.

As one measure of regulatory capital constraints, we consider banks' CET1 risk-based capital requirements as of the end of 2019. We split these capital ratios into a total requirement inclusive of capital buffers, and a voluntary buffer reflecting the amount by which the banks' capital exceeds these requirements. If banks undertook lending decisions in 2020 with the aim of maintaining a particular voluntary buffer amount, then the buffer amount in Q4 2019 should positively predict credit growth, while the amount of the requirement need not be related to credit growth. We use banks' exposure to commercial credit line draws as a second measure of regulatory capital constraints. Given the unexpectedly large draws on these credit lines in March 2020, this exposure represented a shock to regulatory capital requirements, and should be associated with

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[32] e.g. https://www.americanbanker.com/articles/credit-cards-start-cutting-limits-for-people-facing-tough-times

[33] Regulatory actions taken in April clarify the CARES Act intent that PPP loans should bear zero regulatory capital cost. See interim final rule https://www.govinfo.gov/content/pkg/FR-2020-04-13/pdf/2020-07712.pdf

lower credit exposure growth where capital constraints significantly guided lending decisions.[34] While most of these draws ended up being short in duration, banks may not have expected that at the time.

We consider two market-based measures of banks' economic capital, market leverage ratio—defined here as market capitalization to total assets as of the end of 2019—and percentage change in market capitalization in the first quarter of 2020.[35] These measures should relate positively to credit growth to the extent that (i) banks made lending decisions to target a particular market leverage or (ii) bank valuations reflect borrower demand.

To further control for differences in credit demand we include measures of differences in banks' business models as of the end of 2019: total credit exposure growth in 2019, size, interest share of interest plus noninterest income, and the share of the loan portfolio in each of seven different categories of lending.[36] We restrict the regression data to banks with at least $1 billion in assets and CET1 ratios between 0% and 25% at the end of 2019.

Table 7 presents the results of our regressions. Columns A through C use our primary credit growth measure—credit exposure growth excluding PPP loans. Column A includes only our regulatory constraint measures. Column B adds our measures of economic capital and variables representing differences in bank business models, and column C weights each bank in the regression proportionally to its total assets in Q4 2019. Column D adds back PPP lending. Column E measures loan growth instead of total credit exposure growth.

The very small R^2 in column A suggests that variation in capital constraints and exposure to credit line draws explains little variation in credit growth. In fact, the statistically and economically insignificant relationship between capital constraint intensity and commitment growth holds across all columns.[37] This is unlike what we might expect if the banking system were in a "credit crunch," with banks limiting lending due to insufficient capital (see Rosengren and Peek, 1997). These results are consistent with work by Li, Strahan and Zhang (2020) showing that banks' pre-crisis financial position did not constrain their borrowers' access to credit. These results are also consistent with the finding in Carlson et al. (2013) of no significant relationship between capital ratios and credit growth when the banking sector is unconstrained. However, focusing on the larger banks that are subject to stress tests, Berrospide et al. (2020) show that credit growth is modestly positively related to the size of the capital buffer, the amount by which capital ratios exceed regulatory capital requirements.

[34] When drawn, credit lines represent an increase in a banks' risk weighted assets, but do not affect our measure of credit exposure. Credit line draws also likely represent a shock to banks' economic risk exposure, which might also generate an association between credit line exposure and credit growth.

[35] Market capitalization data are from Center for Research in Security Prices, CRSP 1925 US Stock Database, which are linked to FR Y-9C data using the Federal Reserve Bank of New York CRSP-FRB Link.

[36] Categories include commercial and industrial loans, loans to financial institutions, commercial real estate, other wholesale lending, residential real estate, revolving retail lending, and other consumer lending.

[37] Across columns, the coefficients on the CET1 voluntary buffer suggest that for each standard deviation increase, lending growth over the period Q4 2019 and Q3 2020 changes by between a -72bp decrease and +50bp increase.

Table 7: Regressions of Total Credit Exposure and Loan Growth (Q1 through Q3 2020)

