EXECUTIVE SUMMARY\(^1\)

The U.S. financial system is very large, well-diversified, and home to numerous financial institutions which are significant at a global scale. Eight Global Systemically Important Banks (G-SIBs) are incorporated in the U.S., as well as several other large financial institutions, such as asset managers, insurers, and money market funds. Assets of the financial system amounted to about US$100 trillion at end-2019 and accounted for 500 percent of GDP. While the eight G-SIBs dominate the U.S. banking landscape, banking system assets represent only about 22 percent of total financial system assets. The systemic risk assessment (including stress testing) of this FSAP reflect the highly diversified nature of the U.S. financial system and focuses on banks, mutual and money market funds, insurance companies as well as cross-institutional and cross-sectoral linkages and exposures.

The U.S. financial landscape has experienced significant transformation since the global financial crisis as financial intermediation and concomitant risks increasingly shift to non-bank financial institutions. Banking regulation and supervision have been overhauled and large banks have strengthened their capital and liquidity buffers. The financial sector has seen significant deleveraging, with the sector’s indebtedness falling from 125 percent of GDP at the height of the Global Financial Crisis (GFC) to about 77 percent currently. This process was accompanied by the growing role played by the non-bank financial intermediaries. These institutions are supplying a significant proportion of credit to the economy as well as providing liquidity transformation. Many of these intermediaries provide funding to households and nonfinancial corporates. Funding provided by the non-banks is growing faster than funding provided by depositary institutions. At the same time, non-bank intermediaries often depend on banks for liquidity and short-term funding.

The FSAP was conducted and this note was largely written prior to the pandemic onset and did not assess the impact of the shock and effectiveness of policy measures to mitigate that impact. Reflecting post-mission developments, baseline economic growth projections have been significantly revised downward in the April 2020 WEO and subsequently in the June 2020 WEO Update. The U.S. authorities implemented urgent measures to address health concerns, to safeguard economic and financial stability and to prevent adverse macrofinancial feedback loops. Nevertheless, the FSAP’s risk analysis remains broadly relevant. The data cut-off point for this note was Q3 2019, except for the interconnectedness and liquidity analysis performed in March 2020 and the banking sector solvency stress test that relies on Q1 2020 data and June 2020 economic forecasts.

For the past few years, corporate leverage was on the rise, especially among a growing number of highly leveraged firms, while household indebtedness has fallen substantially. Total business sector debt stood at about US$16 trillion (75 percent of GDP) at the end of 2019, with

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\(^1\) The work on the technical note was carried out between October 2019 and March 10, 2020, ahead of significant market disruptions caused by the spread of a new public health risk (COVID-19). The work was overseen by Peter Breuer and the authors are Carlos Caceres, Mindaugas Leika, Fabian Lipinsky, Dulani Seneviratne, Eva Yu (all IMF), and Antoine Bouveret, and Timo Broszeit (external consultants).
corporate sector debt (comprising corporate bond debt and bank loans) accounting for about two thirds. Easy financial conditions and the search for yield have been accompanied by a rapid increase in ‘leveraged finance’ to about 7 percent of total business sector debt—issuance of syndicated loans or non-investment grade bonds by highly-leveraged companies and related structured products, such as Collateralized Loan Obligations (CLOs). This segment has seen a rise in issuance with less covenant protections, and the solid performance of leveraged loans in recent years—characterized by low default rates—is being challenged by developments following the COVID-19 outbreak. Many nonfinancial firms remain vulnerable to changes in the availability and cost of funding and will likely face pressures from falling revenues due to the dual COVID-19 outbreak and oil price shock, most notably the energy sector. In contrast, households entered the crisis on a stronger footing. Total household debt declined from close to 100 percent of GDP at the onset of the crisis to about 75 percent currently. The reduction in indebtedness—and mortgage debt in particular—has been widespread across all income groups, with a large portion of new mortgage loans accruing to relatively high quality borrowers. Nevertheless, rising unemployment and faltering income will put pressure on households debt servicing capacity, particularly those working in hardest hit sectors (leisure, hospitality, transportation services), many of which tend to be relatively low-wage earners.

Risks could be spread through sizeable domestic exposures among banks and non-bank financial institutions, though links with foreign economies are relatively small. Intra-financial system interconnectedness analysis reveals that banks provide significant short-term funding to non-bank financial institutions, households and corporates. Unused credit lines and other funding commitments provided by banks constitute about 15 percent of intra-financial system exposures. At the same time, the U.S. banking system’s average capital impairment due to their exposure to foreign banking systems could be as low as 2 percent of regulatory capital. The U.S. banking system, however, has substantial interconnections with global financial markets including foreign banks.

Outward spillover risk is mitigated by large banks’ solid capital and liquidity buffers, which help to withstand severe economic and funding distress. Banks entered the COVID-19 outbreak well prepared: with substantial capital and liquidity buffers and ability to expand balance sheets to support the real sector. The systemwide Common Equity Tier 1 capital ratio (CET1) before the COVID-19 crisis was 12 percent on average and liquidity (LCR) ratios above 100 percent. Adding to this, banks are subject to a less procyclical (compared to the Internal Ratings Based approach) standardized approach to capital adequacy requirement calculation. In the baseline scenario, which follows the June 2020 WEO update, capitalization levels decline, but all G-SIBs stand above the regulatory minima. In the medium to long term (3 to 5 years), declines in interest rates and intensified pressure from the non-bank financial sector, especially Fintech firms, could lead to a compression of interest margins and loss in revenue from fees and commissions. To capture uncertainty related to the time profile and other specifics of the COVID-19 shock, the FSAP simulated multiple adverse sensitivity scenarios in conjunction with the baseline scenario. In the baseline scenario, industry-wide CET1 ratios decline by 390 basis points on average, reaching their lowest point after 2 years of stress. Smaller, non-G-SIB banks experience the largest impact. If the recovery is as fast as projected in the baseline scenario, the impact on CET1 ratios by the end of the 5-year horizon would be 50 basis points. The declines in the systemwide CET1 ratio in the outer
years are mostly driven by a decline in net interest income due to compressed margins. In the adverse sensitivity scenario, which assumes an additional month of containment measures, median capitalization at the lowest point of the horizon is 7.6 percent, which is lower than the CET1 ratio under the baseline by 190 basis points. In the case of a more severe recession, such as a second wave of infection and subsequent contagion measures, the impact on the systemwide CET1 ratio at its lowest point would be 450 basis points compared to the baseline and 630 basis points compared to the median CET1 ratio at Q1 2020. Nevertheless, all G-SIBs would maintain CET1 ratios above the minimum regulatory requirements.

**Interconnectedness analysis indicates that G-SIBs’ exposure to each other’s solvency and liquidity stress can be contained, but vulnerabilities in Non-Global Systemically Important Banks (Non-GSIBs) tend to increase.** Illiquidity or default of a G-SIBs would affect other banks via counterparty losses, liquidity shocks and asset fire-sales. A joint IMF-FRB analysis indicates that these effects are relatively small within the group of 6 G-SIBs. However, vulnerabilities in smaller banks could increase as they ramp-up risk taking and reduce liquidity buffers in the context of recent regulatory relief. The stress test results indicate that in times of market shocks these banks may struggle to provide liquidity to customers.

**Corporate sector stress could have a considerable impact on the non-bank financial sector and a moderate impact on banks.** A large proportion of corporate sector debt resides outside of the banking sector, including in insurance companies, mutual funds, pension funds, and foreign investors. Over half of leveraged loans outstanding are owned by CLOs, which are in turn held by a wide range of investors, with banks mainly holding the AAA-rated tranches. Stress in the corporate sector would result in significant losses in the non-bank financial sector, especially holders of equity tranches, resulting in some funding redemption pressures for open-ended funds, albeit fire-sales channel would be contained by the contractual structure of CLOs funds. Even in such a scenario, marked-to-market losses would be contained, with the impact on banks being moderate by virtue of their limited direct exposure.

**Mutual funds stress tests conducted by IMF staff indicate that most funds would be able to withstand severe redemption shocks, but high yield and loan mutual funds would face significant shortfalls.** More than 90 percent of funds (measured by assets under management) would have enough highly liquid assets to meet investors’ redemption. However, funds exposed to high yield and leveraged loans would need to sell less liquid securities in their portfolio, (assuming that they do not use any liquidity risk management tools), potentially giving rise to fire sale dynamics. Funds with large exposures to derivatives could face liquidity demands related to variation margins depending on market conditions. Sensitivity analysis shows that potential variation margin calls could be higher than their liquid assets, increasing the potential risk of forced sales.

**While the insurance sector appears resilient to a severe market shock, its profitability is vulnerable in a scenario of continued low interest rates and rising corporate defaults.** The

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2 Banks’ exposure to the corporate sector is largely through commercial and industrial (C&I) loans.
stress test covered more than 70 percent of the life and non-life market by assets and included smaller, regionally concentrated non-life firms. A materialization of the adverse scenario would have a substantial balance sheet impact, especially in the life sector, stemming from impairments on shares, non-investment grade debt, and other investment assets. While current buffers as well as the valuation and solvency regime would prevent major disruptions, persistently low interest rates are expected to further erode profitability of life insurers. In turn, a large interest rate hike, triggering a mass lapse and large cash outflows from the life sector, would affect insurers very heterogeneously: some insurers would need to liquidate only small amounts of Treasury bonds, but a few would have to liquidate larger amounts of assets, including potentially less liquid corporate bonds.

**Climate related risks would have a relatively contained impact on the financial system in the near term, but some companies and segments, like insurers, municipal bond market would be affected more.** A very severe hurricane (expected to occur every 250 years) would have a major impact on companies and households in affected regions, but large and diversified non-life insurers would have enough capital to pay out compensations. Several smaller and more regionally concentrated insurers would face capital shortfalls. Overall impact estimates fall under a wide range considering increased probabilities of extreme weather events and potential damages. Further impact may come from insurers leaving affected regions, a deterioration of income of affected municipalities and a negative impact on municipal bond market.

**While the U.S. financial system’s resilience is strengthened by diversified sources of credit to the economy, the potential system-wide impact of valuation losses of corporate debt securities and leveraged loans is not easily quantifiable and may be non-negligible.** The migration of activities from well-regulated, public and transparent financial institutions, such as banks, towards more opaque, private and unsupervised entities creates challenges for the identification and assessment of systemic risks. Public data is scarce on exposures of regulated financial institutions as well as the ultimate risk holders of leveraged loans and associated securitization vehicles. Greater transparency about those exposures would strengthen market discipline and allow for constant assessment of systemic risk. Results of a system-wide interconnectedness stress test confirm that some corporate bond mutual funds and insurers may have considerable direct losses in the scenario of distress in corporate debt markets. Banks, however, would experience smaller losses because of their limited exposure to the sector, except for potentially higher credit line drawdowns by corporates and non-bank financial institutions.
INTRODUCTION

A. Objective

1. The objective of the risk analysis component of the FSAP is to identify macrofinancial vulnerabilities. The analysis identifies and quantifies risks which could potentially lead to severe disruptions in the provision of financial services in the U.S., including international spillovers via U.S. financial companies’ exposures abroad.

2. The approach to the systemic risk assessment reflects the high degree of complexity and cross-sectoral interconnectedness of the U.S. financial sector. The FSAP team analyzed links among banks, insurers and asset management industry, as well as characteristics of financial companies’ exposures, and different business models, such as global diversification. Holdings of similar securities, exposures to specific asset classes (such as collateralized loan obligations, asset backed securities) were considered in designing the stress test methodology as well as the scenarios.

3. A comprehensive set of risk analyses and stress tests was conducted to assess the resilience of the U.S. financial system and shed light on linkages and potential risks and vulnerabilities. The assessment is based on multiple individual stress tests, which simulate the financial health of banks, mutual funds, and insurers under severe yet plausible (counterfactual) adverse scenarios and various sensitivity tests. The stress tests are largely independent but linked via scenarios where possible. Scenarios include global and regional financial market stress (shocks to term and risk premiums and resulting asset price corrections) and a major slowdown of economic activity. This risk analysis relies on models and approaches designed by the FSAP team for solvency (banks, insurance companies), liquidity (banks, mutual, money market funds) and solvency-liquidity feedback analysis (fire-sales of assets across the financial sector). The approach is thus different from the ones employed by the U.S. regulatory agencies.

4. This note provides a comprehensive overview of all qualitative and quantitative work done by the U.S. FSAP Systemic Risk team. The note is structured as follows: The first section describes key structural features of the U.S. financial system, including interlinkages within domestic sectors and foreign jurisdictions. The second section analyzes key risks and vulnerabilities. Scenarios provide qualitative assessment of risks and quantification of shocks. The following sections discuss the impact of potential shocks on nonfinancial corporates, banks, insurers, mutual and money market funds. The note concludes with a systemic risk overview and an analysis of interconnectedness across various parts of financial system. The appendices provide further technical and analytical details of some of the approaches and models developed.

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3 We only refer to consolidated banking groups at the level of bank holding companies referred as banks in this note.

4 Rapid developments during the COVID-19 crisis prevented updating all individual stress tests with the new scenarios.
B. Stress Testing Work Done by the Authorities

5. The Federal Reserve supervisory stress tests project the impact of the macroeconomic scenarios on banks’ capital position and income using granular models and confidential supervisory data. By contrast, the FSAP stress test are broader and focus on system-wide risks. For banks, the FSAP stress test is a top-down exercise mostly relying on public and non-confidential data as well as scenarios generated by in-house models developed by the FSAP team.5 Relative to the Federal Reserve’s regulatory stress test (CCAR/DFAST), while both the FSAP and the Federal Reserve scenarios broadly share a consistent narrative of risks, they differ in terms of the granularity of data inputs, the calibration of the various shocks and models used. Hence, the Federal Reserve and IMF top-down stress test bank solvency stress testing results are not directly comparable. Stress Testing Matrix (Appendix I) provides further details about FSAP Stress Testing models and assumptions.

6. Mutual funds are not subject to stress testing requirements (with the exception of Money Market Funds) by their managers or by the SEC. Recently, the SEC has proposed that funds using derivatives would be required to perform stress tests.

7. While U.S. authorities perform and are developing a variety of stress tests and analyses, they do not regularly conduct macrofinancial stress tests for the insurance sector. As part of the solvency regime, companies are required to calculate the impact of various natural disasters, and to conduct various sensitivity analyses for their interest rate risks (liability adequacy test). The NAIC is currently developing a liquidity stress test which is expected to be applicable to certain large insurance companies at end-2021. A few state supervisors, e.g., California, have conducted climate-related stress tests, also looking into the transitional risk of carbon-intense investments. Furthermore, the NAIC conducts market-wide exposure studies for various asset classes, e.g., CLOs, on an ad-hoc basis.

C. Risk Analysis and Stress Testing under the U.S. FSAP Program

8. The risk analysis covers multiple types of financial institutions and places strong emphasis on domestic and foreign exposures-based interconnectedness. Risk analysis conducted a battery of stress tests of banks (34 largest institutions), insurance companies (53 large groups and 17 medium-sized and smaller regional insurers), mutual funds (about 2,000 largest players) and selected money market funds (208). The selection is based on the size of banks (assets more than USD 100 billion)6 and insurers (the insurance stress test aimed at a coverage of at least 70 percent of the life and the non-life sectors, comparable to most recent FSAPs also with the aim of having representative sample across different types of insurers).7 Mutual fund stress tests included

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5 Following common practice in FSAPs, the baseline scenario follows the projections published in the IMF’s June 2020 World Economic Outlook (WEO) Update.
6 33 banks with assets above USD 100 billion and one bank with assets close to 100 billion.
7 The inclusion of smaller property & casualty insurers was motivated by concerns about regionally concentrated companies and their exposure to natural disasters.
all fixed income and mixed mutual funds covered by Morningstar. Interconnectedness and systemic risk analysis links stand-alone stress tests. Common exposures and simulated asset fire-sales provide system-wide stressed loss estimates. The exercise gauges the level of resilience of the financial system against simulated severe yet plausible macro and financial shocks.

9. **Like in other FSAPs in large advanced economies, the IMF scenario design is based on multiple approaches and severity benchmarks.** The FSAP team used WEO baseline projections, which included assumptions about duration and severity of COVID-19 crisis, inference about severity from 2019 DFAST/CCAR scenarios, and the 2008–2009 Global Financial Crisis (GFC).

10. **Analytical approaches in FSAP risk analysis are divided into multiple blocks (Figure 1).** The risk analysis covers solvency of banks and insurers, limited (because of data availability) liquidity analysis of banks and mutual and money market funds. Sectoral risk assessment, scenario design and interconnectedness provide an envelope for linking various risks together. Systemic risk analysis relies on a set of models developed by FSAP team.

11. **This technical note reflects discussions, presentations and consultations with the authorities, private sector and data sources available to the team.** Some analyses (banking sector interconnectedness) were undertaken in close collaboration with the FRB staff to preserve confidentiality of the underlying input data based on supervisory reports. The analysis is nevertheless the IMF’s work product and does not reflect the views of the U.S. regulators.

12. **The FSAP team used various public and commercial data sources to perform the analysis and cooperated with the FRB on banking sector interconnectedness and liquidity analysis.** Full-fledged market and liquidity risk analysis of banks and mutual funds typically requires access to supervisory data. The U.S. regulatory agencies require supervised and regulated institutions to publish large amounts of data which otherwise are considered confidential in many other jurisdictions. This enabled the FSAP team to perform analysis of banks, mutual and money market funds using public data. The results need to be interpreted with caution, however, as the FSAP team was unable to conduct a granular stress test of trading books which considers issues such as portfolio hedges and short positions, and also incorporates potential changes in banks’ balance sheets. Insurance stress testing was based on confidential supervisory data. Liquidity stress test of banks are based on public 30-day Liquidity Coverage Ratio (LCR) disclosure templates and omits other time horizons, namely 1 day, 5 days, or 3 months typically employed in other systemic jurisdictions.\(^8\) Structural liquidity risk analysis did not elaborate on Asset Encumbrance because such data were not available.

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\(^8\) Except for liquidity risks for six G-SIBs for which the test was performed by the FRB using supervisory data.
Figure 1. United States: FSAP Systemic Risk Assessment Framework

USA FSAP Systemic Risk Assessment Framework: systemic risk analysis

<table>
<thead>
<tr>
<th>Solvency of Banks</th>
<th>Solvency of Insurers</th>
<th>Liquidity of banks, mutual and money market funds</th>
<th>Interconnectedness</th>
<th>Scenario design and sectoral risk assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance-sheet regulatory approach based on exposures (domestic/foreign).</td>
<td>Balance-sheet regulatory approach based on exposures (aligned with macrofinancial scenarios used for the banking ST.).</td>
<td>Bank liquidity (limited analysis using public data: LCR disclosure reports 33 banks; 8 G-SIBs; 9 subsidiaries of foreign banks and 16 other domestic banks.).</td>
<td>Cross-sectoral exposures (flow of funds among the different econ sectors: financials, households, corporates, public sector, foreign entities).</td>
<td>Scenario design and macro conditions: COVID-19 Baseline and the three Adverse scenarios based on duration of containment measures and a second wave of contagion.</td>
</tr>
<tr>
<td>Forecast of balance sheet and income statement items. 57 equations based on the refined CLASS model. Three or five year ST horizon.</td>
<td>Forecast of pre-loss income, credit and market losses, changes in RWAs based on refined CLASS model as well as internal models and sensitivity analyses. (e.g., real estate price risk). Risks from common exposures (fire-sales of assets).</td>
<td>Sensitivity analyses (e.g., interest rate shocks, default of largest banking counterparties). Coverage: 70 insurance groups.</td>
<td>Sensitivity analyses (e.g., interest rate shocks, default of largest banking counterparties). Coverage: 70 insurance groups.</td>
<td>Housing sector analysis: Expansion of non-bank mortgage lenders.</td>
</tr>
</tbody>
</table>

Source: IMF staff.

FINANCIAL SYSTEM: RISKS AND VULNERABILITIES

A. Financial System Structure and Performance

The U.S. Financial System: An Overview

13. The U.S. financial sector is one of the largest and most complex financial systems in the world (Figure 2). The size of the financial system surpassed US$100 trillion in 2019 and amounts to about five times the U.S. nominal GDP. The U.S. banking sector is one of the largest in the world, although private depository corporations account for about 20 percent of the financial system reflecting the deep and liquid capital markets. Pension funds, MMFs and mutual funds, and insurance industries are also sizable. The mutual funds sector, which encountered a sharp decline in its balance sheet size during the GFC, has now surpassed its pre-crisis peak reaching 16 percent of the financial sector share as of 2019 (Appendix Figures VII.1–3).

14. The U.S. financial system is well diversified: it allocates savings, investments and provides capital through a vast number of financial institutions and instruments. Diversification creates resilience against sudden stop of credit flow via one type of institution (e.g., banks). Capital is allocated via deep and liquid capital markets with equity market capitalization above US$50 trillion (as of 2019) and sizable debt securities markets in addition to loans and deposits. Financial instruments also include personal investment products such as pension entitlements, with assets about US$30 trillion. Mortgages—home, multi-family residential, commercial, and farm mortgages—also remain sizable at about US$15 trillion as of 2019.

15. The systemic importance of the U.S. financial system remains high in the global financial landscape, in part owing to the safe heaven assets and the strength of the U.S. dollar. The demand for safe heaven assets from global investors remained high against the backdrop of external vulnerabilities. For instance, the average daily trading volume of U.S. Treasury
securities grew by 10 percent year-over-year in 2019, reaching nearly US$600 billion per day on average. Overall, the portfolio investment position of foreign residents on the U.S. amounted to above US$20 trillion in 2019, while U.S. residents' portfolio investment position in the rest of the world was over US$12 trillion. Owing to the reserve currency status of the U.S. dollar in the global trade and financial landscape, financial institutions including foreign-owned entities carry-out lending in U.S. dollars and participate in U.S. dollar funding markets as well as rely on foreign exchange swaps vis-à-vis the U.S. dollar. The share of dollar-denominated cross-border claims amounted to about 50 percent of global banks' total cross-border claims in 2019. Foreign-owned banks maintain dollar-denominated cross-border claims over US$12 trillion, amounting to about 10 percent of their cross-border claims on average (October 2019 GFSR Chapter 5).

Banking Sector

16. The U.S. banking system has grown in size, even as banks consolidated over time. The system has undergone numerous mergers and acquisitions in addition to a few bank failures,
UNITED STATES

bringing down the number of banks operating in the system to less than 5,000 from over 10,000 that existed at the end of the last millennium. The U.S. banking system is now dominated by 34 large bank/intermediate holding companies (BHCs/IHCs)\(^9\) with consolidated assets over US$100 billion each, accounting for nearly 80 percent of U.S. banking system assets. The banking system is home to eight globally systemically important banks (G-SIBs), that hold more than 50 percent of banking system assets. The list of 34 banks also includes 12 large intermediate holding companies (IHC) (i.e., foreign-owned). Four IHCs among these are classified as \textit{large and complex} when combined with their branch operations and are supervised under the Federal Reserve’s Large Institution Supervision Coordinating Committee (LISCC) along with the eight G-SIBs. The rest of the holding companies among the 34 are domestically owned large entities, termed “Non-Global Systemically Important Banks” (Non-GSIBs) for the purposes of this note.

17. **Assets of the largest BHCs in the stress testing sample have increased by 23 percent since the 2015 U.S. FSAP.** While the total contribution of the banking sector towards credit provision to corporate and household sectors is falling in relative terms, the largest contributing factor for the growth in their assets (10 percent) is net loans and leases. Net loans and leases are also the largest component of banks’ balance sheets (40 percent of total assets). Growth in trading assets and remaining non-tradeable securities portfolios was more modest. Highly liquid federal funds assets and reverse repos, account nearly 12 percent of total assets. The search for yield contributed for the decline in the share of cash and balances with the central banks, which accounted for 12 percent of the balance sheet during the previous FSAP, but now accounts for only 8 percent.\(^10\)

18. **Loans outstanding have increased steadily by 26 percent since the last FSAP, owing to the robust growth in commercial and industrial (C&I) and commercial real estate (CRE) categories.** Real estate loans remain the largest component in banks’ loan book at 35 percent of total loans, contributing 5 percent towards the total loan growth. The second largest loan component, C&I, accounts for 24 percent of total loans, contributing 8 percent to the overall loan growth. While the underwriting standards for loans in this category has slightly tightened in 2019, growth in some C&I loan subcategories such as leverage loans experienced decline in covenants. Credit card-related loans, which have the highest loss rate, account for 11 percent of the total loan

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\(^9\) These 34 institutions broadly align with, but do not exactly match, the set of domestic bank holding companies and intermediate holding companies listed in the October 2019 FRB-OCC-FDIC final rule on tailoring: https://www.federalreserve.gov/aboutthefed/boardmeetings/files/tailoring-rule-visual-20191010.pdf. See also Appendix V, Table V.1., for a listing of the 34 banks included in this FSAP’s stress testing analysis.

\(^10\) See Appendix Figures IV.4–IV.7 for banking sector performance.
portfolio. Automobile loans and other consumer loan categories account for 10 percent of the loan portfolio.

19. **Banks’ funding to a large extent remains domestic and the share of stable funding increased.** Liabilities of the largest banks increased, mostly due to the growth in domestic deposits which account for 52 percent of the total liabilities. Growth in deposits have allowed to keep unsecured wholesale funding growth (captured through other borrowed funds) contained. Other borrowed funds still account for 15 percent of total assets. Federal funds and repos also account for nearly 9 percent of the total liabilities and have contributed nearly 3 percent to the growth in total liabilities.

20. **Banks maintained robust levels of capital, with the CET1 ratio doubling compared to pre-GFC levels and reaching 12 percent at the aggregate level as of 2019Q3.** The increase in CET1 is mostly attributed to the steady growth in retained earnings, amidst higher risk weighted asset levels banks are required to maintain. Significant disparities in CET1 ratios, however, exist among banks, where most IHCs record significantly higher CET1 ratios compared to domestic banks in the sample. The leverage ratio (i.e., Tier1 capital-to-assets) also increased significantly since the pre-crisis levels, reaching about 8.7 percent as of 2019:Q3.

21. **Off-balance sheet exposures relative to the size of the balance sheet have declined by a factor of about three since 2009 mainly due to lower derivatives positions, but credit line commitments remained stable as of 2019 (Appendix VII).** Total gross off-balance sheet activities accounted for about 110 percent of total assets in 2019. Both, credit derivatives purchased and sold have significantly declined since the crisis from over 100 percent to low double-digit levels.\(^{11}\) Unused credit line commitments relative to balance sheet size remain above 40 percent and are the largest off-balance sheet exposure category (see Appendix VII Figure 4)\(^{12}\). Increase in credit line utilization by corporates and households is expected during economic downturns, hence banks need to have adequate liquid assets to be able to meet those financing commitments without imposing liquidity shocks to the real sector. For instance, based on 8-k filings, credit line utilization between March-mid April 2020 had surpassed $200 billion.

22. **Asset quality of the bank holding companies has improved significantly since the GFC, while underwriting standards for most loan categories show a slight tightening in 2019.** Non-

\(^{11}\) The decline was to a large extent driven by migration of derivatives to Central Clearing Counterparties (CCP), which allowed banks to net exposure against CCP.

\(^{12}\) Rest of the off-balance sheet exposures include credit derivatives purchased (16 percent at of 2019:Q3), credit derivatives sold (14 percent), spot foreign exchange contracts (12 percent), securities lent (9 percent), securities borrowed (7 percent), and letters of credit and guarantees (4 percent).
performing loans (NPLs) of the 35 largest BHCs have substantially declined reaching the lowest levels seen. The NPLs-to-gross loan ratio for delinquencies longer than 90 days fell below 1 percent in 2019. Past due loans of 30 to 89 days also depict similar trends. Moreover, BHCs maintain ample reserves against NPLs, with the reserve-coverage-ratio (i.e., allowances for reserves over the stock of NPLs) steadily increasing in recent years. NPL ratios by loan category reveal relatively higher NPL ratios related to residential real estate loans, albeit the asset quality of this category has significantly improved since the crisis. On the contrary, NPLs on consumer loans show a slight uptick in recent years, calling for continued vigilance in maintaining asset quality.

23. Large banks continue to maintain sound profitability levels, including when compared internationally, owing to favorable macroeconomic conditions. Banks have maintained robust levels of interest income amidst the low interest rate environment and have maintained healthy levels of non-interest income. While non-interest expenses have risen since the crisis, provisions have declined since then. A major contributing factor for the latter is the significantly lower levels of net charge-off levels incurred by the largest banks. Moreover, a sharp rise in profitability was recorded starting 2018 due to the reduction in the corporate tax rate in late 2017, by increasing the return on equity (ROE) of these large banks by about 4 percentage points on average. However, significant dispersion in profitability across banks exists, with foreign banks on average recording lower profitability ratios. Overall, sound profitability conditions have enabled the U.S. banks to maintain regulatory capital levels that are twice as high as the pre-GFC levels.

Mutual and Money Market Funds Sector

24. Fixed income and mixed funds play a significant role in credit intermediation and liquidity transformation. Funds invest in a range of asset classes, including corporate bonds and leveraged loans, thereby providing financing to the real economy. Mutual funds hold more than 15 percent of all U.S. corporate bonds outstanding and about 10 percent of leveraged loans. At the same time, mutual funds play a key role in liquidity transformation by offering daily liquidity to investors.
25. **Some mutual funds can be exposed to a liquidity mismatch.** While the liquidity of funds’ holdings vary, all mutual funds offer daily redemptions to investors. Funds that are significantly invested in potentially less liquid securities, have not effectively managed their liquidity risk and are faced with significant investor redemption demands could be forced to sell assets to meet redemptions. If significant in the aggregate, these sales could contribute to declines in asset prices. For funds using derivatives, liquidity demands can also arise from mark-to-market losses on derivatives exposures, resulting in variation margins. In that context, mutual funds are subject to regulatory requirements related to liquidity risk as well as limits on the use of leverage. Requirements include the need by funds to establish a written liquidity risk management program reasonably designed to assess, manage, and periodically review the fund’s liquidity risk, including under reasonably foreseeable stressed conditions, and generally, to maintain a minimum amount of highly liquid assets; and to limit purchases of illiquid assets to 15 percent of the fund’s net assets.

26. **While most funds make limited use of leverage, some funds have large exposures through the use of derivatives.** Under current rules, mutual funds are only allowed to borrow from banks up to 50 percent of their net asset value, resulting in a maximum balance sheet leverage of 1.5x. However, mutual funds can use derivatives for hedging and also to get exposures to underlying markets, which can result in an increase in synthetic leverage (due to the use of derivatives). According to the SEC (2019), about 60 percent of mutual funds do not use derivatives and 20 percent of mutual funds have adjusted notional amounts above 10 percent of NAV. However, some funds rely heavily on the use of derivatives, which could allow the build-up of a high level of synthetic leverage. The SEC reports that about 14 percent of mutual funds have gross exposures above 50 percent of their NAV. Based on commercial data on fixed income and FX derivatives only, some mutual funds report gross leverage more than four times the NAV (Figure 3).
Some funds have large exposures through the use of derivatives. 42 percent of life insurance sector assets are held in segregated accounts; in the general account, corporate bonds dominate.

Bond maturities are longest in life insurance, as can be expected, with 38 percent of bonds having a maturity of 10 years or more. More than 90 percent of corporate bonds in each sector have an investment grade rating (NAIC 1 and 2).

Notes: Stress test sample only. Sovereign bonds include sub-sovereigns and government-sponsored entities. Source: IMF staff calculations based on NAIC data.
Insurance Sector

27. The U.S. life and health insurance sector is exposed to significant interest rate risks, and has furthermore expanded into less liquid assets. U.S. life insurers actively underwrite long-term annuity products with liability durations exceeding asset durations. The risk-based capital framework includes (mostly factor-based) capital charges associated with asset-liability mismatches. Still, the recent less restrictive stance of the U.S. monetary policy could have a negative impact on life and health insurers with large duration gaps. If long-term interest rates stay low for long, the accounting and solvency positions of life and health insurers would deteriorate gradually but significantly over time.

28. Market risks in life insurance are to a large extent shifted to policyholders in segregated accounts and are rather diversified in the general account (Figure 3, panels 2–4). Segregated accounts represent 42 percent of the life sector’s balance sheet. The remainder (general account) comprises corporate and sovereign bonds with 30 percent and 9 percent, respectively. Equity investments play a minor role in the general account, while corporate bonds are the dominant asset class. Most insurers’ investments are still liquid, but life insurers are taking on more liquidity risks by allocating 8 percent of total assets to mortgages and being important buyers of CLOs. The asset allocation of the non-life sector appears to be more biased towards equity exposures, however this is mainly driven by very few large outliers. Health insurance is mostly a cash-flow business, so investments are typically very liquid and less risky.

The Interconnectedness Landscape

29. The resilience of the financial system depends on the financial health of individual institutions and the interplay of vulnerabilities through direct and indirect exposures within and between segments of the financial system. These exposures can result in amplification or, mitigation of shock transmission. Understanding contagion risks and channels is thus key to the assessment of systemic risk. In addition to the direct interconnectedness between the financial sector agents such as banks, insurance, pension funds, money market and mutual funds, sectors are indirectly interconnected through exposures to common asset classes, such as corporate bonds, equities, agency and treasury securities markets. The exposures to the common asset classes amplify the risk transmission when vulnerabilities arise in one financial subsector through significant marked-to-market losses.

30. The U.S. financial sector is highly connected with the real economy, where credit provisioning remains well diversified. Relatively large share of financial assets of the domestic financial sector is held by household and corporate sectors, while the largest asset share is held within the financial sector (Figure 4, panel 1). The largest proportion of the financial assets of households is also held by the financial sector followed by the corporate sector. In fact, households’ financial assets issued by the financial sector is the largest linkage between any two sectors (see Figure 4 heatmap). Moreover, within the financial sector, non-banks also have large exposures to households. For instance, about two-thirds of the residential real estate loans are held by the non-bank entities (Figure 4, panel 3). Among the 25 largest mortgage originators and servicers, non-
banks currently originate 51 percent of mortgages and service 47 percent (FSOC annual report, 2019). The non-bank financial sector also plays a pivotal role in corporate sector financing, thus maintaining larger exposure levels vis-à-vis the domestic corporate sector (Figure 4, panel 3).

**Figure 4. United States: Macrofinancial Linkages**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households and Nonprofit Organizations</td>
<td>Households and Nonprofit Organizations</td>
</tr>
<tr>
<td>Nonfinancial Business</td>
<td></td>
</tr>
<tr>
<td>Federal Government</td>
<td></td>
</tr>
<tr>
<td>State and Local Governments</td>
<td></td>
</tr>
<tr>
<td>Domestic Financial Sectors</td>
<td></td>
</tr>
<tr>
<td>Rest of the World</td>
<td></td>
</tr>
</tbody>
</table>

**Illustration of Cross-Sectoral Exposures**

(In trillions of US dollars)

<table>
<thead>
<tr>
<th></th>
<th>Banks</th>
<th>Non-bank Financial Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortgages</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Consumer Credit</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bonds</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Other Loans</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>C&amp;I and Other Mortgages</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Sources: FRB, Flow of funds.
Note: Data as of 2018:Q4 except for panel 3 with the illustration (as of 2019:Q3). Panel 1: Node size in reflects the intra-sectoral flow of funds. Edge color in the network map denotes the assets of the sector with the same colored node vis-à-vis the other sector (i.e., liabilities of the other sector). Edge width illustrates the relative size of the linkages between two sectors. Panel 2: Colors in the heatmap are based on the size of the linkages, where red denotes largest linkages and darker shades of green denoting smallest linkages.
31. Financial subsectors are interconnected through their cross-exposures to numerous financial instruments (Figures 5, 6). The insurance sector held nearly 26 percent of corporate bond, while mutual funds held nearly 17 percent of corporate bonds (Figure 6) as of year-end 2018. In addition, mutual funds and pension funds had over 60 percent and 20 percent of assets invested in equities respectively. Agencies and U.S. Treasury securities combined consist of half of the assets of money market funds balance sheet. From a direct intra-sectoral exposure standpoint, insurance sector has exposure to mutual funds, while mutual funds have exposure to banks through providing short-term funding. Such cross-exposures may amplify the transmission of spillovers through asset fire sales.

Figure 5. United States: Intra-Financial Sector Linkages

Pension funds

Banks

Other financial

GSEs

Monetary authority

Insurance

MMFs/MFs

Sources: FRB, Flow of funds.
Note: Data as of 2018:Q4. Node size reflects the intra-sectoral flow of funds. Edge color denotes the assets of the sector with the same colored node vis-à-vis the other sector (i.e., liabilities of the other sector). Edge width illustrates the relative size of the linkages between two sectors.
U.S. Banks Links to Domestic Financial Institutions

32. While the role of banks in providing long-term credit to corporates and households has diminished over time, banks still maintain a key role in distributing liquidity in the U.S. financial system. They offer payment services and liquidity support, other credit lines, hedging services to other banks, non-bank financial institutions. These on and off-balance sheet exposures could propagate shocks during stress times.

33. As expected, the G-SIBs are the key players in domestic financial system. Banks’ domestic interconnectedness indicators reveal strong intra-financial system exposures, reflecting the distribution of capital and liquidity within the system. From a systemic standpoint, G-SIBs maintain the largest assets and liabilities positions against the financial system (Figure 7, panel 1). Some of these banks provide specialized custodial, secured lending, settlement services, thus relate to virtually every other financial institution in the system.
34. Banks have sizable amounts of over-the-counter (OTC) derivatives and unused credit lines that are extended within the domestic financial system. Composition of assets and liabilities reveal significant linkages within the domestic financial system through deposits and OTC derivatives positions (Figure 7, panel 2). About one-half of the liabilities position comes from non-

Figure 7. United States: Banks’ Domestic Intra-Financial System Interconnectedness

Unused Portion of Committed Lines and Standby LCs Extended to Other Financial Institutions (In percent of bank’s exposure)

Banks’ Total Unused Position of Credit Lines vis-a-vis the Financial System (In billions of U.S. dollars)

Source: FRB, FR Y-15, and IMF staff calculations.
Note: Data as of 2019Q3. The size of the bubbles in panel 1 is based on the total exposure; total exposure includes on-balance sheet exposures, derivatives and repo-style transactions exposures, and other off-balance sheet exposures. Bank names are anonymized.
bank deposits, while OTC derivatives suggest large positions are held against non-banks.\textsuperscript{13} Banks also have sizable amounts of unused credit lines in the network. On aggregate, about 15 percent of the total intra-financial exposures consists of unused credit lines. It is also evident that some banks have unused credit line commitments that are sizable even when measured against their total exposures (Figure 7, panel 3). While banks maintain such sizable unused credit line commitments vis-à-vis the financial system, the amount of unused credit lines obtained from the financial system is only about one-tenth of the amount extended. This suggests that the extended credit lines are mostly against the non-bank financial sector (Figure 7, panel 4). A rapid draw-down in such off-balance sheet commitments during stress episodes increase the potential for contagion.

**Cross-Border Interconnectedness of the U.S. Banking Sector\textsuperscript{14}**

\textbf{35. Nearly a quarter of the U.S. banking system’s consolidated claims are held against foreign borrowers.} Consolidated claims based on residency of the ultimate borrowers show some pockets of concentrated exposures. Claims against borrowers in the United Kingdom and Japan stand out with each accounting for about 3 percent of total assets or 35 percent of Tier1 capital of the U.S. banking system, while claims on Germany, France, and Canada are also above 1 percent of the U.S. banks’ assets\textsuperscript{13} (Figure 8, panel 1). Foreign claims of the eight U.S. G-SIBs depict similar trends at aggregate level, with the United Kingdom and Japan accounting for about 4 percent of assets or nearly 50 percent of Tier1 capital of the eight G-SIBs as of 2019:Q3; claims on borrowers in Germany, France, and Canada also account for 1–3 percent of the eight G-SIBs’ assets. From a sectoral standpoint, U.S. banks’ claims vis-à-vis foreign non-bank financial sectors is the highest cross-border sectoral exposure category. Exposure to foreign non-bank financial sectors is at 8 percent of the U.S. banks’ assets. Exposure to foreign banking systems amount to 4 percent of the U.S. banks’ assets at aggregate level (Figure 8, panel 2). Among the exposures on foreign banking systems, the U.K. and Japanese banking systems are the largest counterparty banking systems.\textsuperscript{16}

\textsuperscript{13} Imbalance in derivatives net positive and net negative positions shows the portion of OTC derivatives position held outside the entities in the sample.