	Credit Exposure Growth				Loan Growth, Excl. PPP (pp)
	Excluding PPP Loans (pp)			With PPP (pp)	
	[A]	[B]	[C]	[D]	[E]
CET 1 risk-based req.+buffers (pp, Q4 2019)	-1.564	-0.648	0.058	1.663	-0.034
	(0.886)	(1.226)	(0.813)	(1.277)	(0.972)
CET 1 voluntary buffer (pp, Q4 2019)	-0.240	-0.142	-0.041	-0.074	0.165
	(0.204)	(0.190)	(0.240)	(0.286)	(0.256)
Credit Lines/CET1 (pp, Q4 2019)	-0.002	0.022	0.016	0.030**	0.014
	(0.009)	(0.012)	(0.011)	(0.013)	(0.011)
Q1 Market Cap. Decline (pp)[38]		0.082	0.065	0.057	0.102
		(0.159)	(0.117)	(0.125)	(0.126)
Market Leverage (pp, Q4 2019)		-0.037	-0.033	0.049	-0.254
		(0.152)	(0.133)	(0.157)	(0.176)
Lagged Growth (2019)		0.054	0.004	0.067	0.030
		(0.031)	(0.027)	(0.072)	(0.030)
Size (Q4 2019 log total assets)		-1.560***	-1.388***	-3.311***	-1.538***
		(0.501)	(0.489)	(0.733)	(0.561)
Interest Income Share (pp, 2019)		-0.150***	-0.120***	-0.111**	-0.097
		(0.046)	(0.046)	(0.054)	(0.054)
Intercept	Y	Y	Y	Y	Y
Loan portfolio share variables (Q4 2019)		Y	Y	Y	Y
Asset Weighted Regression			Y	Y	Y
R2	0.004	0.074	0.095	0.127	0.149

Notes: N = 682 (one cross-section). Regressions include firms present Q4 2018 to present with $1 billion or more in total assets and CET1 ratios between 0% and 25% in Q4 2019. Heteroskedastic robust standard errors in parentheses. *** = significant at 1%; ** = significant at 5%. Weighted regressions scale squared residuals by Q4 2019 total assets.

We also find little relationship between our economic capital measures and credit growth in 2020. One interpretation is that banks entered 2020 in robust enough condition that—even though some banks were hit harder than others—few were weakened sufficiently to materially reduce their risk appetite or face funding liquidity concerns.

In contrast, differences in bank size and business model do explain some of the variation in growth. Specifically, credit commitments grew more at smaller banks (+2% per standard deviation decrease) and in 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), as PPP lending is more concentrated at smaller banks.

[38] A dummy for non-public banks is included in the set of controls.

This highlights the important role that smaller banks have played in facilitating the flow of credit during the pandemic. While this regression does not turn up evidence of binding capital constraints, we should bear a few caveats in mind. First, we are assuming that CET1 ratios and credit line exposure are good proxies for how concerned banks are about their capital requirements. Second, we assume that our control variables are able to explain any differences in commitment growth attributable to variation in either (i) other unrelated shocks affecting banks' 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 crisis has affected them differently in ways other than through credit line draws.

Kapan and Minoiu (2020) also study the impact of exposure to commercial credit lines on credit availability—subsequent to the large drawdowns this spring. In their empirical approach, the authors address concerns that banks may face different credit demand by comparing outcomes for particular borrowers across multiple banks. They find that banks with larger credit line exposures reduced their participation in syndicated commercial credit facilities, and tightened lending standards as measured by the Senior Loan Officer Opinion Survey (SLOOS). While this is clear evidence of a reduction in credit supply, the paper is silent on whether credit line exposures reduced supply though regulatory constraints or banks' own desire to manage the increase in credit risk.

More generally, the SLOOS shows that credit officers' report tightening underwriting standards for almost every type of loan in the first two quarters of 2020—by almost the same margins as in the financial crisis of 2007-09.[39] While this is suggestive evidence of a reduction in credit supply, SLOOS provides only qualitative evidence regarding the specific drivers. Nonetheless, the survey suggests that the change in economic conditions and industry risks are the primary drivers of the contraction in credit supply. In addition, SLOOS reports lower demand for every form of credit except for residential mortgages. Given these responses, somewhat weak bank credit growth in the absence of PPP is not surprising.

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

5.2 – Trading Activity

Large banks play an important role in intermediating U.S. financial markets. However, 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. As a result, the post-crisis regulatory regime significantly curtailed risk-taking by banks. This section examines the performance of trading activity at banks to shed light on the efficacy of these changes.

Trading activities at the largest US banks are a source of revenues when volatility in capital markets increases as a result of repricing events, generating increased client activity. Trading