\textsuperscript{14} Data used in this descriptive analysis does not allow us to distinguish between secured and unsecured exposures as well as understand what type of collateral is used for secured exposures. Therefore, the analysis is based on very conservative assumptions that all of the exposures are unsecured.

\textsuperscript{15} The U.S. banks have sizable claims vis-à-vis the Cayman Islands as well; however, this analysis does not focus on exposures vis-à-vis the Cayman Islands given its status as an offshore center for many other counterparty economies.

\textsuperscript{16} While the presence of concentrated exposures per se may not give rise to contagion risks, the nature of the exposures would determine the potential vulnerabilities. For instance, contagion risks could arise if the repayment capacities of borrowers of unsecured claims (or those that are pledged with low-quality collateral) are severely hindered in stress episodes.
36. **U.S. banks are also interconnected with the rest of the world through cross-border off-balance sheet exposures.** Derivatives make up the largest share of cross-border off-balance sheet exposures, though unused commitments vis-à-vis foreign borrowers are also sizable. The latter, amounting to 5 percent of the U.S. banking system assets, may particularly increase the potential for vulnerabilities if borrowers rapidly draw down on unused credit lines during tight financial conditions. From a counterparty point of view, the largest off-balance sheet exposures are vis-à-vis the borrowers in the U.K., France, Germany, and Japan with exposures amounting to 5, 4, 3, and 2 percent of the U.S. banking system assets, respectively.

37. **Bank-level exposures identify several entities with large cross-exposures (i.e., presence of large cross-border claims and domestic intra-financial system liabilities).** In particular, some G-SIBs have large liabilities to the domestic financial system, while also maintaining large cross-border claims (Figure 8, panel 3). To a lesser intensity, some non-G-SIBs including intermediate holding companies (IHCs) also have relatively sizable cross-exposures (Figure 8, panel 4). These tendencies may warrant continued vigilance given the potential for cross-border spillovers to propagate into the domestic financial system through these entities' liabilities vis-à-vis the domestic financial system (e.g., due to deleveraging and asset fire sales). Bank-level exposures further reveal that banks' exposure vis-à-vis foreign banking systems are mostly concentrated in banking systems in the U.K., Japan, Germany, and Canada (Figure 8, panel 5). Moreover, a large proportion of IHC’ claims are concentrated in their parent banking systems.
UNITED STATES

**Figure 8. United States: Banks’ Claims Based on the Ultimate Risk of the Borrowers**

**Cross-Border Claims of U.S. Banks**
(In percent of U.S. banks’ assets; ultimate borrower risk basis)

- **Total internationally active banks**
- **Domestic GSIBs**


**Cross-Border Claims on Ultimate Risk Basis vs. Liabilities against Domestic Intra-Financial System: 2019Q3**

Source: FRB report FR Y15
Note: Data as of 2019Q3. Bubble size = total exposure of the entity.

**Cross-Border Claims of Non-GSIBs vs. Liabilities against Domestic Intra-Financial System: 2019Q3**

Source: FRB report FR Y15
Note: Data as of 2019Q3. Bubble size = total exposure of the entity.

**Banks’ Cross-Border Claims vis-à-vis Foreign Banking Systems on Ultimate Risk Basis**

Source: FFIEC 009a.
Note: Data as of 2019Q3. Edge width = proportion of BHC’s claims vis-à-vis the foreign banking systems.
38. Cross-border funding exposures at banking system-level reveal several important counterparties from the funding-side. Among the U.S. banking system’s consolidated liabilities to the top 10 counterparty banking systems, funding coming from the Japanese banking system is notably larger than the rest of the counterparties, followed by Canada (see purple arrows in Figure 9, panel 1). Further analyses using unconsolidated nationality-based exposures reveal large liabilities to the U.K. banking system, and to the German banking system to a lesser extent (see purple arrows in Figure 9, panel 2). These could be particularly relevant to these banking systems’ deposits held for FX transactions (e.g., U.S. dollar funding activities) and settlement purposes.

Figure 9. United States: Banks’ Claims

U.S. Banking Systems’ Largest Cross-Border Claims and Liabilities vis-à-vis Foreign Banking Systems on Consolidated Basis

U.S. Banking Systems’ Largest Cross-Border Claims and Liabilities vis-à-vis Foreign Banking Systems on Unconsolidated Basis

Sources: BIS consolidated claims on ultimate risk basis (panel 1); BIS unconsolidated claims and liabilities on nationality basis (panel 2).
Note: Data as of 2019Q2. Edge width = proportion of claims vis-à-vis the recipient banking system. Edge color = direction of claims; green arrows are the claims of the U.S. banking system on top 10 foreign banking systems, while purple edges are the claims of foreign banking system on the U.S. banking system (i.e., funding coming into the U.S. banking system).

17 Consolidated balance sheet data however may understate spillovers in the presence of heavy financial intermediation such as in the case of financial centers. To circumvent this, unconsolidated level balance sheet exposures are also explored using BIS locational nationality and residency basis datasets.
B. Resilience and Vulnerabilities of Borrowers

Household Sector Indebtedness and Resilience

39. **Households have continued to reduce their overall indebtedness over the past decade, driven by a large fall in housing-related leverage.** Residential mortgage debt has decreased substantially since the Global Financial Crisis (GFC) across all income groups, mortgage loan performance has been robust (with low delinquency rates, particularly for newly originated mortgages), and debt servicing costs have been falling and maturities extended as households refinanced their mortgages benefiting from low interest rates (Figure 10). That said, the mortgage market is large, with outstanding mortgages exceeding US$10 trillion (roughly 50 percent of GDP, or two-thirds of total household debt), and a deterioration in credit quality could adversely impact financial stability.

40. **Certain segments of consumer credit are rising rapidly.** Although still relatively small, student loans and some segments of consumer credit debt (auto loans) are on the rise—albeit a large part of that growth accrues to households with prime credit scores. Given that most student loans are issued under government programs, the risks to the financial institutions remain limited. That said, delinquencies on student loans remain high, underscoring pre-existing debt repayment pressures among certain households, most notably younger cohorts. The relatively small share of subprime debt in overall consumer debt is a relatively positive development. However, rising vulnerabilities in these sub-segments of household credit would still call for close monitoring, to ensure that these do not reach systemic proportions.

41. **Vulnerabilities in specific segments combined with adverse effects from the COVID-19 outbreak could put pressure on household debt-servicing capacity.** Notwithstanding the abovementioned vulnerabilities, households entered the current crisis with lower indebtedness levels than at the onset of the global financial crisis. House price deviations from fundamentals were significantly smaller too, as evidenced by lower house price-to-income and house price-to-rent ratios. However, the COVID-19 outbreak and related-containment measures are expected to have a significant impact on employment and income. In particular, if economic strains owing to long-lasting hysteresis effects and behavioral changes related to social-distancing norms leads to subdued demand, with significant output and employment losses in hard-hit sectors (e.g., entertainment, hospitality, transportation services)—which tend to have relatively low wages—could severely impact households ability to service their debt, particularly at the lower end of the income distribution.

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18 High-end service sectors, such as financial, legal, IT, and other professional & business services have experienced relatively small losses following the COVID-19 outbreak, in terms of both output and employment.
Figure 10. United States: Household Borrowing

Household and NFPO debt
(In percent of GDP)

Mortgage Debt Across Income Groups
(In percent of gross income)

Outstanding Household Debt
(In billions of U.S. dollars)

Recent Growth in Household Debt
(In percent change)

Household Debt Service Ratio
(In percent of disposable income)

Consumer Credit Debt Ratio
(In percent of disposable income)

Sources: FRBNY Consumer Credit Panel/Equifax; Haver Analytics; Bureau of Economic Analysis; PSID; and IMF staff estimates.

Notes: NFPO = Not-For-Profit Organizations.
42. **The government continues to play a central role in the U.S. housing market.** The Government-Sponsored Enterprises (GSEs)—most notably, Freddie Mac and Fannie Mae—currently own or guarantee about half of all mortgages. In the early 1980s, the GSEs owned or guaranteed about 8 percent of outstanding single-family mortgage debt. That share grew to 25 percent by the end of that decade and to 44 percent in the early 2000s, close to where it currently stands. Likewise, the share of outstanding multifamily debt owned or guaranteed by the GSEs grew from 25 percent at the onset of the global financial crisis to about 40 percent currently. Moreover, the GSEs—together with Ginnie Mae—dominate the MBS market, with outstanding MBS guaranteed by these entities of more than US$8 trillion, representing about 85 percent of that market.19 Moreover, the market for MBS guaranteed by these entities is one of the most liquid fixed income markets worldwide, with average daily trade volumes exceeding US$200 billion. Given the size of the market, any reform to the housing finance market, could have significant financial depth and stability implications.

43. **Non-bank lenders are important players in the mortgage loan market.** The share of mortgages originated by non-depository mortgage companies has increased in recent years. Non-bank mortgage lenders’ business model has also become more complex, with their range of activities including origination, loan servicing, as well as securitization of MBS. Their operations rely heavily on short-term credit lines for mortgage origination, which are subject to liquidity risks in periods of stress. In addition to the risks posed by their capital structure—with limited buffers to absorb adverse shocks—loan defaults pose additional liquidity risks, as servicers are usually required to comply with tax and insurance payments related to delinquent borrowers and, at times, make mortgage payments to MBS investors (“servicing advances”) even when a borrower does not make a payment. Given their growing share of the market and complex interlinkages with the broader financial system, non-bank mortgage lenders could be a source of risk (see Box 2 of the 2020 FSAP FSSA).

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19 The GSEs and Ginnie Mae guarantee the timely principal and interest payment of these MBS, and benefit from an implicit—explicit in the case of Ginnie Mae—government guarantee.
Corporate Sector Indebtedness and Resilience

44. **Nonfinancial corporate sector debt in the U.S. is at a historic peak.** Debt of nonfinancial corporates (NFCs) in the United States—at 47 percent of GDP—has surpassed the 2009 peak of 44 percent (Figure 11). Total debt of the business sector, i.e., including noncorporate firms, mirrored the same pattern, rising from 65 percent of GDP in 2012 to almost 75 percent of GDP. Its current level is comparable to household and financial sector leverage. The largest share (about two-thirds) of nonfinancial corporate debt is in the form of corporate bonds and commercial paper, amounting to about US$6.5 trillion. The remaining is comprised of bank loans (C&I loans) and leveraged loans, among others. In addition, the amount of outstanding commercial real estate (CRE) loans exceeds US$2 trillion, but has been growing in line with the economy in recent times.

45. **The recent deterioration in corporate earnings caused the debt-to-earnings and the interest coverage ratios to creep up.** The ratio of corporate debt to earnings before interest and taxes (EBIT) improved in the years following the GFC but has recently shot up to about six (Figure 11). Similarly, the interest coverage ratio—ratio of EBIT to net interest expense—has weakened. In 2013–14, EBIT covered nearly seven times annual interest expense. That ratio stands at around five today, comparable to levels seen during the global financial crisis.
Figure 11. United States: Business Sector Borrowing

**Business Sector debt**
*(In percent of GDP)*

**Outstanding Business Sector Debt**
*(In billions of U.S. dollars)*

**Recent Growth in Business Sector Debt**
*(In percent change)*

**Debt Servicing Capacity Measures**
*(In ratios)*

**Leveraged-loan issuance by Debt-to-EBITDA**
*(In percent)*

**Share of Covenant-Lite Loans**
*(In percent of new issuances)*

Sources: FRB; Haver Analytics; PSID; and IMF staff estimates.

Notes: CRE = Commercial Real Estate; EBIT[DA] = Earnings Before Interest and Tax [Depreciation and Amortization].
C. Leveraged Finance: Leveraged Loans and CLOs

46. The recent flurry of borrowing by highly-leveraged corporates—the so-called “leveraged loans”—has emerged as a potential vulnerability. Both the historically high corporate borrowing and the concentrated increase in debt among the riskiest firms were highlighted as important vulnerabilities in the Federal Reserve’s November 2019 Financial Stability Report and the IMF’s recent Global Financial Stability Reports. The low interest rate environment has created an opportunity for highly leveraged corporates to obtain funding as investors accept greater risks in search of higher returns. The United States, which accounts for over 80 percent of global issuances, saw peak annual issuance of leveraged loans in 2017 at US$650 billion. Issuance volume has since come down, with US$491 billion issued in 2019. Institutional loans, i.e., those made by non-bank institutional investors, make up the bulk of primary market issuances. Corporates typically use leveraged loans for mergers and acquisitions (M&A), refinancing, leveraged buyouts, and recapitalization. The sectors that account for the highest shares of leveraged loan issuances are computers & electronics, followed by healthcare and services & leasing.

47. While leveraged loans remain a small share of corporate borrowing, its nature and rapid growth have drawn comparisons with the subprime mortgage market. Outstanding leveraged loans, currently estimated at US$1.1 trillion (about 5 percent of GDP), constitute a small share of the US$15.8 trillion total debt owed by the nonfinancial business sector (in mid-2019). But, fueled by easy financial conditions and the search for yield, the market has been growing at an average annual growth rate of nearly 15 percent since dipping to US$497 billion in 2010. Some measures of leveraged loan (e.g., that published by the Bank of England) which also include smaller, less liquid loans extended by non-banks as well as loans held by banks put the estimated size of the leveraged loan market at US$2.2 trillion.

48. A steady erosion of credit quality and investor protection was becoming apparent in the leveraged loan market. The underlying vulnerability in this market is likely even greater than suggested by reportedly highly debt-to-EBITDA ratios. In recent years, companies increasingly used “add-backs,” which can include ill-defined items such as cost savings or synergies, to artificially boost their EBITDA and therefore lower their leverage ratio. Additionally, the borrower-friendly environment allowed for more leveraged loans to be issued without the traditional investor protections such as financial maintenance requirements that ensure the debt service capabilities of the borrower. These so-called ‘covenant-lite’ loans have accounted for more than half of new leveraged loan issuances in the U.S. market for the past four years (Figure 11). The concomitant deterioration in credit quality and investor protection would leave leveraged loan investors heavily exposed to a downturn in the corporate sector.

49. Related structured products such as Collateralized Loan Obligations (CLOs) have also fueled the leveraged loan growth. CLOs are special-purpose vehicles set up to invest in pools of leveraged loans. The pools are divided into tranches and sold to CLO investors. Of the US$1.1 trillion in outstanding leveraged loans, CLOs held roughly US$617 billion at end-2018. CLO investors are wide ranging and include, among others, U.S. and foreign banks, insurance companies, mutual funds, and pension funds. While data gaps impede a complete view of this market, estimates show
that CLO holdings are concentrated among insurance companies, mutual funds, and banks. At end-2018, insurance companies held 28 percent of the market, mutual funds 15.5 percent, and banks 15 percent.\(^{20}\)

50. **Banks have a complex interconnection with the overall leveraged loan market.** Banks are both directly and indirectly exposed to the leveraged loan market. Their direct exposure comes from the portion of the leveraged loans they originate and retain on their balance sheets as well as the revolving credit lines extended to leveraged corporates. Several channels indirectly connect banks to this market. Among these are loans in the form of “warehouse credit lines” to CLO arrangers to purchase leveraged loans.\(^{21}\) Banks additionally invest in CLOs—albeit largely in higher credit AAA tranches. Lower-rated CLO tranches are mainly held by asset managers, insurers, hedge funds, and structured credit funds, as well as foreign entities, some of whom may have credit lines with banks.

51. **A key concern is that the markets for leveraged loans and the associated CLOs, which have grown since the GFC, will experience significant stress during the ongoing macroeconomic downturn.** While regulatory and underwriting standards for securitized products like CLOs have been strengthened since the crisis, the markets and their interlinkages are complex. There is uncertainty about how resilient the products will be under prolonged stress. Moreover, CLOs which are held by a wide range of investors could prove to be an important channel for spillovers.

52. **The interplay between corporate vulnerabilities and the financial system is complex and can act through direct and indirect channels.** Banks’ direct exposure to corporate sector remains limited. Exposure to the leveraged loan market is mainly in the form of holdings of AAA-rate CLO tranches, and holdings of corporate bonds and commercial paper are relatively low following the global financial crisis and subsequent regulatory changes (e.g. Dodd-Frank Act). However, banks have important off-balance sheet commitments—mainly credit lines—provided to corporate clients estimated at around US$760 billion by the FSB, and facilities granted to CLO issuers for a smaller amount (around US$28 billion by end-2018 for U.S. banks). Funding liquidity stress, such as that observed at the onset of the COVID-19 outbreak, can trigger large uses of these credit lines by the corporate sector, potentially creating liquidity challenges for banks with lower liquidity buffers. These liquidity challenges could be further amplified by delays in repayment of warehouse facilities to CLO issuers. In addition, corporate stress can translate into added pressures to nonbank investors—for instance, loan funds and other funds facing potentially large redemptions (see mutual funds liquidity stress tests section). Waves of credit ratings downgrades for leveraged loans could also lead to stress for CLO tranches, through direct downgrades or by resulting failures of overcollateralization tests by CLO managers. Such stress could lead to asset sales by investors, and to a lesser extent by CLO managers as they seek to replace downgraded loans with higher quality

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assets. Depending on the severity of a potential stress episode, and if large parts of the corporate sector are under stress, this could trigger contagion losses acting through indirect channels—such as through asset liquidations by exposed financial institutions, resulting in mark-to-market losses—which could affect other segments of the financial system, including banks. These mechanisms are analyzed in more detail in the “systemic risk, interconnectedness, and contagion analysis” section of this technical note.

53. **Overall, the ongoing crisis will put significant stress and amplify existing vulnerabilities on an already leveraged corporate sector.** The rise in leverage in the risky credit markets—including leveraged loans, high yield and private debt—combined with a weakening in underwriting standards could see segments of the U.S. nonfinancial corporate sector underperform under stress. Owing to the combined COVID-19 outbreak and oil price shock, corporates faced the combined effects of recent financial market volatility, tightening in financing conditions and, for many, a collapse in sales. Corporate short-term liquidity needs are large, but most of these are concentrated in investment-grade companies whose debt markets are supported by the recently introduced Fed liquidity facilities—including the so-called “fallen angels”, which have recently lost their investment grade status. However, with the potential of a protracted economic slowdown and behavioral changes induced by evolving social-distancing norms, the long-term sustainability of certain business models could be challenged. Solvency risks could materialize, leading to large credit risk losses. Sectors such as energy, entertainment and leisure services, retail, and durable-goods manufacturers appear to be among the most vulnerable.

**STRESS TESTING SCENARIOS**

**A. Scope**

54. **The sensitivity test-based scenarios developed by the FSAP team incorporated risks related to the corporate sector and followed Risk Assessment Matrix (RAM) (Appendix VI).** The RAM takes into account existing vulnerabilities as well as salient risks, stemming in particular from the COVID-19 outbreak. In the years up to the current crisis, households experienced a significant deleveraging—mainly driven by a reduction in mortgage indebtedness—while nonfinancial corporates have seen their leverage levels reach record highs and a significant deterioration in the underwriting standard in a few sub-segments of this sector (notably, the leveraged loan market). The COVID-19 crisis represents a real-life stress event, materializing through adverse shocks to both macroeconomic and financial conditions. In this context, the scenario design aims at quantifying the potential shocks and their impact on adequacy of the capital and liquidity levels of financial institutions, examining some of the existing vulnerabilities among corporates, and assessing how potential risks and vulnerabilities would transmit among different sectors and institutions (i.e., contagion) in certain stress environments.

55. **The FSAP team used one baseline and three separate sensitivity scenarios to conduct its stress testing.** The design process of the scenarios was different to regular IMF FSAP stress testing exercises. Shocks to GDP were derived using a simple accounting-based framework which measured
sectoral output losses subject to duration of containment measures, as well as intensity of recovery after re-opening of economic activity. Employment losses and the unemployment rate path are proportionately linked to the severity of each scenario in terms of GDP losses. Short-term interest rates are underpinned by the assumption that the policy rate remains at the effective zero lower bound (ZLB) throughout the projection horizon in all scenarios. Longer-dated Treasury bill rates are derived from short-term interest rates and a term premium component which varies according to the scenario severity. Other macro-financial variables remained similar to those observed during the Global Financial Crisis. Sensitivity scenarios include, in addition to a baseline scenario—based on the June 2020 WEO Update projections—which embeds the expected macroeconomic consequences from the COVID-19 outbreak, three additional scenarios as sensitivity analysis. The FSAP stress test scenarios cover a five-year ahead horizon over the period 2020–25. This complements the Federal Reserve’s severely adverse CCAR/DFAST scenario, which has a three-year horizon.22

56. **The scenarios were applied consistently to test the resilience across all types of financial institutions included in this note.** These scenarios were used for the banking sector and corporate sector stress tests and inform the stress tests of other financial institution affected by market developments following the COVID-19 outbreak. The additional sensitivity scenarios, with appropriate modifications to reflect immediacy of realization of some market shocks, were used to stress test insurance companies, and mutual and money market funds.

**B. Scenario Narrative and Calibration**

57. **The following scenarios have been used for the stress tests (Figure 12):**23

- The FSAP baseline scenario follows the June 2020 WEO Update projections. It entails a sharp contraction (mainly in 2020Q2) owing to containment measures in response to the COVID-19 outbreak, and subdued activity and reduced demand in sectors affected by social-distancing norms. This is then followed by a tepid economic recovery as the economy starts to open again, but private sector balance sheet deterioration—with the unemployment rate peaking at 13½ percent in 2020Q2—combined with long-lasting behavioral changes, keeping GDP below its pre-crisis (i.e., 2019Q4) level through end-2022. Asset prices face a commensurate short-term fall, and then recover back to their previous levels within two-year horizon.

- Three alternative sensitivity scenarios are also considered, which assume different length of containment and de facto mobility measures:

  * **Sensitivity Scenario 1:** relative to the baseline, this scenario assumes that the reduced de facto mobility observed during the containment period lasts for the entire second quarter of 2020. Output losses during this period are assumed to be 25 percent (non-annualized) relative to pre-

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22 Most of the analysis in the FSAP was completed before DFAST/CCAR 2020 scenarios were published.

23 See Appendix VIII for a numerical representation of the stress scenarios.
COVID levels. In other words, the level of economic output in 2020Q2 is equivalent to 75 percent of the pre-shock output level. This is then followed by a slower economic recovery relative to the baseline, hysteresis losses are assumed to be commensurately larger. The fall in financial asset prices is proportionately adjusted to the severity of the output losses embedded in the scenario.

Sensitivity Scenario 2: this scenario follows the same logic as the above scenario, but the containment measures and reduced mobility are assumed to last for another quarter. In other words, output levels in both 2020Q2 and 2020Q3 are only 75 percent of the pre-crisis level. This would lead to larger employment, income, and business losses, thus also translating into larger and longer-lasting economic ‘scarring’ relative to the previous two scenarios.

Sensitivity Scenario 3: initially, this scenario follows the same pattern as Sensitivity Scenario 1, but it also assumes another wave of increased infections followed by a new containment period in the first quarter of 2021. This leads to a “W-shape” in the level of output, triggering more economic and balance sheet losses for longer. Consequently, economic activity recovers even slower in this scenario in subsequent years. Compared to historical patterns observed in previous economic crises as well as the latest CCAR/DFAST scenario, the economic losses in these FSAP scenarios are unprecedented, reflecting the unprecedented nature of the ongoing global pandemic. For instance, the sharp real GDP contraction in 2020Q2 in the June 2020 WEO Update is equivalent to 12 times the historical standard deviation of the quarterly growth series recorded since the end of WWII. This same number is equivalent to 17 standard deviations in the case of the adverse scenarios. In terms of financial variables, the FSAP stress test scenarios follow closely the behavior of those embedded in the CCAR scenario but adjusted proportionately to the severity of the output losses in the FSAP scenarios. This includes large shocks to corporate risk premia, stock market prices, and real estate prices (which tend to exhibit a more delayed response).

24 Medium-term GDP growth rates are broadly similar across scenarios, but depending on the severity of the initial shock (intensity and duration of the reduced mobility period), output levels would thus differ across scenarios.

25 This refers to the supervisory scenarios that were disclosed in February 2020 at the outset of the DFAST exercise, and not to the additional scenarios that the Federal Reserve disclosed subsequently in June 2020 as part of DFAST 2020 sensitivity analysis.
Figure 12. United States: Stress Test Scenarios

Delayed recovery leads to subdued activity... 

Real GDP Levels
(Index: 2019Q4=100)

Unemployment Rate
(In percent)

House prices fall... 

House Price Index
(Index: 2019Q4=100)

Stock Market Index
(Index: 2019Q4=100)

Risk premiums go up, especially for lower rated corporates...

BBB Corporate Spread
(In percent)

Slope of the Yield Curve
(In percentage points; 10-year minus 3-month yield)

Sources: FRB, CCAR scenarios; Haver Analytics; IMF staff estimates.
Note: the baseline scenario is based on the June 2020 WEO Update projections.

C. Risks Related to High-impact Events and their Transmission Channels

58. The FSAP considered the impact of extreme weather events and exposures of insurers to carbon-intensive assets. The frequency of extreme weather events increased in recent decades, thus raising the probability of severe damage to businesses, households, and municipalities located...
in selected geographical areas, with direct implications for the insurance sector. Idiosyncratic risk includes weather-related catastrophes such as hurricanes and flooding (see Section 7 on Insurance Stress Testing). Structural risk factors include a shift in technology (such as focus on green energy and decline in carbon-intense production, transportation, etc.). These factors are beyond assessment of the FSAP because there is little probability that structural shocks which could lead to rapid adoption of new technologies would happen within the FSAP time frame. At the same time, weather-related severe events will make an impact on financial condition of private corporates public utilities and municipalities in the affected areas. Figure 13, while not being US specific, provides a general description of climate risk transmission channels with two specific highlighted ones described in this technical note.

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Risks</th>
<th>Institutions most affected</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banks</td>
<td>Credit losses due to exposure to corporates, commercial and residential mortgage portfolios in affected areas. See Figure 18 for a sectoral distribution of loans.</td>
<td>Smaller, less diversified regional banks operating in high impact areas</td>
<td>Reduce exposure: diversify away or ration credit to corporates, households, municipalities</td>
</tr>
<tr>
<td>Insurance companies</td>
<td>Increase in reinsurance premiums, underestimation of severity/frequency of climate related events</td>
<td>Selected non-life insurance companies (see Chapter Insurance Solvency Stress Tests)</td>
<td>Increase insurance premiums and/or leave the affected areas altogether</td>
</tr>
<tr>
<td>Investment funds</td>
<td>Market risk related to investments in stocks and bonds of corporates</td>
<td>Funds with high exposure to affected corporate sectors, municipalities</td>
<td>Reduce exposure: diversify away or ration credit to corporates, households, municipalities</td>
</tr>
<tr>
<td>Corporates</td>
<td>Cash flow decline: carbon taxes, fall in demand, increase in liabilities and cost of insurance, damage to equipment and infrastructure</td>
<td>Sectors affected: energy (oil and gas), public utilities in affected areas, telecommunications, mining, real estate (in affected areas), transport, agriculture</td>
<td>Bankruptcies, restructuring</td>
</tr>
<tr>
<td>Municipalities</td>
<td>Decline in population (loss of tax revenue), increase in costs related to infrastructure/damage repairs</td>
<td>Municipalities located in high impact areas, particularly</td>
<td>Bankruptcies, debt restructuring, increases in taxes</td>
</tr>
</tbody>
</table>

Source: IMF staff.

**CORPORATE SECTOR STRESS TESTS**

59. **Stress tests were conducted to assess the resilience of the U.S. corporate sector, with a focus on ‘leveraged firms.’** Leveraged firms are active borrowers in the U.S. leverage loan and high yield corporate bond markets. Stress tests are used to assess solvency and liquidity risks of a sample of about 2,000 nonfinancial corporations with total assets amounting to US$19 trillion (87 percent of GDP) and aggregate indebtedness of US$9 trillion. Balance sheet and profit-and-loss data come from Capital IQ.26

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26 The list of companies that are active in the U.S. corporate bond and commercial paper market was extracted from Bloomberg, whereas the list of firms that borrow in the leveraged loan market was extracted from S&P Leveraged Commentary Data (LCD).
60. **Stress tests consist of projecting the firms’ net income and debt servicing capacity under different macroeconomic scenarios.** The projected net income flows as well as debt amortization and rollover patterns are gauged against the firms’ initial level of capital and liquidity buffers. For instance, when the cumulated net losses of a firm exceed the reported amount of capital, then the firm falls into negative equity—and is considered to be in “distress.”27 Similarly, to gauge the liquidity (or refinancing) needs of the corporates in our sample, we compare the amount of cash and cash equivalent held at the beginning of the stress period relative to the potential liquidity needs from amortizations and maturing debt as well as any other potential net cash inflows (such as retained earnings, investment spending, etc.).

61. **Firms profit and loss items are linked to macroeconomic variables through regression analysis.** In the stress tests, gross revenues are modeled as a function of real GDP growth, and for certain industries (such as food and energy and utilities), these also depend on oil price developments. Another important parameter is the degree to which companies are able to adjust their non-interest expenditures to changes in revenues. Intuitively, firms that can cut costs substantially during downturns (i.e., falling revenues) will be more successful at absorbing a macroeconomic shock relative to those with more rigid cost structures. Finally, interest expenditures are modeled based on the existing debt profile, accounting for the share of debt that can be re-priced (e.g., variable rate loans) at any given period and applying the corresponding interest rate from the stress test scenarios (see Caceres et al. (2020a) for details).

62. **Corporate sector stress tests suggest that potential losses could be significant.** Stress tests were conducted on approximately 2,000 companies that are active in the corporate bond and leveraged loan markets. Results suggest that leveraged firms—defined in the stress tests as those firms with a debt-to-EBITDA ratio higher than 5—are likely to experience relatively large solvency and funding pressures, representing roughly three quarters of all firms with negative equity under the baseline projections (Figure 14).28 In such a situation, and despite the relatively small size of the leveraged loan market, these firms would account for a large share of the potential losses (over 80 percent of the US$400 billion in potential debt-related losses). In a more severe scenario (c.f. FSAP Sensitivity Scenario 3—which assumes a second wave of infections in early 2021), losses stemming from corporate debt holdings could reach US$675 billion (US$465 billion related to leveraged firms). Although these losses are sizeable, banks have limited direct exposure to these products, and would suffer more limited losses.29 However, indirect exposures and market dislocations combined with liquidity shortages could play an amplifying role in a situation of stress.

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27 In practice, firms with negative equity could continue operating if the market continues to provide funds to satisfy their cash needs. Conversely, firms with positive equity could default on their debt obligations, for instance, if they run out of cash or for other reasons. Nevertheless, in a stress testing setting, it would be difficult to model the motives and behavior of firms driving their decision to default on their debt obligations, and such approach would inherently need to rely on a set of arbitrary assumptions.

28 These numbers do not correspond exactly to the potential losses for equity and debt holders. In case of default or liquidation, investors and lenders would still recover part of their investments. However, these numbers can be seen as equity and debt exposures “at the moment of stress”.

29 Banks hold slightly less than 20 percent of outstanding corporate bonds and loans, representing roughly one-tenth of their own assets.
Figure 14. United States: Corporate Stress Test Results

Number of New Firms with Negative Equity in the “Baseline Scenario”
(number; percent of total)

Equity and Outstanding Debt of Firms with Negative Equity in the “Baseline scenario”
(In billions of U.S. dollars)

Equity Position of Firms in Negative Equity in the “Baseline Scenario”
(In billions of U.S. dollars)

Equity and Outstanding Debt of Firms with Negative Equity in “Sensitivity Scenario (3)”
(In billions of U.S. dollars)

Equity Position of Firms in Negative Equity in “Sensitivity Scenario (3)”
(In billions of U.S. dollars)

Sources: Capital IQ; Caceres et al. (2020a); and IMF staff estimates.

Notes: ‘Leveraged’ denotes firms with a debt-to-EBITDA ratio higher than 5.
BANKING SECTOR STRESS TESTS

A. Solvency

Scope

63. The key emphasis in quantifying risks to banks was placed on banks’ ability to sustain losses due to a sharp deterioration of macroeconomic environment and increase in corporate default rates, at the same time distinguishing between different types of banks in terms of size, systemic importance and business models. This chapter analyzes how the baseline and adverse scenarios described in the previous section affect the solvency of banks. Elevated corporate sector vulnerabilities translate into large C&I loan losses, corporate defaults lead to higher unemployment. In turn, losses on loans to households rise, and pre-provision income and expenses (PPNR) falls because of lower income from trading, loan origination and associated fees. The FSAP team used various satellite models to translate these macro shocks into credit risk and market losses associated with all domestic and foreign exposures (aggregated). Analysis on derivative positions were not performed due to the lack of suitable data, and accordingly the associated risks were not fully assessed. Counterparty credit losses, as reported in DFAST/CCAR public disclosure, was added to the PPNR of relevant institutions.

64. Both top-down (TD) solvency and liquidity stress test were performed. The stress tests cover the 34 largest U.S. bank holding companies (BHCs), which account for about 86 percent of BHC assets, and 75 percent of total banking system assets (Appendix X). The TD stress test builds on the Capital and Loss Assessment under Stress Scenarios (CLASS) model developed by the Federal Reserve staff and uses FRB and publicly available data (such as reported in FRB reporting templates FR-Y 9C, FR-Y 15). Given the importance of corporate credit losses in assessing risks, an additional robustness check was performed to compare stress testing results under accounting (write-offs) and market implied PDs (EDFs) models. Also, a set of additional sensitivity analysis was performed to account for challenges to banks’ profitability given low interest rate environment, high shareholders’ payout ratios, Fintech related competition and credit growth assumptions. A reference date for the banking data used in the stress test was Q1 2020.

Solvency Stress Testing Methodology

65. Bank balance sheet and income statement components are projected for bank holding companies (BHCs) using multiple panel regression models. The framework for this top-down stress testing exercise is based on a modified version of the CLASS model. Quarterly data from 1991 to 2020:Q1 from FR Y-9C report on consolidated financial statements for BHCs are used to gauge historical relationships between bank balance sheet and income statement variables and macrofinancial conditions. The elasticities obtained from these historical relationships are then used

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in a model that forecasts income statement and balance sheet ratios (Appendix X). Based on the forecasted ratios through the stress testing horizon (i.e., 2025:Q1), net income, balance sheet, and capital ratios are calculated (see the schematic in Appendix X).

66. Overall, unemployment, house prices, corporate credit spreads and interest rates remain the most significant driving factors of losses. FSAP team satellite models reveal, that in line with FRB scenarios, a key set of macrofinancial variables in the CLASS model specifications explain the largest part of variation in accounting-based losses (charge-offs, recoveries) and pre-provision net revenue (PPNR). As expected, unemployment, housing prices impact losses on loans to households, while GDP, corporate spreads and interest rates losses on C&I loans. Overall, without adjustments explained in paragraphs below, loss rates (except for credit card loans (see Figure 18)) would be slightly lower compared to the ones observed during the GFC; mainly due to lower interest rates and risk premiums than the ones prevailing at the onset of the crisis in 2008–09. The U.S. banks derive relatively small share of income from abroad (except for some trading banks), thus their ability to diversify away from the U.S. domestic recession is rather limited.

67. Rapid developments due to the COVID-19 outbreak highlighted the need to make adjustments to the model to reflect the unprecedented increase in unemployment and deep shocks to quarterly GDP. Satellite models calibrated using historical data before the COVID-19 crisis underestimated risks in certain exposure classes and overestimated the potential impact of other PPNR components. Namely, losses to corporate loans, commercial real estate loans may be higher due to specificity of this crisis which affected small businesses, travel, hotels, office rent and retail trade sectors disproportionately. At the same time the model overestimated potential expenses unrelated to credit risk, i.e., it is expected that banks would be able to minimize costly restructurings, face lower fines etc. which were prevalent after the GFC. Banks may also retain income by lowering capital and other expenditure, minimize shareholder payouts. To account for these factors, we used CLASS model adjustments outlined below.

68. Three types of adjustments to CLASS loan loss satellite models were explored: (i) based on market data; (ii) a separate corporate risk stress test and COVID-19 market intelligence-based adjustments; (iii) adjustments for salaries growth as well as growth of non-interest expenses (excluding wages).

69. A market data-based alternative to accounting based (write-offs) loan loss specifications was performed to check robustness and compare results of corporate credit risk. The PD proxy for exposures to tradeable securities were extracted from bond yields using a Merton-based approach. The FSAP team used data from public returns (FR- 9 Y) on the breakdown of financial assets to back out banks’ exposures to various types of securities. It extracted estimates of probabilities of default (PD) from the spreads projected in the scenario using a reduced-form

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31 This test was performed before COVID-19 shock with cut-off date for the data as of end of 2019.
32 An increase in sovereign issuer risk is reflected in higher loan loss impairment charges on HTM and AFS portfolios.
structural model.\textsuperscript{33} Using the credit spreads for counterparty representing sector $i$ linked to the scenario $S_{i,t}$, time to maturity $(T-t)$, and assuming $LGD=45$ percent, the implied risk-neutral $PD$ is backed-out as:

$$PD_{t,T}^i = \frac{1 - e^{-S_{i,t}r.(T-t)}}{LGD_t^i}$$

70. **Banks exposures to different sectors of the commercial and industrial loans was linked with estimates of market data-based PDs for these sectors.** The banking system is exposed to various sectors of industry, with manufacturing and construction receiving most of the loans (Figure 18 below). A set of regressions was constructed to obtain stressed market data implied PDs. Overall, the results yielded shocks to PDs like the ones observed during the GFC (Figure 18). Flow of loan loss provisions was obtained by multiplying stressed PDs, LGDs, and bank-by-bank exposures.

71. **Overall, the use of market-based commercial and industrial (C&I) loss estimates led to an additional decline in the system-wide CET1 ratio by 50 basis points.** The impact was small given that models capture developments observed during several past crises, namely the dot-com bubble (2000–2001) and the GFC (2008–2010) (Figure 15). Based on that, the FSAP team did not use market data-based PDs, but utilized the second approach, i.e., made use of separate corporate risk stress test and COVID-19 market intelligence-based adjustments.

72. **Historic data on C&I loan losses may not reflect structural risk related to rapid growth of leveraged loans with few or even without covenants.** Instead of using the CLASS C&I loss satellite model, the FSAP team used the output from the corporate ST exercise to guide losses in the C&I exposure class. Team developed a multiplier approach, i.e., calculated a relative increase of C&I compared to the base quarter (Q1 2020). The multiplier then was applied for each bank C&I loan portfolio to derive the flow of provisions. The potential losses from the C&I loan category increase compared to the recent historic peak (reached during the GFC): 

(i) in the baseline scenario, the loss rate reaches 11.2 percent and is 4 times higher; 
(ii) adverse sensitivity 1 scenario - losses reach 14.9 percent and are 5 times higher; 
(iii) adverse sensitivity 2 scenario: maximum losses reach 18.1 percent (6 times higher); 
(iv) In adverse sensitivity scenario 3: maximum losses reach 15 percent (5 times higher).\textsuperscript{34}

73. **The FSAP used market data to guide estimates of potential losses from commercial real estate (CRE) portfolios.** The unprecedented nature of the crisis does not allow to fully rely on historic data about banks’ losses from commercial real estate loans. These loan portfolios were hit

\textsuperscript{33} This approach assumes that the difference between a risk-free security and a risky security is the put option on the value of the assets which includes the loss induced by the stressed PD and LGD of the bond.