[39] See https://www.federalreserve.gov/data/sloos/sloos-202007.htm

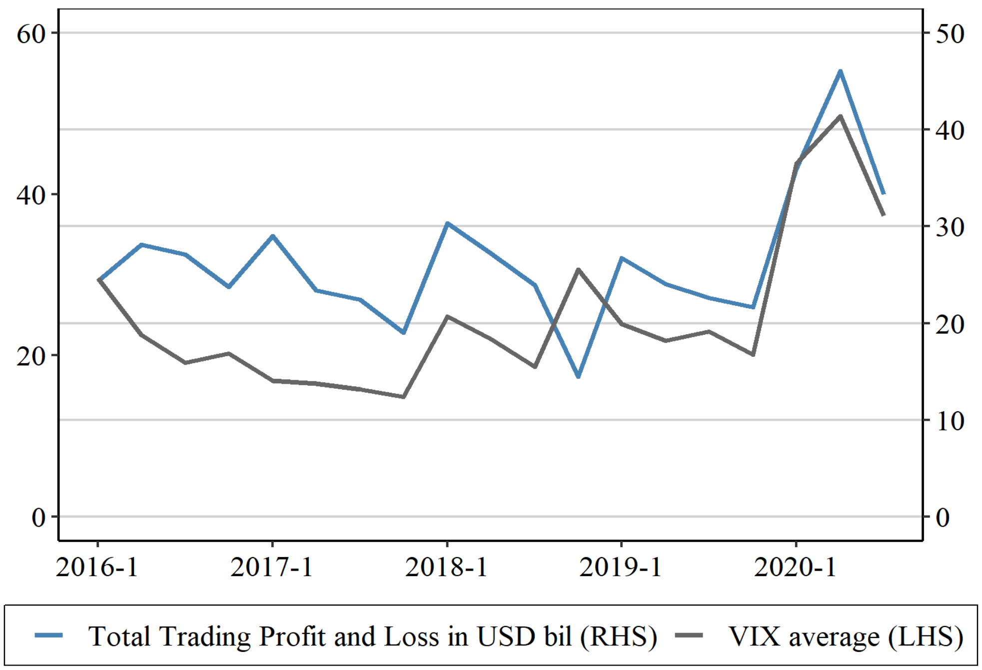
revenues include fees, commissions, and bid-ask spreads arising from new transactions, as well as cash flows and mark-to-market profits and losses from banks' trading inventory positions. Iercosan et al. (2017) and Falato et al. (2019) shows that banks reduced their trading inventories and exposures to potential future losses due to a collapse of asset values following the implementation of the post-crisis regulatory reforms. The reduction in trading inventories from the highs preceding the financial crisis of 2007-09 follows from 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.

Figure 6 shows quarterly trading revenues for largest US trading banks that report Volcker Rule metrics. In Panel A, we show the time series of trading profits and losses aggregated across the top US banks, which indicates that the first three quarters of 2020 were particularly profitable. These quarters were the most profitable quarters for trading in the most recent 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. While revenues increased by 66%, 112%, and 54% in Q1, Q2, and Q3 2020 respectively relative to Q4 2019, the overall size of the trading portfolios remained relatively stable as net trading assets only increased by 3% , 7% and 8% in the first three quarters relative to year end 2019, as shown in Figure 7. Moreover, Figure 7 shows high transaction volume was a major driver of the increase in revenues as transaction count went up by 34%, 17% and 9% in Q1, Q2 and Q3 2020 relative to Q4 2019. We address potential seasonality in Panel B by showing that trading revenues for Q1 through Q3 2020 were higher and statistically significant relative to the average of the preceding years for the respective quarters. These findings indicate that the Volcker Rule and other regulatory reforms have 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.

Banks' trading positions are subject to stress testing losses under a hypothetical global market shock (GMS) where regulators specify steep asset price declines and associated increases in credit spreads. While the GMS determines trading stress losses instantaneously, our findings that banks earned significant trading revenues in the first three quarters of the COVID-19 crisis suggest that the revenue increases in a stress scenario can help offset the losses arising 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 absent such policy interventions.

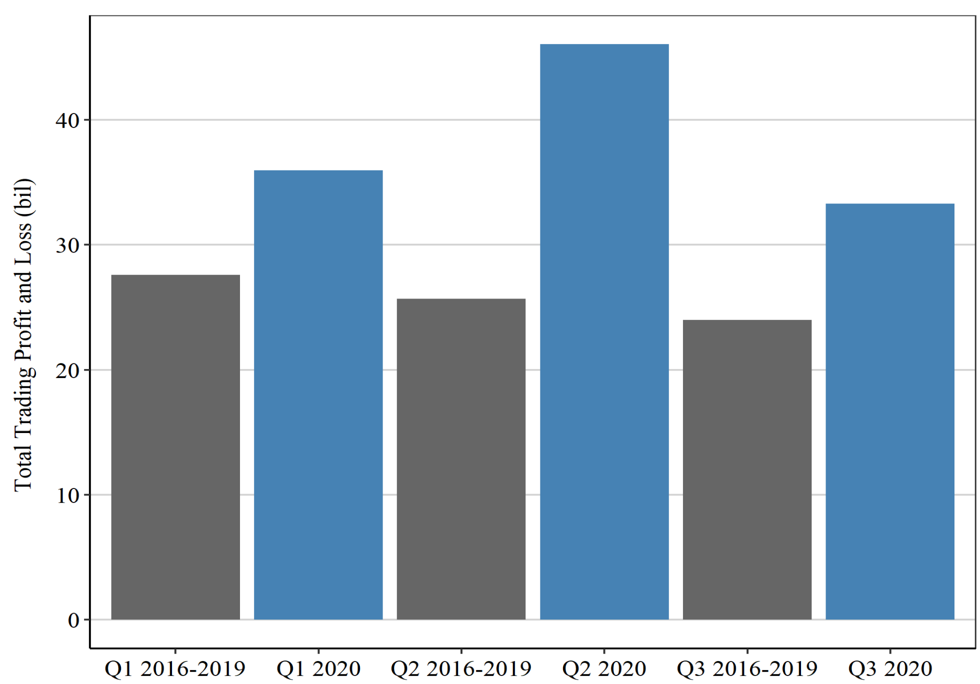
Figure 6 Trading Profit and Loss

Panel A: Time series



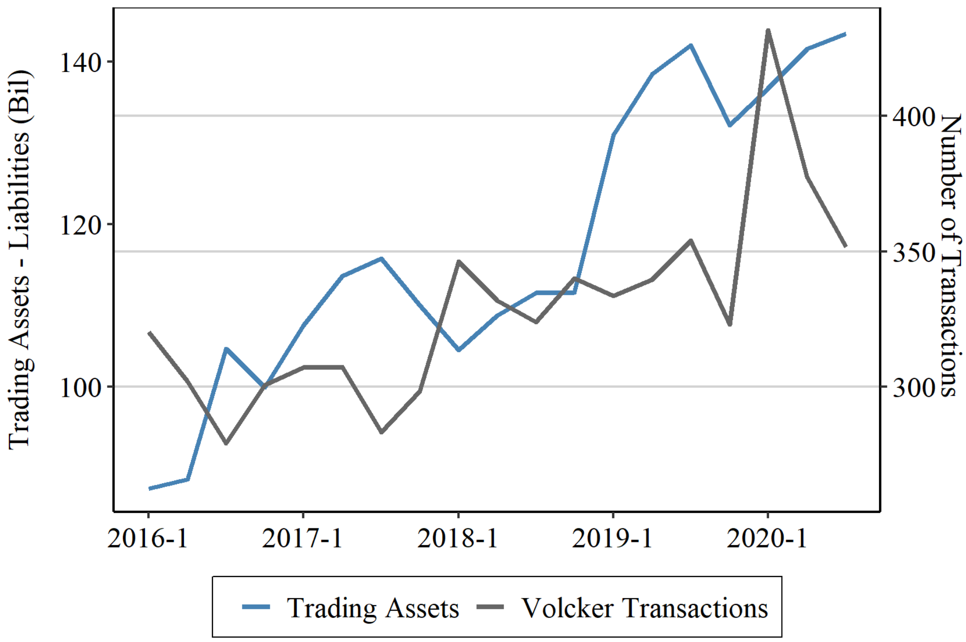
Source: Volcker Rule Quantitative Measurements (FR VV-1) and Bloomberg Finance LP

Panel B: Comparison by quarter



Source: Volcker Rule Quantitative Measurements (FR VV-1)

Figure 7: Net Trading Assets & Transactions Volume



Source: Y9-C and Volcker Rule Quantitative Measurements (FR VV-1)