\textsuperscript{34} Scenario 2 is more severe than Scenario 3 in terms of GDP losses in 2020 (it entails two quarters of reduced mobility, compared to only one quarter in Scenario 3); however Scenario 3 is more severe in 2021 (the second wave of infection triggers a quarter of reduced mobility in Q1 2021, which does not affect 2020). Accordingly, corporate sector expected losses are higher in Scenario 2 in 2020 (distress rate of 13 percent compared to 11.1 percent in Scenario 3), but corporate losses are higher in Scenario 3 in 2021 (4.8 percent compared to 1.3 percent in Scenario 2). Cumulatively (over 2020-25), Scenario 3 entails larger losses than Scenario 2.
hard by the containment measures with expected losses far exceeding observed loss rates during previous cyclical downturns. CRE loan losses follow a path projected by market sources, with estimates that the impact will lead up to a 3-fold increase in losses exceeding those observed in 2008–9.35

74. **Non-interest expense data shows high historic volatility (Figure 15), hence adds to the overall uncertainty of stress test estimations.** A significant degree of uncertainty related to the ST results is driven by the largest components of non-interest related expenses: wages and all residual items, such as operating losses, mergers and acquisitions, restructuring costs, fines banks paid after the GFC. Many of these items are discretionary, thus their dependency on macro data are weak (except for wage growth). Applying a large increase in unemployment and a shock to quarterly GDP lead to an overestimation of shocks to these items in the ST. To overcome this issue, the FSAP team adjusted the model: It introduced upper bounds which are lower than historic average growth rates (reference period 2015–2019), i.e., assumed that annual wage growth would not exceed 1 percent and the residual non-interest expenses would not exceed 2.6 percent in all scenarios. Based on these caps, the estimated expenses omit some potential large discretionary expense items due to litigation, operational risk events etc. These items however are not determined by the scenarios, i.e., behavior of macro variables.

![Figure 15. United States: Loss Estimation](image)

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Market based corporate loss rates: simulations reveal an increase similar to the GFC

Market based loss metrics leads to an additional 50 basis points of CET1 impact.

Non-interest income and expenses exhibit high volatility in the past five years

Source: IMF staff estimates.
Hurdle Rates

75. The definition of eligible capital and hurdle rates considers Basel III and the U.S. regulatory minima on CET1 ratios (4.5 percent), the Capital Conservation Buffer (CCB) and include additional requirements for Global Systemically Important Financial Institutions (G-SIBs) and leverage ratio. The capital definition includes CET1, Tier 1, and total CAR. The hurdle rate consists of a 4.5 percent CET1 requirement. The fully loaded level of capital conservation (CCB) buffer applicable in 2019 (2.5 percent) and the bank-specific G-SIB surcharge buffer is allowed to be depleted in the adverse scenario. The Tier 1 leverage ratio is based on the U.S. implementation of the Basel principles, namely 4 percent for all banks in the sample, except for the G-SIBs with more than US$700 billion of assets, for which 6 percent minima applies.

Results

Baseline

76. The banking system entered COVID-19 crisis with solid capital buffers, though future capital depletion is subject to multiple sources of uncertainty, including duration and intensity of COVID-19 containment measures. Solid capital buffers allowed banks to provide credit to the economy, namely extend credit lines to cash trapped corporates and households. Were the October 2019 WEO baseline macroeconomic scenario to materialize, banks would maintain high capital buffers and profitability. In contrast, the current June 2020 WEO Update—informed by the initial set of macroeconomic indicators since the pandemic crisis started unfolding—assumes sudden and a sharp decline in economic activity more severe than real and financial sector crisis in the past, which focused on a gradual increase in unemployment and decline in economic growth. The uncertainty around duration of the crisis and impact of various regulatory, monetary and fiscal measures required simulation of additional adverse scenarios and making of ad hoc assumptions listed below. Namely, the stress testing exercise thus incorporated multiple sources of uncertainty related to the recent outbreak and possible reaction of banks: sensitivity to duration of containment type of scenarios in addition to the COVID-19 baseline, assumptions about payouts to shareholders, dynamics of non-interest expenses, and credit portfolio growth. The stress tests exercise however was not able to fully estimate and incorporate impact of various fiscal measures, such as payments from the fiscal stimulus package and measures, like e.g., temporary postponement of loan repayments on condition of banks’ borrowers.

77. Capital depletion rates are high in the baseline (Figure 16), as expected given the unfolding sudden and sharp economic contraction yet remain manageable. The impact of COVID-19 is significant, and plays out mainly via two channels: i) immediate increase in credit losses, especially exposures to credit cards (losses of up to 3 percent of risk-weighted assets (RWAs)); C&I loans (losses of up to 1.8 percent of RWAs) ii) growth of RWAs due to a utilization of credit and funding lines, which lead to an additional depletion of CET1 of up to 1 p.p.36 Banks are

36 Assuming a system-wide expected utilization of 20 percent (see Figure 12) and a credit conversion factor of 50 percent.
expected to generate a cumulative loss of 4 percent of total assets over the five-year scenario horizon. This compares to the 1.9 percent cumulative losses in the October 2019 WEO baseline. Net interest income offsets majority of losses, albeit declining margins due to policy rates being close to zero are lowering PPNR. Policy rates have a small additional positive effect on funding costs but a significant negative one on loan interest rates. Cumulative five-year gross interest income goes down from 15.5 to 12.2 percent of total assets (when compared to the October 2019 WEO baseline). This leads to a 360 b.p. annual capital uplift from net interest income compared to 420 b.p. one before the COVID outbreak. If shareholder payouts remain at an average level of 40 percent of net income, up to 4 banks (none of them G-SIBs) would need additional capital to meet the minimum 4.5 CET1 requirement within the three-year horizon.\(^37\) Recapitalization amounts would be small (0.4 percent of GDP). No G-SIB would fall below minimum requirement also within the five-year horizon. Only one additional non-GSIB bank would fall below minimum, leading to the total number of five banks, requiring additional capital. Recapitalization needs would be around 0.8 percent of GDP. If shareholder payouts are zero for the stress test horizon, only four non-GSIBs would need additional capital with the recapitalization needs falling to 0.6 percent of GDP over the five-year horizon.

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\(^37\) For the purposes of comparing different business models of the banks, in the charts G-SIB group of banks includes 4 universal banks designated as G-SIB and excludes other 4 G-SIBs which fall under the trading banks category due to the underlying business model. In the text however, we refer to all G-SIBs to emphasize that no G-SIBs as defined by supervisors, require additional capital.
Most of the banks would be able to maintain leverage ratios above the minimum requirement (Figure 17). Some trading banks designated as G-SIBs would face a challenge in maintaining a 6 percent leverage ratio without the reducing the dividend payout ratio or asset growth.\textsuperscript{38} Notwithstanding, the recent actions by the US supervisors to grant a temporary relief by excluding some assets from the calculation of the supplementary leverage ratio (which is at 3 percent in addition to the minimum) allowed G-SIBs to remain within the regulatory limits. Foreign and some non-GSIBs, which are not subject to the supplementary leveraged ratio rule, would need additional capital to remain within the minimum Tier 1 leverage ratio of 4 percent.

\textsuperscript{38} The analysis did not take into account the temporary rule which excludes U.S. Treasury securities and deposits at Federal Reserve Banks from the calculation of the supplementary leverage ratio. See \url{https://www.federalreserve.gov/newsevents/pressreleases/bcreg20200401a.htm}.
G-SIBs face little change to their leverage ratios, given the temporary regulatory relief...

Some Trading banks are more affected by the crisis and need higher capital buffers to maintain 6 percent leverage ratio

Foreign owned banks cannot maintain historic growth of balance sheet and continue to payout the same amount of retained earnings to parent companies. ...

Non-GSIBS may need to retain more profit as well.

Sources: IMF staff estimates.
79. The potential impact of competition from Fintech companies is relatively small system-wide, and highest for smaller non-GSIBs banks (Figure 18). The growing competition for deposits, fee revenues, and payment services from fintech companies will pose risks to banks’ business models in the medium term, unless banks increase their spending on IT and other innovative technologies. Non-GSIBs are most vulnerable given that their market share in local deposits markets may decline as online channels would erode their natural advantage of physical presence in serving local communities. Moreover, smaller banks do not have the resources large banks deploy to upgrade and adapt their information technology (IT) systems to online distribution channels. As a result, non-GSIBs compared to G-SIBs may need to invest relatively more into IT systems. Industry estimates reveal that banks spend on IT about 15 percent of their total expenses on average, with an average spending growth rate increase of up to 4 percent annually. Without such investments and upgrade in the infrastructure, smaller banks may lose up to 14.5 percent of potential revenue from payment processing. In the sensitivity analysis we assumed that banks either increase investments into IT or risk losing potential revenue. Applying IT spending and revenue loss projections from industry surveys and rating company reports in the pre-COVID-19 period, sensitivity test leads to an average 10-basis point decline in CET1 ratio. An increase in IT expenses leads to a larger impact on CET1 than the loss of payment revenue in the sample of banks. The result is not surprising given a simplifying assumption that banks would maintain their share in payments market and that fees and commissions revenues would grow at an average historic rate. The uncertainty is driven by multiple factors, including a potential redistribution within the market resulting from increases in IT. Banks with better systems would gain the market share in payment revenues at the expense of other banks. Moreover, the analysis was conducted before COVID-19, and the impact of COVID-19 on digitalization of retail banking and pressures for cost cutting via closure of physical branches may accelerate further.


41 The sensitivity analysis was performed using Q3 2019 data.
**Adverse Sensitivity Scenarios**

80. Assuming a more prolonged economic disruption leads to a further depletion of banks’ capital buffers, yet no G-SIB falls below the minimum required CET1 level within the three years (Figure 19). Due to an unprecedented uncertainty about duration of the crisis, including potential second waves of infection, the three adverse scenarios focused on impact of credit losses on banks’ capital position due to an extension of containment measures. Overall, C&I loans as well as consumer loans (credit cards) constitute the bulk of credit risk related losses. As expected, banks with the highest exposures to these types of loans are affected more. Figure 20 provides decomposition of evolution of the key PPNR items. Focusing on the three-year period, up to 6 banks (all of them are non-GSIBs) would need additional capital in the adverse sensitivity scenario 1. The overall capital shortfall against the 4.5 percent CET1 minimum is small and amounts to about 0.5 percent of GDP. Only one additional bank (non-GSIB) would need to be recapitalized if the stress test horizon is expanded to the five-year horizon. The scenario reveals that systemically important banks have high enough capital buffers to withstand the simulated shocks.
Most of the banks would stay above 4.5 percent CET1 minimum within the first year of the scenario...

G-SIBS show greatest resilience due to the diversified nature of their business models and high initial capital buffers...

...while banks focused on market trading are hit less because of higher relative exposure to market and counterparty risks which are not assumed to materialize due to monetary and market support measures

Some foreign banks would need additional capital buffers, especially those exposed to consumer lending segment....

...as would Non-GSIBs, especially those with lower initial capital buffers and higher exposure to consumer and C&I loans

Overall, credit cards, C&I loans are the largest contributors to credit risk.

Sources: IMF staff estimates. 1/ The box plots illustrate the interquartile range through the orange rectangular shaped objects, while the whiskers denote upper and lower bounds (latter is set to zero).
A detailed decomposition of evolution of P&L items in the Adverse scenario reveals that profitability of banks remains high even during the severe downturn, and most of the decline in CET1 is due to non-interest expenses, such as salaries.

Contributions to CET1 base over 5 years: adverse sensitivity scenario 1 (in US$ billions)

Sources: IMF staff estimates.
81. Sensitivity analysis using different assumptions about duration of the current crisis and a hypothetical second infection wave indicates a range of impact on banks’ capital positions. An additional quarter of lockdown reduces system wide CET1 ratio on average by an additional 90 b.p (Q2 2022); up to 8 banks (non-GSIBs) would need additional capital, but the overall capital shortfall against the 4.5 percent CET1 minimum is similar to Adverse Scenario 1 and amounts to about 0.6 percent of GDP. In case of a second wave of infections and subsequent reactivation of full containment measures, the CET1 declines compared to the baseline by additional 450 b.p. in the third year. Overall, prolonged containment (beyond Q2 2020) and the second wave of infection would lead to 10 non-GSIB banks failing to meet minimum CET1 within the first three years of the crisis. The capital shortfall against the 4.5 percent CET1 minimum amounts to about 0.8 percent of GDP. The recapitalization needs would be on average 0.1 p.p. lower in the scenarios which assume that shareholder payouts are zero during the simulated crisis period.

82. Banks with a high share of retail funding, diversified asset portfolios, and high initial CET1 capital buffers are more resilient. G-SIBs with diversified business lines fare well, with trading banks experiencing limited impact on their balance sheets, mainly due to prompt actions from the FRB (setting up of various lending facilities to stabilize market liquidity). Non-G-SIBs and some foreign owned banks with considerable exposure to C&I loans, lower capital buffers, and large shareholder payout ratios are relatively more vulnerable to shocks. Non-G-SIBs are primarily exposed to losses from unsecured lending to households (e.g., credit cards), secured loans (e.g., residential mortgages), and commercial and industrial (C&I) loans, as well as commercial real estate lending. Some smaller non-GSIBs have high exposure to consumer lending, such as credit cards. Moreover, banks differ in terms of exposures to various sub-segments of consumer credit, with some banks having targeted lower income households which were particularly strongly hit by the crisis.

83. Leverage under the stress scenarios evolves in line with projected capitalization levels. As in the case of the baseline scenario, some of the G-SIBs would need additional capital to maintain their required minimum leverage ratios of 6 percent (without taking into account the temporary relief rule, which effectively reduced the CET1 requirements by up to 2 percentage points on

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42 Trading banks is the group of banks in the sample which have high share of trading related income and trading assets. This sample includes inter alia 4 G-Sibs.

43 Liquidity stress tests were conducted prior to COVID-19 crisis, thus do not take into analysis FRB actions to support the economy. See Federal Reserve announces extensive new measures to support the economy; March 23, 2020 https://www.federalreserve.gov/newsevents/pressreleases/monetary20200323b.htm.

44 This group includes large banks with consolidated total assets above US$100 billion, excluding U.S. G-SIBs and Intermediate Holding Companies.
average), albeit within the first two years of the stress horizon only. While foreign and non-GSIB banks are not subject to supplementary leverage rule and have lower Tier 1 leverage requirement they show less resilience due to a rapid decline in CET 1 capital base. The measure of their leverage (defined as total capital over total assets) falls below their required minimum of 4 percent (Figure 21).

Figure 21. United States: Solvency Stress Testing Results—Leverage Ratio under the Adverse Sensitivity Scenario 1/
Without regulatory relief, some G-SIBs would need additional capital or reduce balance sheet to maintain minimum leverage ratios in the sensitivity scenario within the first two years... as is the case for trading banks.

Sources: IMF staff estimates.
1/ The box plots illustrate the interquartile range through the orange rectangular shaped objects, while the whiskers denote upper and lower bounds (latter is set to zero).
Additional Sensitivity Tests

84. To gauge sensitivity of results to behavioral assumptions, the stress test considered two options for dividend payouts. The main set of simulations involved the assumption that banks would continue dividend payouts at long term historic average levels (i.e., at approximately 40 percent of net earnings, excluding share buybacks) and will reduce relative expenses while balance sheets will grow at the rate of up to 4 percent per year reflecting lower demand for credit compared to average growth rates of 7.5 percent. An alternative set of simulations assumed that banks would reduce shareholder payouts to zero. Based on these assumptions and the four scenarios, 8 simulations were performed in total.

85. Given the uncertainty of duration of the crisis and firmness of the post-crisis recovery, reduction in shareholder payouts would help to preserve capital in the Baseline and Adverse scenarios, while allowing banks to continue extending credit (Figure 22). Even under the adverse scenarios most of the banks earn enough interest income to offset credit risk related losses, yet other non-interest expenses drive the overall impact on capitalization. U.S. banks have a track record of reducing operational expenses quickly by closing branches and reducing workforce and staff compensation. Nevertheless, to ensure preparedness for the longer duration of the crisis and further growth of the loan portfolio even in the adverse scenario, higher share of earnings would need to be retained or a temporary moratorium on shareholder payouts instituted. By keeping shareholder payouts at zero for the duration of the crisis, banks would save an average of 60 b.p. of CET1 by the Q2 2022. This would also help banks to maintain staffing ensuring robust business continuity.
**Figure 22. United States: Solvency Stress Testing Results—Results Under Multiple Adverse Scenarios and Assumptions About Dividend Payouts**

**Dividend payout rate across all banks in the sample...**

Dividend Payout Ratio: Post-GFC

![Box plot of dividend payout ratios across banks](image1.png)

Overall, shareholder payout ratios (including share buybacks) exceeded net income in some banks.

Shareholder Payout Ratio for G-SIBs: 2014-19

![Box plot of shareholder payout ratios for G-SIBs](image2.png)

...and temporary lower or zero shareholder payouts would help to conserve additional capital which may be needed to remain above the minimum requirements in case of an extended duration of the current pandemics.

**CET1 Ratio — With Dividend Payouts**

![CET1 ratio graph](image3.png)

Systemwide CET1 ratio would remain above the 4.5 percent CET1 minimum within the stress test horizon...

**CET1 Ratio — Without Dividend Payouts**

![CET1 ratio graph without payouts](image4.png)

System-wide leverage ratio also improves, however marginally, as banks which face significant decline in CET1 ratios still struggle to remain above the minimum requirement.

**Tier1 Leverage in Baseline Scenario Without Dividend Payouts**

![Tier1 leverage graph](image5.png)

Source: IMF calculations.
Conclusions

86. The banking system has solid capital buffers, and thus system-wide capital shortfall in the baseline and adverse sensitivity scenarios is relatively small. While six smaller Non-GSIBs would fall below the CET1 ratio of 4.5 percent, recapitalization needs would be manageable from 0.52 in case of adverse sensitivity scenario 1 to 0.81 percent of GDP (10 banks, all of them non-GSIBs, below CET1 minima) in the most severe case of the double recession due to a second wave of COVID-19. In recent years’ banks increased dividend payout ratios to shareholders, share buybacks and in some cases (especially Non-GSIBs) reduced their CET1 (see Figure 25). This leads to procyclicality of capital planning if additional severe shocks are to materialize, especially given the uncertainty related to the swift recovery from the negative impact the virus outbreak had on the economy. Additional sensitivity tests were conducted to estimate the impact of different assumptions regarding the impact of dividend payout ratio impact on the evolution of CET1/leverage ratios. The potential capital shortfall in terms of GDP under the scenarios would be higher up to 0.2 percentage points higher if banks maintain average dividend payout ratios of 40 percent to the shareholders.

87. The stress tests results are subject to numerous uncertainties, however they also demonstrate that the banking system has flexibility to cut expenses and ability to generate income to adjust to the COVID-19 crisis without unnecessarily reducing exposure to the real sector. Banks are primarily exposed to risks related to losses from unsecured lending to households (credit cards) as well as secured loans: residential and commercial real estate. C&I loan losses would be high under a distress in corporate sector scenario, which assumes increase in default correlations of highly leveraged companies. Nevertheless, even under the adverse scenario most of the banks earn enough interest income to off-set credit risk related losses. As in the case of the baseline scenario, the U.S. banking system benefits from labor market flexibility: the largest expense item—administrative costs—may be adjusted further downwards by reducing staff number, salaries, and bonuses.

88. The stress test results also confirm that leverage requirements become more binding during stress scenarios. Simulation results indicated, that some of the banks, including G-SIBs would face challenges to maintain leverage ratios above minimum requirements. Absent the recent changes to the supplementary leverage ratio calculation, affected banks would need to either increase their capital base by retaining higher share of profit, raising additional equity or shrinking their balance sheets, for example, by reducing exposures to counterparties, holdings of securities etc. All of these actions by banks would introduce several system-wide effects, such as asset fire sales, shocks to funding liquidity and thus further amplify liquidity shocks in the markets.

45 The analysis did not take into account the temporary rule announced in April which excludes U.S. Treasury securities and deposits at Federal Reserve Banks from the calculation of the supplementary leverage ratio and will be in effect until March 31, 2021. See https://www.federalreserve.gov/newsevents/pressreleases/bcreg20200401a.htm.
B. Banking Sector Liquidity Risk Analysis and Stress Tests

89. The aim of the liquidity risk analysis and stress testing is to evaluate to what extent U.S. banks would be able to sustain severe funding shocks and at the same time continue to provide liquidity to the customers. As emphasized in the previous chapters of this note, banks play an important role in providing short-term funding and liquidity to various non-bank financial institutions as well as corporates and households. For example, existing commitments to the leveraged loan borrowers account for US$760 billion in credit facilities (drawn and undrawn revolvers).\(^4\) The capacity to extend those credit lines to customers depends on banks’ ability to obtain liquidity in the market, cope with the stressed liquidity outflows without breaching regulatory requirements.