6 – Evidence from Financial Markets

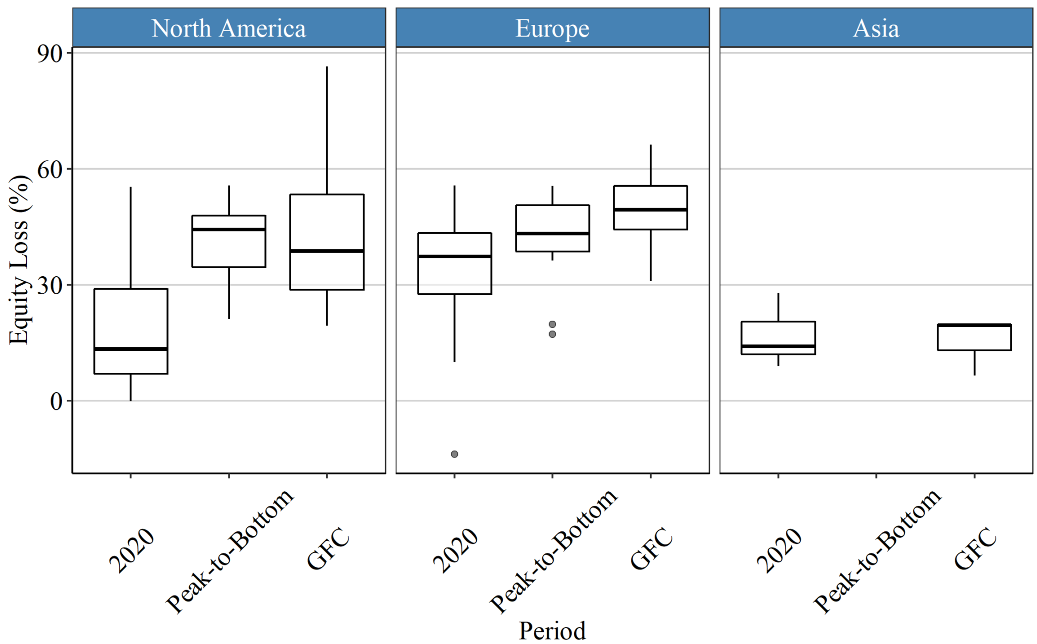
Financial market data provide an additional perspective on the strength of the banking system in the early stage of the COVID-19 crisis. We examine Global Systemically Important Banks' market performance based on the magnitude of their equity price losses and CDS spread increases following the coronavirus outbreak. We compare GSIBs equity price declines and increases in credit spreads over three time periods: the year 2020; a second period starting with the US and European market peak in mid-February up to the market bottom near the end of March 2020; and, as a benchmark, a third period covering the financial crisis of 2007-09. The magnitude of equity losses indicates the market perception of GSIBs' profitability relative to the overall market, while changes in CDS spreads indicate the market's view of the GSIBs' credit risk.

6.1 – Banks' Stock Prices Performance

In Figure 8, we show the equity share price losses of GSIBs across the three periods mentioned above, for three separate regions, North America, Europe and Asia. In each region the left panel covers the year 2020, the middle panel covers the peak to bottom in the first quarter of 2020, and the right panel covers the financial crisis period. Focusing first on the equity performance during the stock market peak-to-bottom in the first quarter of 2020, we find that North American and European banks suffered similar losses during the initial sell-off to those experienced during the financial crisis of 2007-09 (see Aldasoro et al. (2020) for a similar finding).

Since the US and European market hit bottom in March 2020, bank stock prices recovered moderately, especially in North America, consistent with a strong equity market performance and a broad recovery in asset valuations. By the end of 2020 we find that GSIBs are underperforming the broader market, as indicated by the Global MSCI index retracing all the losses during February and March of 2020. The weaker performance of bank equity prices likely reflects a combination of the weak prospects for growth amidst a period of prolonged low interest rates and the potential for future credit losses as a result of the pandemic. In contrast, Asian GSIBs equity prices exhibited only modest declines, both during the financial crisis of 2007-09 and in the recent pandemic.

Figure 8: GSIBs' Equity Returns



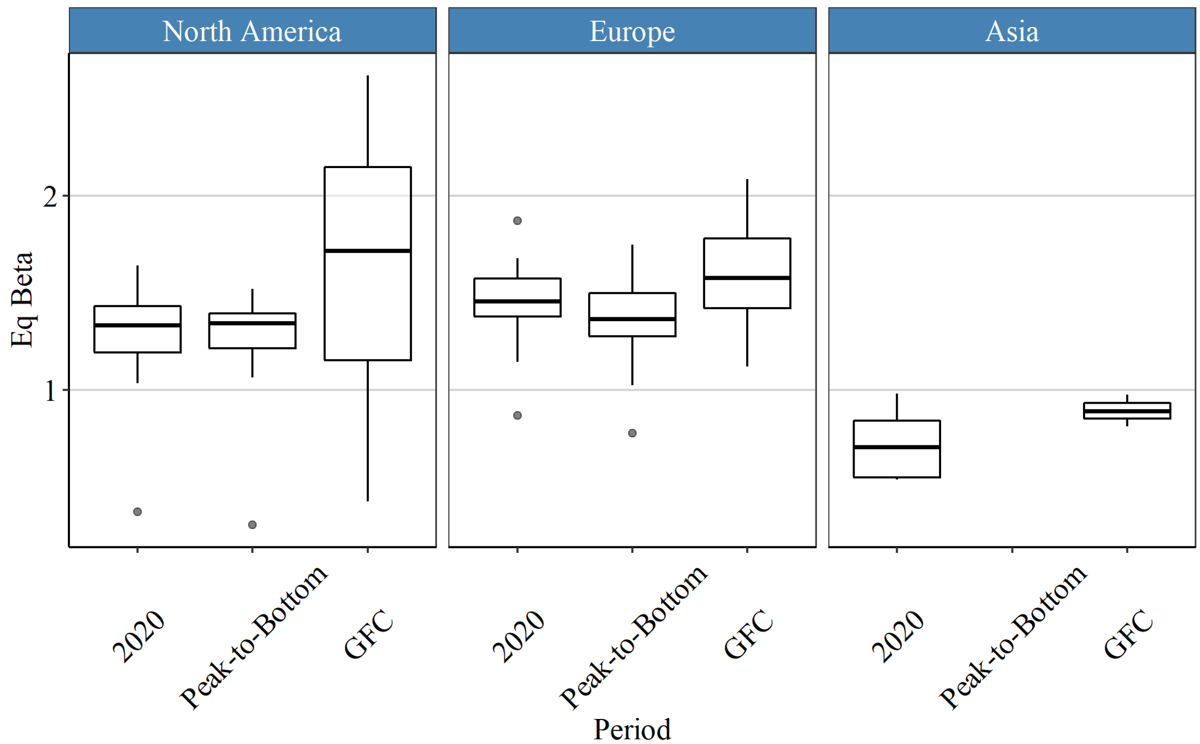
Note: GFC return period used is August 29, 2008 to March 31, 2009; market peak-to-bottom period is February 14 to March 23, 2020; and 2020 period is December 31, 2019 to December 31, 2020

We next examine the CAPM beta's of European and US GSIBs to understand the systemic risk posed by these banks.[40] In Figure 9 we show most European and North American banks have an equity beta in the range of 1 to 1.75 – the equity beta is measured relative to their currency specific market index – during the peak-to-bottom and the year 2020 periods.[41] These beta values are smaller on average, albeit statistically significant only for European banks, than the betas ranging between 1.2 and 2.6 during the financial crisis of 2007-09, indicating that the banking

[40] The CAPM beta is an input into systemic risk measures including the market equity shortfall definition in Acharya et al. (2017) and SRISK definition in Brownless and Engle (2017).
[41] The market specific indices used were S&P 500 index for the US, FTSE 100 for the UK, Swiss Market Index for Switzerland, Nikkei 225 for Japan, S&P/TPX index for Canada, Shanghai Composite index for China, and STOXX Europe 600 for Europe.

system is more resilient today. For Asian GSIBs, betas are below one, both in the financial crisis and during the entire 2020 period, highlighting that the Asian financial system experienced a lower degree of systemic risk. Overall, the findings suggest that equity market participants viewed the North American GSIBs as less stressed during the most recent period than during the financial crisis of 2007-09.

Figure 9: GSIBs' Equity Betas

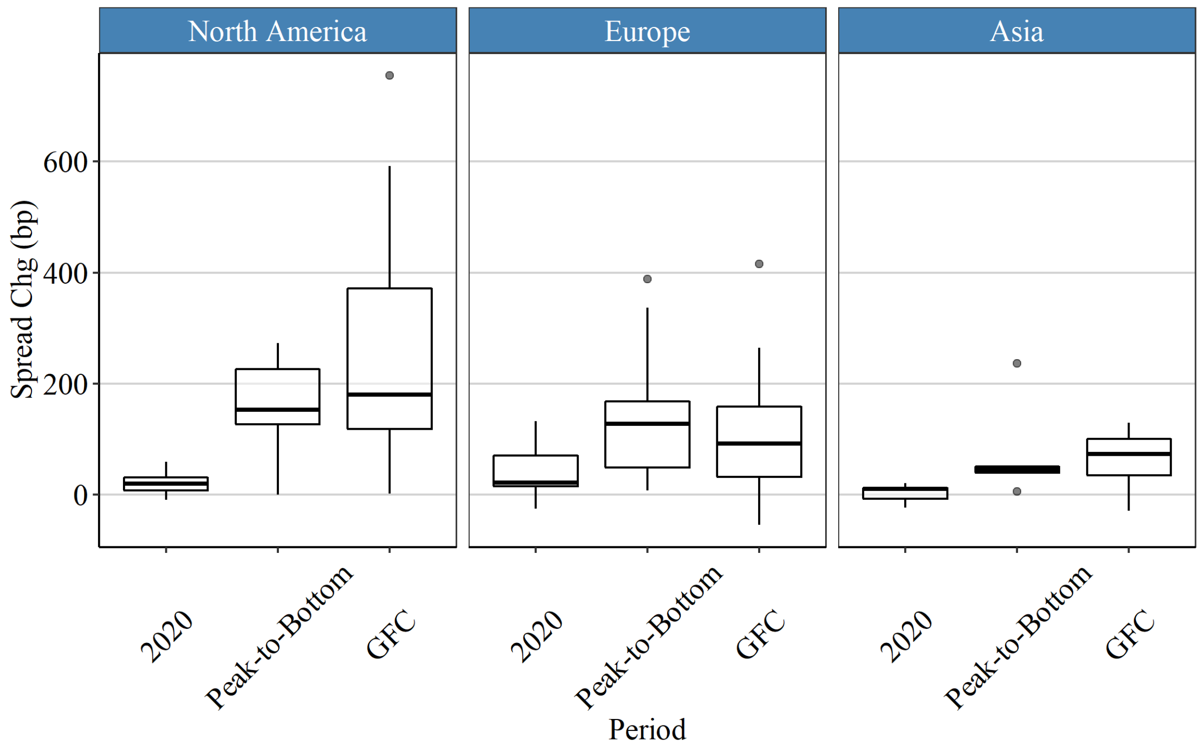


Note: GFC return period used is August 29, 2008 to March 31, 2009; market peak-to-bottom period is February 14 to March 23, 2020; and YTD period is December 31, 2019 to December 31, 2020

6.2 – Banks' CDS Spreads Performance

After the COVID-19 shock, market participants' expectations of the GSIBs' credit risk, implied by their CDS senior 5-year spreads shown in Figure 10, also indicate that these banks were distressed in the first quarter of 2020 and are less distressed today than during the financial crisis of 2007-09. In the peak-to-bottom period, North American GSIBs' CDS spreads widened on average 115 basis points, less than during the financial crisis of 2007-09 when their spreads widened on average 165 basis points with a higher dispersion across banks. Moreover, the modest change in CDS spreads, between 0 and 25 basis points, indicates that policy interventions and the easing of uncertainty about the depth of the current crisis have led to a recovery, demonstrating the resilience of banks. As of the end of 2020, the market perceives, as implied by credit spreads, that GSIBs are in better financial condition following the COVID-19 shock than during the GFC. By comparison, subordinate CDS spreads widened about twice as much as senior spreads. This spread behavior is consistent across all regions both in the peak-to-bottom period as well as in the financial crisis. It is not surprising since subordinate debt is positioned lower in the capital structure and thus has higher risk.