90. To assess liquidity risks, a comprehensive analysis of large banks’ structural liquidity ratios is complemented with a variety of liquidity stress tests. The structural analysis considers the Basel III liquidity coverage ratio (LCR) and funding concentration. While the former measures short-term liquidity risks, the latter ratios gauge more structural longer-term refinancing and funding risks. Cash flow-based liquidity stress tests were conducted using public (LCR disclosure) and, for the six G-SIBs - supervisory (FRB) data. This approach employs multiple scenarios of increasing severity covering a 30-day horizon with varying assumptions regarding liquidity buffers and shocks to cash inflows and outflows.

Funding Structure and Concentration

91. Banks rely on cash, central bank reserves and U.S. Treasury securities to meet expected and stressed outflows, but Non-GSIBs hold smallest relative amount of highly liquid assets. The quality of HQLA is very high (see Figure 23), as nearly three-quarters of it consists of highly liquid assets (such as Treasury securities) which tend to perform a role of safe heaven during market distress events. At the same time, HQLA assets represent just a fraction of all potential sources of liquidity in a stressed environment. All unencumbered assets can be used to obtain liquidity in a market or (subject to collateral eligibility) a central bank. While data on asset encumbrance is not available, the FSAP team used balance sheet FR Y9 data for structural liquidity assessment. Overall, in the current low yield environment, banks tend to hold bonds with longer maturities which implies lower liquidity and higher haircuts for sales and/or repo transactions. The share of HQLA is highest in market trading banks, which reflects their market making activities and higher reliance on wholesale funding. Smaller domestic banks have lower regulatory liquidity requirements, hence target lower liquidity ratios overall.

Figure 23. United States: Funding Structure and Liquid Assets

Much of the HQLA is comprised of Treasury securities, cash and CB reserves. Most of the securities banks hold are long-term, hence subject to higher haircuts for secured funding transactions.

Foreign banks and Non-GSIBs have lowest relative HQLA buffers. Domestic deposits establish the largest funding source for banks.

...Non-GSIBs have high share of stable, deposit-based funding. Foreign banks to a large extent rely on secured lending inflows, while trading banks and foreign banks rely on other types of funding, thus vulnerable to disruption in secured funding market.

92. Funding structure shows reliance on domestic deposits. Most of the domestic banks (G-SIBs and Non-GSIBs) rely on stable deposit-based funding sources, while some market trading banks as well as the majority of foreign-owned banks often depend on repo markets. COVID-19
crisis and massive market liquidity support provided by the Fed led to a significant (US$1 trillion) increase in bank deposits by households and corporates (as of Q1 2020). In case of repo market distress and/or funding shocks, these banks would face large challenges to maintain adequate liquidity. Due to stable funding sources and low reliance on secured and unsecured interbank borrowing, Non-GSIBs have the lowest share of highly liquid assets in their assets.

**Structural Liquidity Risks**

93. **All banks have LCR ratios above 100 percent (Figure 24).** All banks in the sample meet 100 percent LCR requirements, albeit some of them only due to a 70 percent outflow multiplier applied by smaller banks (mostly Non-GSIBs). G-SIBs tend to have marginally lower LCR, due to the two factors: (i) the maturity mismatch add-on and (ii) higher assumed outflows due to absence of 70 percent outflow multiplier. To mitigate intraday mismatch risk when calculating LCR, supervisors require large systemically important banks to include maturity mismatch add-on in calculating LCR. The add-on reflects the largest potential gap within the 30-day period. This add-on is applied to selected banks (17 out of 33 in our sample) and requires them to keep additional liquid assets equivalent to 1 percent of total liabilities on average. Non-GSIBs have considerable structural liquidity risks: i) they have large contractual funding gaps, some of them have largest in the sample off-balance sheet committed facilities coupled with lowest expected utilization rates (Figure 24). Moreover, as highlighted in FRB (2017) publications, commercial banks use Federal Home Loan Banks (FHLBs) as short-term wholesale funding providers, partially to benefit from LCR requirements (a maximum 25 percent run-off rate for FHLB advances in 30 days). FHLBs receive some of their funding form Money Market Funds (MMFs), hence any funding distress related to the MMF funding withdrawal could lead to a reduction of funding FHLBs provide to commercial banks. Withdrawal of funding from banks may be a source of risk. The IMF analysis conducted by FRB using supervisory data revealed that potential liquidity squeeze due to withdrawal of funding from FHLBs from the six largest G-SIBs is insignificant. An additional set of scenarios was used to test the impact of a closure of repo markets for other than HQLA1 type of collateral (discussion and results in the Liquidity Stress Testing section).

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47 Structural liquidity analysis as well as liquidity stress test focus on idiosyncratic (i.e. bank specific) risks and ignore system-wide distribution of liquidity as well as evidence that liquidity may dry up for some banks and at the same time other banks may experience large inflows.


49 At the same time, the importance of FHLBs on the rest of the banks in the sample was not tested due to the lack of access to supervisory data.
The median LCR ratio increased since 2018 and all banks have buffers above 100 percent...

Overall, liquidity risk exposure is high, with the 30 day funding gap close to 40 percent of total assets...

Non-GSIBs have the highest unsecured funding gap, but the source of the gap is stable retail deposits which are typically insured and sticky*

Excluding off-balance sheet commitments, 30 day contractual funding gap is on average of 50 percent of TA

Maturity mismatch add-on is on average an additional 1 percent of total liabilities*

* Calculated as Deposits+Unsecured funding outflows – Inflows over total liabilities

*only some banks in the sample are subject to add-on requirements.

Sources: IMF staff estimates. Yellow dots represent median values while bars – quartiles. Red line – 100 percent minimum requirement (LCR).
94. The gap between contractual inflows and outflows at the 30-day horizon excluding retail and operational deposits is high, and mostly driven by off-balance sheet financing facilities. The contractual funding gap represents the most severe liquidity risk scenario for a bank. As evidenced during crisis times, affected banks experience outflows approaching contractual maturity. On-balance sheet net cash and securities flows (including retail, sight and operational deposits) over 30-day period constitute on average around half of banks’ balance sheet. Off balance sheet credit and liquidity facilities constitute another 25 percent of Total Assets (TA). Most of these commitments are credit lines to corporations and households (credit cards), loans to other financial institutions, including mutual, investment, hedge funds. Banks do have leeway to estimate expected utilization of such lines for LCR purposes.

95. Evidence suggests that in the past banks with a low utilization rate of credit and liquidity facilities may underestimate liquidity risks (higher outflows than expected) during stress scenarios. As evidenced during the GFC, and during the COVID-19 stress period, more financial and nonfinancial counterparties utilize revolving credit facilities (due to inability to obtain term loans, refinance existing debt, receive trade credit, etc.), credit card accounts, etc. as loans of last resort before declaring insolvency or illiquidity. In a business as usual scenario, banks may underestimate potential outflows due to the need to grant such facilities in stressed market conditions. For example, many of these loans may be committed, but have multiple covenants or be uncommitted with a bank having an option to unilaterally cancel the line. While it would be perfectly rational for a bank to cancel the lines, macro consequences of such a collective behavior would lead to further increase in corporate default rates. As evident from the LCR disclosure data, some of the Non-GSIBS have a high share of credit and liquidity facilities coupled with low expected utilization rate (Figure 25).

**Figure 25. United States: Credit and Liquidity Facilities and their Utilization**

Most of the banks expect that only about a quarter of amounts of credit and liquidity facilities will be utilized... with Non-GSIBS having the lowest modeled ratios.

Sources: IMF staff estimates. Yellow dots represent median values while bars—quartiles.

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50 Measured as all contractual inflows minus contractual outflows.

51 See for example research by Reich and Falato (2019) which documents that during stress times firms are more likely to draw banks’ credit lines and the FSB report “Vulnerabilities associated with leveraged loans and collateralized loan obligations,” Financial Stability Board, December 19, 2019” which highlights LCR limitations by not distinguishing higher credit utilization rates by lower rated corporates.
Liquidity Stress Testing Methodology and Scenarios

96. **Liquidity stress tests incorporated various assumptions on how banks and their clients would behave under stressed market conditions.** To deal with parameter uncertainty, the cash flow tests were conducted over a wide range of scenarios featuring different degrees of severity. Public LCR cash flows disclosure templates were used to calculate system-wide average inflow/outflow parameters as well as haircuts on HQLA.

97. **Haircuts on liquid assets holdings of banks are based on an empirical attempt to quantify asset fire-sales during different market liquidity regimes.** Multiple types of securities (Treasury, Corporates, Mortgage-Backed, U.S. Agencies, etc.) are included into Counterbalancing Capacity (CBC) of banks. The stress test applied non-linear estimation techniques, such as Markov regime switching models, to calibrate haircuts on CBC securities. It was assumed that during distress in the markets, these securities will be sold under asset fire sales prices, i.e., with significant haircuts (see Appendix XVII). Haircuts were determined based on collective amount of assets sold (as opposed to linear haircuts and individual amounts). The estimations reveal, that asset prices (haircuts on them) tend to behave non-linearly with haircuts being much higher during market turmoil. Increase in market volatility tends to be a good predictor of illiquidity, thus higher haircuts on assets sold.

98. **Secured cash inflows and off-balance sheet commitments represented the key risk drivers in the 30-day tests (Figure 26).** Liquidity stress test scenarios assumed wholesale funding shock, high utilization of credit lines and asset fire-sales. In line with key risks stemming from corporate sector, it was assumed that banks would need to provide liquidity to cash strapped companies. This scenario assumed a gradual increase in utilization ratios of credit and liquidity facilities. Another scenario assumed withdrawal of wholesale funding, including a partial closure of repo markets. The most important caveat is that stand-alone liquidity stress tests are not meant to simulate redistribution of liquidity within the banking system, i.e., situations when withdrawal from one bank or group of banks leads to an increase in inflows in another one(s) or when credit line utilization leads to redistribution of deposits within the same bank.
Liquidity Stress Test Results

99. A gradual increase in utilization of credit and liquidity facilities scenario leads to a significant shortage of liquidity in several individual banks, but the system-wide impact is contained (Figure 27). It is expected that in times of stress nonfinancial corporates, households would increase utilization of available credit and liquidity facilities from banks. Liquidity stress tests reveal, that many banks (including G-SIBs) would need additional liquidity to provide funding to distressed corporates and other institutions in times of wholesale funding stress or adverse conditions in the market, if drawdowns exceed 30 percent.52 Depending on the share of committed and uncommitted credit lines, assumed credit conversion factors, additional depletion of CET1 ratios due to the increase in RWAs would be from 20 (minimum of 5 percent drawdown) to 250 basis points were banks to allow full drawdown of the lines. Failure to grant credit lines would lead to various non-linear feedback effects within the financial sector and further defaults of distressed (cash trapped) corporates. While the FRB actions at the outset of the COVID-19 outbreak helped to shore up liquidity, it is therefore important to ensure that banks have high enough liquidity buffers and predictable access to central bank liquidity facilities.

52 The test assumed that banks’ inflows/outflows follow LCR rates, except for higher (standardized for all banks) outflow (utilization) rates applied for credit and liquidity facilities. Full amount of HQLA without haircut is used to cover the gap. The test does not distinguish between committed/uncommitted lines.
100. Additional cash flow-based stress test was conducted by the FRB using IMF scenarios and models to assess funding and market liquidity risks in the network of U.S. G-SIBs (see Appendix XVII for technical details). The test focused on two key scenarios: (i) the LCR-based shock scenario, which used LCR stress parameters but assumed more severe outflow rates on contingent liquidity items, such as credit and liquidity facilities, derivatives, loss of rehypothecation rights; (ii) the LCR-based shock scenario coupled with the assumption of a partial closure of repo markets (i.e., repos with MBS, agency, and corporate securities not possible) and outflow rates on selected cash flow items the same as in scenario i).

101. G-SIBs have enough liquidity to withstand severe LCR-like liquidity shock coupled with additional contingent liquidity and committed line outflows over 1-, 5-, and 30-day horizon. Compared to the results of the analysis above conducted for 35 banks using public LCR data (where a number of Non-GSIBs were illiquid), the G-SIBs do not have a gap after HQLA sales and do not need to repo assets. The liquidity gap and impact on CET1 are thus zero across all scenarios and maturity horizons. There is also no further transmission of funding risk in the network due to counterparty exposures among the G-SIBs.

102. Closure of the repo market for non-treasury securities would lead to a small and short-lived cash flow gap in several banks, but the system-wide impact from asset fire sales is small. Unless daily asset trading volume exceeds five times the historic average, an immediate closure of the repo market for non-treasury securities would lead to a small and short-lived cash flow gap in several banks, but the system-wide impact from asset fire sales is small.54

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53 The analysis was performed by the FRB staff using IMF scenarios and models and does not reflect the views of the U.S. regulators. Further details are in Caceres, C., M. Leika, D. Seneviratne and E. Yu “Keeping It Real”: Enhanced Network Analysis in IMF FSAPs.” IMF Working paper (2020c), forthcoming.

54 The test was performed before the COVID-19 and did not consider that ability to repo or sell US sovereign securities may be limited. Moreover, that test did not considered increase in RWAs because of utilization of credit lines.
Closure of the non-Treasury repo markets affects banks during the one-day to five-day horizons (Figure 28). The worst observed cash flow gap (before a bank needs to repo treasury securities) would be from 0.09 percent of total assets (one day) to 0.27 percent (one week). This gap is fully covered by other inflows on the 30-day horizon (i.e., no shortage of liquidity is observed). If affected banks liquidate assets in stressed markets, this would lead to an insignificant 9 basis points decline of CET1 on average (because the assets liquidated are treasury securities). No bank would become technically illiquid and there would be no additional losses due to interconnectedness among G-SIBs. It is worth noting, that in case of a complete closure of repo markets (i.e., including Treasury securities), affected banks would face higher asset liquidation needs. Albeit probability of such a scenario is very low. Withdrawal of funding from FHLBs itself would not lead to a cashflow gap.

103. **Closure of repo market may lead to illiquidity of a G-SIB when this severe shock is combined with an increased utilization of credit and liquidity facilities by other financial institutions or corporates.** The stress test found one G-SIB illiquid, albeit under an assumption of very high outflow rates from the credit and liquidity facilities (40 percent and above) and only under a 30-day test horizon. Overall, the impact of asset fire sale, including repricing of remaining assets on affected G-SIBs balance sheets, is small with a similar decline in CET1 capital by 9 basis points as in the previous case, and funding gap of only 7 basis points of total assets in the worst-case scenario (Figure 31). The liquidity impact depends on changes in market depth: the largest impact on daily liquidity of banks comes from assumptions about changes in average daily trading volumes of HQLA securities.

104. **Overall, “liquidity pipeline” risk in the financial system is high as banks maintain their central role in providing liquidity to other financial and nonfinancial customers which do not have access to central bank facilities.** Analysis in the next chapter shows how the sample of banks is linked to the rest of the banking and financial system. This analysis and liquidity stress tests reveal that banks’ role in liquidity provisions to the financial system is critical: failure to grant credit lines would lead to various non-linear feedback effects within the financial sector and further defaults of corporates. It is therefore important to ensure that banks have high enough liquidity buffers, predictable access to central bank liquidity facilities.

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55 See for example, Sooji Kim, Matthew C. Plosser, and João A.C. Santos “Macroprudential Policy and the Revolving Door of Risk: Lessons from Leveraged Lending Guidance,” FRB NY Staff Reports May 2017 Number 815. The report estimated that nonbank financial institutions (NBFIs) increased borrowing from banks by 125 percent in 2016–2017. The loans were used to extend NBFIs’ investments into leveraged loans.
Figure 28. United States: Liquidity and Asset Fire Sales Scenario for U.S. G-SIBs

Impact of the closure of the repo market is small, and on its own will not lead to illiquidity of banks (one-week horizon is shown), especially if they can sell multiple amounts of liquid securities (5 times average daily trading volume in the figure below means that the gap becomes zero).

Under the 30-day scenario, all G-SIBs would retain positive cash flow gap if outflow shock on credit facilities would remain below 40 percent.

CET1 capital impairment solely due to liquidation losses is about 4.5 basis points

...while marked-to-market losses are also around the same level, thus yielding a combined CET1 impact of 9 basis points

Sources: IMF calculations performed by the FRB based on FRB supervisory data.
C. Banking Sector Interconnectedness

Domestic Interbank Network Stress Testing

Modelling domestic bank interconnectedness reveals that direct (funding and credit) contagion among G-SIBs is small and failure of one G-SIB would not lead to direct default of another one. The joint interconnectedness modelling exercise performed by the FSAP team in collaboration with the FRB staff assessed the propagation of such idiosyncratic and systemic shocks through the network of U.S. G-SIBs, linking solvency and liquidity risks (Figure 29). The analysis considered unsecured, secured (repos/reverse repos, swaps, etc.) and contingent (derivatives, CDS contracts) exposures among six largest G-SIBs. While the closure of non-Treasury repo markets coupled with severe scenario parameters would lead to one G-SIB becoming illiquid over 30-day horizon, the impact of asset fire sale on remaining banks in the network is limited to a decline in CET1 by 25 basis points, depending on banks’ asset liquidation strategies and daily trading volume constraints (Figure 30).

Figure 29. United States: Enhanced Interconnectedness Analysis—Solvency and Liquidity Risk Linkages

Source: IMF staff.
Note: The analysis is based on two stages. First stage—funding liquidity risk based on cash flow data, second stage—network contagion model. The first stage simulates conditions under which a bank would be illiquid or insolvent under severe yet plausible funding shocks; in the second stage a bank which fails the first stage (illiquid because of revaluation of its assets using fire-sale prices) does not meet its contractual obligations to the other banks in the network. Entity h in this illustration refer to any entity outside of bank i and j.

56 The test used two strategies: waterfall when banks liquidate most liquid assets first and slicing when banks liquidate proportional amount of each type of security.
The impact of asset sales on CET1 would be 9 basis points for affected banks if they use proportional liquidation approach to sales (slicing)...

...the network contagion and fire-sales impact would be higher if banks were to adopt waterfall liquidation strategy (i.e., liquidate most liquid assets first), albeit no one bank would be insolvent and final impact would be 25 basis points of CET1 loss.

Sources: IMF calculations performed by the FRB based on FRB supervisory data.

Cross-Border Bank Network Analysis

106. Potential cross-border contagion risks are assessed using exposure-based network analyses. The analyses aim at quantifying the capital impairment incurred by the U.S. banking system or BHCs due to an idiosyncratic shock originated in a counterparty banking system or transmitted via a counterparty banking system (i.e., the cascade effect). Two shock transmission channels are explored. First, spillovers are assumed to be transmitted through a credit shock in which—due to a hypothetical default of a counterparty banking system—the U.S. banking system/BHC does not recover a fraction of its claims on the system in distress. Second, spillovers are amplified due to a funding shock assuming that the hypothetical default of a counterparty banking system would lead to liquidity pressures owing to foregone funding and asset fire sales. These analyses are performed using the network contagion model and methodology developed by Espinosa-Vega and Sole (2010). The cross-border bank network analysis consists of two separate

57 Data used in the analysis does not allow us to distinguish between secured and unsecured exposures as well as understand what type of collateral is used for secured exposures. Therefore, the analysis is based on very conservative assumptions that all of the exposures are unsecured. It is worth noting however that, based on supervisory data, 2019 France FSAP stress testing technical note reveals that majority of U.S. dollar funding exposures of the French banking system are secured exposures. Based on BIS cross-border exposures, nearly 50 percent of all reporting countries exposures is denominated in U.S. dollars.

58 Due to the lack of granularity in the available cross-border exposures data, cross-border network analysis does not use the enhanced interconnectedness model developed during this FSAP in collaboration with the FRB staff for the domestic interconnectedness analysis.
analyses: the first set of simulations assesses network contagion at banking system-level; the second set of simulations assesses network contagion at U.S. BHC vis-à-vis foreign banking system level (see Figure 31).