Figure 10: GSIBs' CDS Spread Changes



Source: Markit North America, Inc., Credit Default Swaps (CDS)

Note: GFC return period used is August 29, 2008 to March 31, 2009; market peak-to-bottom period used is February 14 to March 23, 2020; and YTD period used is December 31, 2019 to December 31, 2020.

6.3 – Capital and Liquidity Ratios and Banks' Equity Prices and Spreads

Aikman, Haldane and Kapadia (2018) show that, during the financial crisis of 2007-09, market measures better captured the resilience of banks compared to regulatory capital ratios, thus highlighting a weakness in the extant measures of regulatory capital. Financial regulators have significantly refined the measure of capital to address these limitations. We carry out a similar analysis using data from the early days of the COVID-19 crisis to compare the relative information content of regulatory and market measures on the performance of banks.

We perform a multivariate regression of the change in GSIB's CDS senior 5-year spreads from February 14, 2020, to March 23, 2020, on a firm's CET 1 ratio (or the market equity to total assets ratio) and LCR, see Table 8. We find no statistically significant relationship between either regulatory capital measures or market measures on the changes in CDS spreads.[42]

Table 8: Effect of equity measures on CDS spreads

Independent Variable	Effect on CDS Spreads	
CET 1 risk-based ratio	1.50 (8.17)	--
Market equity to total assets ratio	--	-0.06 (5.35)
LCR	-0.11 (0.68)	-0.10 (0.68)
Dummy for Europe	27.00 (32.19)	28.82 (31.48)
Dummy for North America	66.51** (31.48)	67.46 (45.98)
Intercept	43.92 (131.71)	61.19 (98.26)
Adjusted R^2	7.79%	7.63%

Notes: N = 24. ΔCDS Spreads in basis points. Standard errors in parentheses. ** = significant at 5%.

The lack of a statistical significant effect of the CET 1 ratio or the LCR on the changes in CDS spreads questions whether market participants see regulatory ratios as reliable indicator of firm's resilience to economic downturns. Still, in this COVID-19 episode, a market based equity to assets ratio did not outperform the regulatory CET 1 ratio as a predictor of deterioration in CDS spreads. More broadly, the lack of statistical significance for both measures suggested that market participants viewed the sudden deterioration in CDS spreads during March of 2020 as reflective of a broader concern about the soundness of the financial system, rather than exhibiting concerns about the health of individual G-SIBs.

[42] A similar analysis on subordinated CDS 5-year spreads revealed no statistically significant relationship.