**Figure 31. United States: Schematic Representation of the Network Contagion Analyses**

- **Contagion analysis 1 (interbank exposures at banking system-level)**
  - U.S. Banking System
  - Foreign Banking Systems
  - Credit Channel
  - Shock Transmission Channel
  - Funding Channel

- **Contagion analysis 2 (interbank exposures at bank-level vis-à-vis foreign banking systems)**
  - BHC
  - Foreign Banking Systems
  - Shock Transmission Channel
  - Credit Channel
  - Liability side data not available

Source: IMF staff.

### Contagion Analysis 1: Network Contagion at Banking System Level

107. Network analysis in this section quantifies the potential spillovers\(^{59}\) between the U.S. banking system and large counterparty banking systems through several types of exposures\(^{60}\). First, spillovers emanating from exposures unrelated to intra-group positions are assessed, thus quantifying the spillovers between U.S.-owned banks and foreign-owned banks. Nevertheless, the presence of branches and subsidiaries (the latter to a lesser extent in many cases based on the regulatory landscape) may alter the spillover transmission between banking systems; for example, sizable exposures may exist due to large credit lines provided by parent entities. The role of financial centers, large banks, and foreign banking operations in intermediation of cross-border flows of funds—for instance related to FX transactions including U.S. dollar funding activities—may also amplify potential spillovers particularly in deleveraging episodes. The second and third exposure types aim at capturing additional spillovers due to such activities, while the

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\(^{59}\) The term “spillovers” in this section refer to the capital impairment incurred by an entity or a system due to distress in another banking system.

\(^{60}\) The analysis is based on BIS consolidated and locational statistics (both residency and nationality basis) and uses the 10 largest counterparty banking systems for which bilateral consolidated and locational interbank exposures are available.
distinction between the two exposure types rely on how the banking system is defined (i.e., banking systems including foreign operations vs. banking systems based on the domicile).61

108. The following scenario and assumptions are used in the simulation on shock transmission through credit (solvency) and funding (liquidity) channels:

- The scenario considers the effect of a severe credit shock combined with a funding shock under the assumptions below;

- Assumptions: 100 percent of the interbank lending provided to the banking system in distress is not recovered (i.e., loss-given-default parameter is 1.0).62 Assets are liquidated to meet the funding gap at a 50 percent discount during an asset fire sale. It is also assumed that banking systems will be able to roll-over 65 percent of the lost funding through other means such as raising equity (therefore, the share of lost funding that is not recovered is 0.35).

109. The analysis suggests inward spillovers into the U.S. banking system from other large counterparty banking systems is limited on average. The sources of potential vulnerabilities—due to direct exposure as well as through the cascade effect of other foreign banking systems with exposure to the U.S. banking system—are concentrated in few large foreign banking systems such as the United Kingdom and Japan (Figure 32). At a much lower intensity, potential vulnerabilities may also arise from the banking systems in Canada, Germany, and France.63 The results also suggest that the quantification of vulnerabilities may benefit from capturing different types of exposures such as those that are previously discussed, as the intensity of spillovers may vary based on the nature of stress episodes. Potential vulnerabilities could in fact diverge depending on the type of exposure assessed. Specifically, potential inward spillovers into the U.S. banking system ranges between 2–8 percent of initial regulatory capital of the U.S. banking system depending on the type of exposure. This capital impairment is transmitted mostly via the credit channel (i.e., due to direct and second-round credit exposures). However, incorporating funding shocks in the simulations increase the systemic importance of some banking systems from a liquidity point of view, thus increasing inward spillovers into the U.S. banking system by one-third.

110. The U.S. banking system has the potential to be a source of significant contagion to large banking counterparts. In particular, the potential contagion risks transmitted through a

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61 Specifically, in the second exposure type, the residency-based exposures are reorganized to include exposures of branches and subsidiaries domiciled outside the parent country along with the parent country exposures. The third type is based on residency-based exposures, where foreign branches and subsidiaries are included under the host banking system.

62 A loss-given-default rate of 100 percent is used with the assumption that these exposures are unsecured exposures and due to the difficulty of recovering assets at the time of banking system failure. Data used in this analysis does not allow us to distinguish between secured and unsecured exposures as well as understand what type of collateral is used for secured exposures. Therefore, the analysis is based on very conservative assumptions that all of the exposures are unsecured.

63 These five banking systems are the largest potential spillover transmitters into the U.S. banking system based on all three exposure types assessed.
credit shock result in an impairment of about 10 percent of the initial regulatory capital of recipient foreign banking systems on average (Figure 33). Additional amplification of potential contagion through the funding channel also amounts to about one tenth of the capital impairment from the credit shock. However, the contagion effect could also vary depending on the type of exposure that would transmit spillovers. For instance, the average impairment stemming from contagion risk to foreign-owned banks could increase from 10 percent of capital to 40 percent of initial capital when contagion risks to host banking systems is considered.

111. Contagion risks are concentrated in several banking systems and concentrations vary depending on the type of exposures (Figure 32). Canadian-owned, Japanese-owned, and French-owned banks (latter to a lesser intensity) at aggregate level have the highest potential contagion risks due to a hypothetical systemic shock to U.S.-owned banks. This alludes particularly to heavy financial intermediation activities between foreign-owned banks and globally active U.S. banks including dollar funding activities carried out via large U.S.-owned banks. On the other hand, when foreign banking systems including branch and subsidiary operations are considered, the U.K. banking system has the highest potential for contagion. This is not only due to the United Kingdom’s direct exposure to the U.S. banking system, but also due to the cascading effect owing to U.K.’s exposures to other foreign banking systems that are large counterparties of the U.S. banking system. The role of the U.K. banking system as a financial center in intermediation of cross-border flows is in part behind these large contagion effects.64 The host banking systems in Canada, the United Kingdom, and Japan (France and Germany to a lesser extent) have large potential for contagion, also emphasizing the ability of contagion to cascade in the presence of branch and subsidiary operations.

112. Potential contagion from the U.S. banking system would still be significant under a less severe scenario. Given the uncertainty surrounding the loss-given-default parameter used, as it may vary depending on the nature of exposures—unsecured or secured—and the collateral pledged, a sensitivity analysis is performed. For robustness, the scenario assumes a 50 percent loss-given-default rate.65 Results reveal that even under this scenario, foreign banking systems would lose a sizable share of their capital due to contagion from the U.S. banking system by about 5 percent to 15 percent of their initial regulatory capital (Figure 34). Compared to the severe scenario presented earlier, this is about a one-half reduction in losses. Similar to the previous simulation results, contagion is specifically larger in the U.K., Japan, and Canada. Potential capital impairment of the U.S. banking system is also about one-half lower in this scenario (ranges from 1–3 percent of initial capital of the U.S. banking system).

64 Belgium also has large potential contagion risks, owing to financial intermediation such as cross-border dollar funding activities conducted through Belgium banks’ foreign operations. Spillover analysis performed at host country-level reveal that the presence of foreign operations increases the potential for contagion to the host banking system.

65 Banking systems is assumed to roll-over 90 percent of lost funding (share not recovered = .1) under this scenario, while assets are liquidated at a 10 percent haircut.
**Figure 3.2. United States: Cross-Border Inward and Outward Spillovers by Type of Exposure**
(Purple edges = inward spillovers to the U.S. banking system; green edges = outward spillovers)

**Exposure Type 1: Spillovers between U.S.-owned and Foreign-owned Banking Systems**
Banking system defined at parent country level (without intra-group operations); against counterparty banking systems on ultimate counterparty/guarantor residency

**Exposure Type 2 & 3: Spillovers between U.S. and Foreign Banking Systems (with Intra-group Operations)**
Exposure type 2: banking system defined at parent country level; against counterparty banking systems based on counterparty residency
Exposure type 3: banking system defined at host country level; against counterparty banking systems based on counterparty residency

Sources: BIS, IMF FSI, IMF staff
Edge width = proportion of contagion vis-à-vis the recipient banking system. Edge color = direction of contagion; green edges are the potential contagion emanating from the U.S. banking system into top 10 foreign banking systems (i.e., outward spillovers), while purple edges are the potential vulnerabilities (i.e., inward spillovers) from foreign banking systems into the U.S. banking system.
Figure 33. United States: Average Spillover between the U.S. Banking System and Foreign Banking Systems
(In percent of initial capital of the spillover recipient)

Sources: BIS, IMF FSI, IMF staff.

Figure 34. United States: Sensitivity Analysis using a Less Severe Scenario: Average Spillover between the U.S. Banking System and Foreign Banking Systems
(In percent of initial capital of the spillover recipient)

Sources: BIS, IMF FSI, IMF staff.
Contagion Analysis 2: Network Contagion between U.S. Banks and Foreign Banking System

113. A separate simulation is performed in order to assess the spillovers at individual BHC-level using publicly available data on cross-border claims against foreign banking systems.\(^{66}\) In the absence of liabilities-side data and bilateral bank-to-bank exposures, the analysis is performed under several major caveats. First, this analysis only captures the first-round effects direct exposures; in the absence of exposure against other banks in the network, the analysis does not capture the cascading effect due to other large counterparty banks’ exposure to large foreign financial systems. Second, the simulations are limited to a credit shock scenario given the liability-side cross-border exposures are not available. This scenario assumes 25 percent of the credit provided to the foreign banking systems is not recovered\(^{67}\).

114. Results reveal some concentrated inward spillovers due to a hypothetical distress in foreign banking systems transmitted through a credit shock, though spillovers are modest on average (Figure 35). Domestic G-SIBs have particularly larger direct inward spillovers emanating from the Japanese banking system. While the analysis is unable to capture the cascading effect given the data limitations, U.S. banks with limited inward spillovers may also experience larger spillovers if their counterparty exposure vis-à-vis the G-SIBs are sizable. On average, potential capital impairment incurred solely due to direct exposures by a G-SIB is about 1.2 percent of their initial regulatory capital. Other domestically owned BHCs in the sample on average have potential capital impairment of less than 1 percent of their initial capital, when the cascading nature of spillovers are not considered. Intermediate holding companies (IHCs) on average are susceptible to potential inward spillovers due to direct exposures at about 1 percent of initial capital. These potential spillovers could amplify in the presence of large counterparty exposures vis-à-vis the other banks in the network. However, significant concentrations exist among the IHCs against potential spillovers emanating from their parent banking systems.

\(^{66}\) Data for this section comes from FFIEC 009a report.

\(^{67}\) The assumption of LGD at 25 percent as oppose to a more stringent assumption at a higher LGD is used given the partial availability of the exposure data (i.e. exposure of a bank vis-à-vis a banking system, as oppose to bank-to-bank exposures).
LIQUIDITY STRESS TESTING FOR U.S. MUTUAL FUNDS

A. Objective and Scope

115. This stress testing exercise examines liquidity risk for U.S. mutual funds. The objectives are to assess whether mutual funds are able to withstand severe but plausible redemption shocks, identify which types of funds are potentially more vulnerable to liquidity risk and estimate the extent to which funds can transmit shocks to the financial system.68

116. The emphasis is on fixed income mutual funds, since they invest in a range of fixed income assets with varying degrees of liquidity. Based on commercial data, the sample includes 2,743 funds for a net asset value of about US$6.4 trillion as of end-2019, covering the entire mutual

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68 For the remainder of the document “funds” refer to mutual funds unless specified otherwise.
fund universe tracked by the Investment Company Institute (see Appendix XI for details). The sample is subdivided into nine categories reflecting the type of fixed income instruments mutual funds invest in. The categories are IG and HY corporates, loan funds, global bond funds, EM funds, government bond funds, municipal bond funds, mixed funds and multi-strategy funds (Table 1).

D. Methodology

117. The stress tests are based on three pillars: calibration of the redemption shock, composition of asset sales and the price impact of sales. The analysis compares for each fund the level of redemptions with the level of highly liquid assets at the disposal of the manager. Then, following the shock, it is assumed that the manager will sell some of the assets in the portfolio according to a liquidation strategy. When assets are sold, sales are assumed to have a negative price impact on the market, the extent to which depends on the amounts of sales and on the absorption capacity of the market (see Appendix XII for details about the methodology).

Calibration of Redemption Shocks

118. One set of redemption shocks are calibrated based on historical data. For each fund, historical data are used to calibrate the redemption shocks based on the most extreme outflows observed in the past by funds in the same category. Within each of the nine fund categories, funds face the same redemption shock (‘homogeneity assumption’), which is calibrated based on the average of the worst 3 percent net flows observed by funds in a given category. The resulting levels of redemptions range from 7 percent of the net asset value for municipal bond funds to more than 15 percent for HY and EM bond funds, which tend to experience more volatile flows (Table 1). The redemption shock is also calibrated at fund-level (‘heterogeneity assumption’), where each single fund faces an idiosyncratic shock based on its own historical net flows. The levels of shocks are in line with previous FSAPs (see IMF (2015, 2016, 2017, 2018)).

119. A second set of redemption shocks is calibrated using the adverse scenario. The banking sector adverse scenario is utilized to estimate redemption shocks for funds. Given the projected levels of macrofinancial variables, returns are estimated for each fund and given the flow-return relationship, net flows are estimated, as detailed in Appendix XII. Overall, the redemption shocks are milder compared to the historical approach, with most funds facing levels of redemption below 3 percent (Table 1). However, under the adverse scenario, all funds face redemption shocks at the same time, which could result in a large amount of forced sales.

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69 As a robustness check, other thresholds and methods are used, resulting in twelve different redemptions shocks.

70 Using the adverse scenario designed for the banking sector stress test allows the possibility to assess the aggregate impact of shocks across all mutual funds at the same time. This analysis therefore complements the historical approach, where results cannot be aggregated since the different fund categories would not face severe outflows all at the same time.
Table 1. United States: Mutual Funds Stress Test—Sample and Approach

<table>
<thead>
<tr>
<th>Sample of U.S. Mutual Funds</th>
<th>Steps in Mutual Fund Stress Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fund category</strong></td>
<td><strong>Net asset Value (US $ bn)</strong></td>
</tr>
<tr>
<td>Corp. IG</td>
<td>2,427</td>
</tr>
<tr>
<td>Mixed funds</td>
<td>1,752</td>
</tr>
<tr>
<td>Municipal</td>
<td>799</td>
</tr>
<tr>
<td>Multisector</td>
<td>432</td>
</tr>
<tr>
<td>Government</td>
<td>326</td>
</tr>
<tr>
<td>Corp. HY</td>
<td>257</td>
</tr>
<tr>
<td>Global</td>
<td>247</td>
</tr>
<tr>
<td>Loan funds</td>
<td>91</td>
</tr>
<tr>
<td>EM funds</td>
<td>66</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,398</strong></td>
</tr>
</tbody>
</table>

Sources: Morningstar, ICI, IMF staff calculations

<table>
<thead>
<tr>
<th>Redemption Shocks by Fund Category</th>
<th>Historical approach</th>
<th>Adverse scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fund category</td>
<td>Homogeneity</td>
<td>Heterogeneity</td>
</tr>
<tr>
<td>Municipal</td>
<td>6.8</td>
<td>5.8</td>
</tr>
<tr>
<td>Mixed funds</td>
<td>8.6</td>
<td>6.7</td>
</tr>
<tr>
<td>Corp. IG</td>
<td>12.9</td>
<td>10.3</td>
</tr>
<tr>
<td>Multisector</td>
<td>13.2</td>
<td>9.9</td>
</tr>
<tr>
<td>Loan funds</td>
<td>13.3</td>
<td>12.3</td>
</tr>
<tr>
<td>Global</td>
<td>14.3</td>
<td>11.8</td>
</tr>
<tr>
<td>Government</td>
<td>14.4</td>
<td>11.3</td>
</tr>
<tr>
<td>HY</td>
<td>15.0</td>
<td>11.8</td>
</tr>
<tr>
<td>EM funds</td>
<td>17.5</td>
<td>13.8</td>
</tr>
</tbody>
</table>

Redemption shocks in % of NAV. Median net flows under the heterogeneity approach. Positive values indicate outflows.
Sources: Morningstar, IMF staff.

Liquidity Demands Raising from Derivatives Exposures

120. Variation margins on swap and forward exposures are estimated in the context of interest rate and foreign exchange shocks. For a sample of 10 funds with large derivative exposures totaling US$41 billion in total assets, variation margins are estimated assuming a 50 basis points interest rate increase and a 1 percent depreciation of the U.S. dollar against all currencies. The variation margins are calculated using the duration of each instrument, based on regulatory filings by mutual funds (SEC form N-PORT as of end-2019). It is assumed that variation margins can only be paid in cash, in line with industry practices.71

71 According to the 2018 ISDA margin survey, cash accounts for 75% of collateral posted for variation margins (ISDA, 2019).
Ability of Funds to Withstand Shocks, Liquidation Rules, and Transmission of Shocks

121. **Redemptions are compared to funds’ holdings of highly liquid assets to assess their ability to withstand shocks.** The redemption coverage ratio (highly liquid assets to redemption, both in percent of NAV) is used to estimate the ability of funds to meet redemptions without resorting to the sale of less liquid assets in their portfolio.

\[
RCR = \frac{\text{Highly liquid assets}}{\text{Redemption shock}}
\]

Highly liquid assets are estimated at fund-level using the composition of the portfolio and applying liquidity weights derived from Basel III framework for the calculation of High-Quality Liquid Assets (HQLAs).\textsuperscript{72} When funds have an RCR below one, a liquidity shortfall is computed, as the difference between the redemption shock and the available highly liquid assets.

122. **Fund managers can use different liquidation approaches when facing redemptions.** Following the redemption shocks, we assume that fund managers will sell some of the fund assets to meet investors’ redemptions. Different liquidation strategies can be used: vertical slicing (pro rata)—where the manager sells each asset class in proportion of their weight in the fund’s portfolio—waterfall (where most liquid assets are sold first), or a mixed approach where cash is used first and then the manager follows a slicing approach.

123. **The sales of securities by funds following redemptions can have an impact on markets.** Given a redemption shock and a liquidation strategy, funds have to sell a given amount of securities across different asset classes. To estimate the price impact of the sales, the volume of sales is compared to the liquidity of the underlying market. Liquidity is measured by market depth which is positively related to the ratio of average daily trading volumes to asset volatility. Market depth is measured under average trading conditions and during stress periods (see Appendix XII for details).

Vulnerabilities of U.S. Mutual Funds and Interconnectedness

124. **Some fund categories might be more vulnerable or more likely to transmit shocks than others.** The analysis of vulnerabilities and interconnectedness within mutual funds is based on two concepts of risk. Vulnerable funds are funds that are likely to be in distress when other funds (or the market) are in distress. Spreader funds are institutions for which other funds are likely to be in distress when the spreader fund is in distress. The identification of vulnerable and spreader funds is based on two methodologies: tail-dependence using copula and the interconnectedness approach (Diebold and Yilmaz, 2016). Under the first approach, the dependence structure of net flows across funds categories is modelled using historical data, conditional on one fund category being in distress (i.e., facing large outflows), expected net flows for the other categories are then calculated. Under the interconnectedness approach, weekly returns for a sample of 70 funds (the 10 largest for 7 categories) are used to estimate spillovers from and to each fund in the sample.

\textsuperscript{72} A similar approach was used for the 2017 Luxembourg FSAP (IMF, 2017).
E. Results

Funds’ Ability to Withstand Severe Redemption Shocks

125. **Under the historical approach nearly all funds would be able to withstand severe redemptions, with the exception of high yield (HY) and loan mutual funds.** Overall, more than 90 percent of the funds would have enough highly liquid assets to meet investors’ redemptions. However, most funds exposed to HY and leveraged loans would not have enough highly liquid assets and would need to sell liquid securities in their portfolio, assuming that they do not use any liquidity risk management tools. The result remains valid when shocks are calibrated at category level (homogeneity) and at fund-level (heterogeneity).

126. **Loan funds may be particularly vulnerable to redemption shocks, but a large majority has credit lines.** Loan funds invest mainly in leveraged loans, which are less liquid than corporate bonds and are subject to relative long settlement (average of 10 days according to LSTA), which make them subject to significant potential liquidity risk (Figure 36). Most loans funds have credit lines in place, which usually are committed lines from banks, and most of them are shared with other funds. Such credit lines could provide liquidity buffers to funds experiencing large outflows. However, due to the shared nature of the credit lines, under stress other funds could need to draw on the same line at the same time.