7 – Conclusion

We assess the bank regulatory framework in light of the COVID-19 shock. We find that the banking system was able to absorb this shock and continue to support the economy by lending to firms and intermediating in financial markets, partly due to the fact that banks entered the crisis with robust capital and liquidity levels. In addition, Federal Reserve facilities helped banks strengthen their liquidity positions and the financial system weather an initial bout of uncertainty.

Appendix A: Dynamic Regression Model Specification and Diagnostics

Model specification

In our analysis, we use the following regression specification

$$y_{i,t} = \sum_{k=1}^{p} a_k y_{i,t-k} + \sum_{k=0}^{3} \boldsymbol{\beta}_k^\top \boldsymbol{x}_{i,t-k} + \sum_{k=1}^{3} \boldsymbol{\gamma}_k^\top \boldsymbol{z}_{i,t-k} + c + \varepsilon_{i,t} \tag{2}$$

where $y_{i,t}$,$\boldsymbol{x}_{i,t}$, and $\boldsymbol{z}_{i,t}$ respectively 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 total assets, or the LCR, expressed as a percentage of thirty-day net cash outflows, as defined in Equation (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 $k = 0$).

- The vector of pre-determined explanatory variables (i.e., $\boldsymbol{x}$) consists of
    - required reserves (% of total assets)
    - deposits (% of total assets)
- The vector of co-determined explanatory variables (i.e., $\boldsymbol{z}$) 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 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 firm, which are based on customer decisions in the past.

We consider the use of DW, MMLF, PDCF funding, and net 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 firm may borrow from these sources to alleviate liquidity shortages, it is plausible that the firm'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. With regard to 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 Equation (2). 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 firms. (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 firm liquidity position. (iii) Residual autocorrelation only vanishes when $p \geq 1$ and $p \geq 3$ for HQLA and 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 LCR in the model.

Table A.1: Dynamic regression model fit diagnostics

This table shows diagnostics for the dynamic regression model specified in Equation (2), which we apply to dependent variables HQLA and LCR, using different lags (p). At the top of the table, α_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. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***.

	y = HQLA (% of TA)			**y = LCR (% of NOF)**		
	p = 1	p = 2	p = 3	p = 1	p = 2	p = 3
α_1	0.995***	0.929***	0.933***	0.972***	0.784***	0.758***
α_2		0.067	0.096		0.195**	0.086
α_3			–0.033			0.139*
observations	992	992	992	992	992	992
adjusted R^2	0.990	0.990	0.990	0.963	0.964	0.965
corr{ε, L1(ε)}	–0.056	0.008	0.005	–0.190**	–0.030	0.001
corr{ε, L2(ε)}	0.011	0.004	–0.030	–0.090	–0.126*	–0.033
corr{ε, L3(ε)}	–0.013	–0.008	–0.007	0.096	0.030	–0.002

Appendix B: The 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. Historically, 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.[43] 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 a liquidity regulation perspective, reducing RR increases excess reserves, which fully count as HQLA, thereby increasing the LCR's numerator. As RR changes have no direct effect on thirty-day net cash outflows, the LCR's denominator would be unchanged. Therefore, in principle, reducing RR would increase the LCR of firms and increasing RR would have the opposite effect. In practice, however, since firms 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 dynamic regression model specified in Appendix A, we estimate the effect of RR changes on the HQLA and LCR of large bank holding companies in the time period from January 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 Figure 2, which indicates no visible change in HQLA at the elimination of the RR on March 26. The result also suggests that, in this time period, large bank holding companies had sufficient flexibility in their asset and liability maturity structures to dynamically offset the impact of RR changes on excess reserves—and thus on HQLA and the LCR.

[43] See Statement Regarding Monetary Policy Implementation and Balance Sheet Normalization, Federal Reserve Board of Governors, 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.

Appendix C: Institutions in Sample by Section

Section	Institutions
3 – Capital requirements and capital levels	
3.1 – Capital Requirements and capital levels going into crisis	8 US GSIBs, 13 European GSIBs, 14 non-GSIB US banks, and 29 non GSIB European banks
3.3 – Procyclicality of Capital Requirements	11 firms supervised by the Large Institution Supervision Coordinating Committee (LISCC) – 8 US GSIBs and 3 IHCs
3.4 – Usability of Capital Buffers	34 firms subject to the 2020 Comprehensive Capital Analysis and Review (CCAR) stress test exercise
4 – Liquidity Positions	8 US GSIBs, 6 US BHCs, and 7 IHCs
5 – Lending and Trading	
5.1. – Lending during the crisis	All US Banks (Y9C & FFIEC Call Report filers), and Foreign GSIBs
5.2. – Trading revenue analysis	9 largest trading banks subject to Volcker Rule metrics
6 – Financial Markets	All GSIBs

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