![Figure 36. United States: Loan Funds](image)

127. **Under the adverse scenario, almost all funds would be able to withstand redemptions** (Figure 37). The result is directly related to the very mild shock in the adverse scenario (less than 3 percent of NAV for most funds). Only 1 percent of funds would not have enough highly liquid assets to meet redemptions, all HY funds.
128. **Funds with large exposures to derivatives could face significant liquidity demands related to variation margins.** A 1 percent depreciation of the USD and a 50 bp increase in interest rate would cause variation margins on the derivatives portfolio that would range between 3 percent and 10 percent of the NAV. For several funds the variation margins would be more than 50 percent of available cash and cash equivalents, depleting funds liquidity buffers (Figure 38). Results are illustrative since the sample is small and only focuses on simple derivatives. In practice, funds use other types of more complex derivatives (such as swaptions), which were not considered in the analysis.
129. **Under the current derivatives proposal, mutual funds using absolute Value at Risk (VaR) risk measures could potentially be substantially leveraged.** Under the SEC proposed rule, synthetic leverage would be indirectly limited by a VaR limit of either 150 percent of a reference benchmark or 15 percent of the one-month VaR of a fund (absolute VaR), rather than by a limit based on the NAV. For funds using absolute VaR, allowable synthetic leverage could potentially be high, if the funds invest in a portfolio with a low VaR: for a portfolio with a VaR of 5 percent, the fund could lever up to 3x times to reach the 15 percent VaR limit (5 times for a VaR of 3 percent etc.). A simulation exercise shows that for the 15 percent VaR constraint to be binding, the volatility of the underlying portfolio would need to be very high (about 25 percent annualized volatility, see Box 1). In addition, the current proposal includes an exemption for some funds which would allow them to be leveraged up to three times (provided that (i) funds disclose in their prospectuses that they are not subject to the proposed limit on fund leverage risk and (ii) funds would be subject to sale practice rules).

**Figure 38. United States: Use of Derivatives and Liquidity Demands**

<table>
<thead>
<tr>
<th>Use of USD fx forwards and USD swaps (% of NAV)</th>
<th>Variation margins (% of cash and cash equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fund 1</td>
<td>Fund 2</td>
</tr>
<tr>
<td>Cash in %</td>
<td>USD FWD</td>
</tr>
<tr>
<td>12%</td>
<td>81%</td>
</tr>
<tr>
<td>40%</td>
<td>3%</td>
</tr>
<tr>
<td>298%</td>
<td>111%</td>
</tr>
</tbody>
</table>

Sources: SEC form N-PORT, IMF staff.

Note: Variation margins in % of cash and cash equivalents as reported in B.2.f. Sources: SEC form N-PORT IMF staff.

Source: IMF staff calculations.
Box 1. Maximum Allowable Leverage under the Absolute VaR Approach

For funds using the absolute VaR approach, leverage is indirectly limited by the absolute VaR limit: the one-month 99 percent losses should be below 15 percent of the NAV of the fund. To assess the maximum allowable leverage, it is assumed that the returns of the portfolio of a fund follow a lognormal distribution. The VaR depends solely on the expected returns and the volatility of the portfolio. The figure below shows the result one-month 99 percent VaR given different levels of asset volatility: if the asset volatility is 4 percent, then a fund could lever up to 5.6 times the NAV since the VaR would be 2.7 percent.

Impact of Funds’ Forced Sales on Markets

130. **Asset sales by mutual funds to meet redemptions could have a sizeable impact on markets, based on certain assumptions.** Under the slicing approach—where funds sell securities in proportion of their weights in the portfolio—mutual funds exposed to less liquid asset classes (such as EM bonds, HY corporate bonds or leveraged loans) would sell large amounts of bonds, which would create some downward pressure on prices. Under the waterfall approach, the price impact would be more limited since funds would sell first their most liquid assets. However, remaining investors would end up with a less liquid portfolio, which could amplify the first-mover advantage (i.e., the incentive to redeem before other investors as trading costs are not passed on redeeming investors). At fund-level there is a trade-off between reducing the price impact of sales (thereby preserving the returns of the fund) and maintaining the portfolio allocation in line with the investment objective.

131. **Under the historical approach, prices would experience large declines, especially under stressed conditions.** Overall, the price impact of sales from mutual funds on their underlying
market ranges between 50 to 200 basis points in normal times, and between 150 to 700 bps during stress periods under the slicing approach. If funds sell their most liquid assets first (waterfall approach), the price impact on underlying markets is muted (less than 100 bps under normal conditions and less than 200 bps under stress for most asset classes).

132. Under the adverse scenario, the combined sales of assets would mainly impact EM debt and HY bonds. Under the slicing approach, the price of HY bonds would decline by more than 300 bps, mainly due to sales from HY funds (220bps) (Figure 39). IG bond prices would decline by about 120 bps, due to the combined selling of IG bond funds (70bps) and mixed funds (40 bps). The impact on the sovereign bond market is muted due to limited sales and deeper liquidity.

133. Asset sales can generate second-round effects. Due to the price impact of asset sales, funds return would be negatively affected, causing additional outflows from investors. Overall, the second-round effects are limited under normal trading conditions, but outflows could be more sizeable under stress conditions, with additional outflows above 3 percent of NAV for IG, HY and loan funds under the historical approach. The higher effect for IG corporate bond funds is explained by the large size of IG corporate bond funds (US$2,427 billion) rather than by the relative liquidity of the IG corporate bond market.
Vulnerability Analysis

134. Based on our assumptions, some fund categories are potentially more vulnerable to distress in the fund industry. When other fund categories are in distress (i.e., facing large outflows), EM bonds funds are likely to experience large outflows. IG corporate bond funds are also vulnerable to distress affecting municipal and government bond funds.

135. Based on our assumptions, some fund categories may be more systemic than others. When some fund categories are in distress, other funds’ categories might also be in distress at the same time, indicating the systemic nature of the first category. Systemic categories include IG corporate bond funds, multi-strategy bond funds and to a lesser extent municipal bond funds, mixed funds and global funds. Fund categories which are most exposed to liquidity risk such as HY, EM and loan funds are not systemic since when they are in distress, other fund categories do not experience large outflows, partly due to substitution effects, with investors moving out of those funds into safer funds (government or IG corporate bond funds).

136. The interconnectedness analysis based on funds’ returns yield similar results. According to our analysis, HY bond funds appear to be net receivers of spillovers from other funds and hence more vulnerable (Figure 40). Similarly, IG bond funds may be more vulnerable to spillovers from municipal and government bond funds. On the other side, government, municipal and corporate bond funds appear to be net senders of spillovers to the rest of the fund industry.
Figure 40. United States: Vulnerability Analysis across Fund Categories

Average Net Spillovers

Note: Average spillovers from other fund categories.
Sources: Morningstar, IMF staff.

Potential Flow Spillovers

Heatmap: Relative Average Spillovers

Note: Expected net flows conditional on distress in %.
Negative values indicate outflows.
Sources: Morningstar, IMF staff.

Source: IMF staff calculations.
MARKET RISK STRESS TESTING FOR MONEY MARKET FUNDS

A. Objective and Scope

137. The 2014 Money Market Fund reform required non-government institutional MMFs to maintain a floating NAV, reflecting the mark-to-market value of the fund instead of maintaining a constant NAV (CNAV). Since the reform, the overwhelming majority of the MMF market remains CNAV (government CNAV or Prime retail CNAVs), as VNAV prime funds only account for 15 percent of the industry and tax-exempt municipal MMFs for less than 1 percent (Panel 1).

138. Money market funds holdings are diversified according to the MMF type. Prime MMFs invest mainly in commercial paper and certificate of deposits, tax exempt MMFs in municipal debt, government MMFs in U.S. Agency debt and repo as well as UST debt and repo while Treasury MMFs invest in UST debt and repo (Panel 2).

139. U.S. MMFs have increased their exposures towards Federal Home Loan Banks and FICC through sponsored repos. Discount notes issued by FHLB account for 16 percent of U.S. MMFs holdings, and MMFs provide about 60 percent of FHLB funding through those instruments. Most FHLB notes are short-term (within 60 days) so that they can be considered weekly liquid assets according to the SEC definitions. Recently, MMFs have increased their exposures to FICC by entering into sponsored repo, where a large bank sponsors the MMF so that repo trades can be cleared through FICC (Figure 41). Sponsored repos are concentrated, with the top three banks accounting for 50 percent of repos.

140. As part of the 2014 Money Market Fund reform rules, the SEC requires MMFs to perform regular stress tests. MMFs using CNAV must be able to maintain a mark-to-market NAV within 0.5 cent of US$1, i.e., the shadow NAV must not fluctuate by more than 0.5 percent.
B. Methodology and Results

141. Stress tests estimate the impact of interest rate and credit spread shocks on the NAV of MMFs. The stress test was applied to 208 funds (see Table 2). MMFs are subject to two different and complementary shocks: (i) an increase in interest rates, and (ii) a widening of spreads on non-collateralized instruments held by MMFs. The impact of the shocks is calculated by computing the duration of each instrument in the portfolio of each MMF and using this measure to estimate the mark-to-market losses due to the shocks. The interest rate and credit spread shocks are calibrated based on the largest daily increase observed in 2008 and are both equal to 100 bps. The credit
spread is applied to all MMFs holdings excluding UST and U.S. agency debt as well as UST and U.S. agencies repo.

142. **All U.S. MMFs would be able to withstand large shocks to yields.** Under a 100 bps interest rate shock, U.S. MMFs NAV would not fluctuate more than 0.16 percent, which is well within the allowable range, due to the low duration of MMF portfolio (about 0.1 year on average). Under a combined interest rate and spread shock of 100 bps each, prime retail funds would see their NAV fall up to 0.27 percent, within the allowable range.

143. **Very large yield shock would be required for MMFs to break the buck.** Reverse stress tests are used to estimate the interest rate shock required to produce a 0.5 percent deviation from US$1. Interest rates would need to rise by more than 600 bps on average to produce such a deviation. For MMFs, with the highest duration, the required shock would be about 350 bps.

144. **Liquidity risk was not assessed for Prime MMFs.** The stress tests did not asses the liquidity of MMFs which do not use constant net asset value (Institutional prime MMFs). During the beginning of the COVID outbreak in March 2020, institutional prime MMFs experienced very large outflows from investors. At the same time, prime MMFs faced challenges in selling their assets due to strains in short term money markets. As a result of those combined shocks on the asset and liability side, some prime MMFs received sponsor support in March. Two affiliate banks purchased assets from the MMFs to improve their liquidity position. Following multiple steps taken by a number of government agencies to support the economy liquidity stress receded and prime MMFs had inflows starting early April.

<table>
<thead>
<tr>
<th>Type</th>
<th>Valuation</th>
<th>Size (USD bn)</th>
<th>No. of funds</th>
<th>Average</th>
<th>Max</th>
<th>Average</th>
<th>Max</th>
<th>Min</th>
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<tr>
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<td>0.14%</td>
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<td>0.14%</td>
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<td>0.27%</td>
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<td>0.11%</td>
<td>0.15%</td>
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<td><strong>0.16%</strong></td>
<td><strong>0.11%</strong></td>
<td><strong>0.27%</strong></td>
<td><strong>319</strong></td>
<td><strong>660</strong></td>
</tr>
</tbody>
</table>

Sources: CRANE, IMF staff

Note: Impact of a 100 bps interest rate shock on the NAV of the MMF and impact of a combined 100 bps interest rate shock and 100 bps increase in yields on uncollateralized instruments.
THE INSURANCE SOLVENCY STRESS TESTS

A. Objective

145. To quantify the risks, the FSAP used a broad range of scenario analyses, sensitivity tests and exposure analyses. In addition to the macrofinancial scenario which is broadly aligned with the narrative and severity of the banking sector stress test, further insurance-specific sensitivity analyses were performed (Figure 42). These analyses included:

(i) a prolonged period of low interest rates;
(ii) a lapse and surrender event with liquidity outflows from the life insurance sector;
(iii) the default of the largest banking counterparty; and
(iv) a stock-take on exposures to carbon-intense sectors.
(v) The results of these analyses are not added to the outcome of the main stress scenario, although it is possible to assume that the materialization of the stress scenario coincides with (i) or (ii), or both of them.

146. Compared to the 2015 FSAP, the FSAP uses a broader variety of analytical tools and more granular data, in particular on the asset side (Figure 42). The NAIC has shared detailed asset holdings of insurance groups in the stress test sample, most notably Schedule D, which includes all equity and bond exposures. The cut-off date for all analyses is December 31, 2018.
B. Valuation and Capital Standard

147. An important point of context for the stress test is that statutory accounting and U.S. GAAP do not require a full market-consistent approach to the valuation of assets and liabilities. Under statutory accounting, the liabilities of P&C insurers are generally not discounted which adds a layer of conservatism. Also, under statutory accounting, life insurance liabilities are discounted with a rate that is set at the time when the policy is sold to the policyholder or with a discount rate based on the expected return of assets associated with the insurance liabilities. This currently results in average discount rates above current market rates. Under statutory accounting, amortized cost is the predominant accounting regime for fixed income assets, which means that neither unrealized gains nor losses are recognized.

148. For the stress test model, this results in a significant difference in the impact of a shock to the risk-free interest rate: In a truly economic balance sheet with a fully market-consistent valuation of both assets and liabilities, life insurers, with their structural mismatch of assets and liabilities which is very common in that type of business, would see their liabilities increase more than their assets with falling interest rates. While the duration mismatch is usually smaller for non-life insurers, the same mechanics apply. State insurance regulation requires that companies perform an asset adequacy analysis at least annually to measure the structural mismatch of assets and liabilities under a range of different interest rate scenarios.

149. Under statutory accounting, also the impairment rules for life insurers differ from a fully market-consistent regime. Investment assets are impaired only when the fair value loss is deemed to be other than temporary. Once impaired, a bond cannot be written back up to its original fair value after recovery.

C. Sample

150. The macrofinancial stress test includes a sample of 50 insurance groups (See Appendix XV). FSAP insurance stress tests strive for a market coverage of at least 70 percent both in life and non-life, typically calculated based on gross written premiums. This target coverage was reached in the United States by including 21 groups predominantly active in life insurance business and 22 in Property & Casualty (P&C) business. In addition, seven health insurers with a market share of about 45 percent form a third group. For analytical purposes, sub-samples were formed of a) life insurers with a high share in VA business (6 companies) and b) foreign insurers (6) were formed. Most of the groups in the sample are publicly listed.

73 The actual treatment depends on the credit quality. For life insurers, fixed income assets in NAIC credit quality buckets 1 to 5 (i.e., AAA – CCC) are valued at amortized costs, and so are, for P&C insurers, assets in buckets 1 and 2 (i.e., AAA – BBB). For the remaining credit quality buckets (6 in life and 3 to 6 in P&C) the lower value of amortized cost and market value is used.
D. Stress Test: Adverse Scenario

151. The scenario for the insurance top down stress test builds on the narrative and severity of the banking sector stress test. Given the nature of insurance business and its balance sheet structure, the main focus of the stress test is on investment assets. The market risk stresses include shocks to bond holdings (sovereigns, municipals, and corporates), securitizations, equity, property and other investments (such as hedge funds and private equity). All stresses are assumed to occur instantaneously. Table 3 provides an illustration of the granularity of shocks.

152. Some shocks were slightly adjusted to make them more operational for the insurance stress test. The equity shock was re-calibrated and effectively lowered to be meaningfully applicable at end-2018 when equity markets were temporarily depressed. The yield increase of fixed-income instruments reflects a sizable portion in insurers’ portfolios of debt instruments for which no market prices exist—hence the shocks are a bit lower than those shocks applied to the banks’ trading books. Finally, the haircut on mortgage loans acknowledges a relatively high quality of the mortgage loan portfolio with average loan-to-value ratios about 60 percent.

<table>
<thead>
<tr>
<th>Table 3. United States: Market Risk Parameters</th>
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<tr>
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<tr>
<td>Equity Unaffiliated</td>
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<td>Affiliated</td>
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<td>Property held for sale</td>
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<td>Fixed-income instruments NAIC 1</td>
</tr>
<tr>
<td>NAIC 2</td>
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<td>NAIC 5</td>
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<td>NAIC 6</td>
</tr>
<tr>
<td>Mortgage Loans First Lien</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

Source: IMF staff.
E. Stress Test: Modeling Assumptions and Output

153. The stress test used publicly available, consolidated data of insurance groups from regulatory returns. As data files published by S&P Global Market Intelligence lack the necessary granularity for some of the analyses proposed, the NAIC has provided data on investments on an asset-by-asset basis.

154. Given the specificities of the statutory accounting for insurance companies, the modelling of the adverse scenario included the following steps:

- Mark-to-market impairment, based on the macrofinancial scenario, for holdings in equity, fixed-income instruments below investment grade, other investment assets (so-called Schedule BA assets);

- Default losses in the corporate bond and securitizations portfolio as well as on mortgage loans.

155. The U.S. regulatory framework does not include a capital requirement for insurance groups at the consolidated level. Hence, the stress test produces only a balance sheet impact expressed as the reduction in statutory capital, in line with the 2015 FSAP methodology.

156. The stress test did not take into account any mitigating effect from hedging, profit-sharing, or other management actions. Insurance companies usually apply a sophisticated hedging strategy regarding their interest rates (mainly via swaps and swaptions), and also hedge against declines in the stock market via options and futures. As these hedging activities can vary substantially among companies, it is difficult to estimate the mitigating effect in times of stress. In any case, it is very likely that the stress test gives a maximum impact. A range of life insurance products includes profit sharing features between the insurance company and the policyholder which allow the insurer to (partially) pass on investment losses by reducing discretionary benefits. In a risk-based solvency regime, it is also possible for the companies to de-risk their investments in order to reduce their capital requirements, resulting in higher solvency ratios; similarly ceding risks to a reinsurance company could be considered. Finally, dividend policies, both up-stream from subsidiaries to the top (holding company) level and from the top level to shareholders can be actively managed, especially with larger and diversified groups. As the range of management actions is very broad, no general modeling result can be provided based on available data.

157. The stress test was performed before the COVID-19 outbreak started. Box 2 provides a summary of the outbreak impact on insurance sector.
Box 2. COVID-19 Impact on the Insurance Industry

The insurance sector is affected by the pandemic mainly through higher claims, operational challenges and lower investment returns. Claims will be made under various types of household and commercial insurance. Revenues are expected to decline, at least temporarily, as the demand for insurance coverage declines. The risk of fraudulent claims increases when economic conditions deteriorate. All insurers face investment losses as a result of stock market declines, bond defaults and spread increases, while lower interest rates weigh heavily on life insurers with return guarantees. Equity exposures are material, but a substantial share of market-value changes is directly passed on to policyholders through investment-linked products. As the duration of the liabilities is generally longer than the assets, reinvestment risk has increased. Bond downgrades to non-investment grade would have substantial impact due to the requirement for capitalization of higher risk exposures. Finally, insurers are generally more liquid than their liabilities require, but some may face liquidity pressures if product cancellations and surrenders increase sharply while new business and renewals decline.

Life insurance

Beneficiaries on life insurance policies with a death coverage will submit claims on those policies, while annuity providers might experience reduced payouts given higher mortality rates. Excess mortality is covered by reinsurance to a large degree, mostly with U.S. affiliates of reinsurers outside the U.S. One global reinsurer has indicated that its exposure to COVID-19 life and health insurance claims, even under a very severe 1-in-200 years scenario, is similar in scope to a medium-sized natural catastrophe. Mortality increases might appear to be an immediate financial gain for annuity providers, but many of these products have guarantees that effectively reduced any perceived benefit for the insurer. Lower investment returns are a significant negative for life insurers, both in terms of reinvestment risks and the difficulty to earn a guaranteed rate of return.

Health insurance

Health insurers face higher costs and claims as policyholders may require testing, more medical care, and hospitalizations. An increase in unemployment will affect the level of uninsured health expenses. Under the Affordable Care Act, consumers who lose their coverage or become eligible for subsidies due to loss of income are able to enroll in coverage on the Exchange and most state-based Exchanges have created special enrollment periods to facilitate coverage. COVID-19 testing, hospitalizations, and premium grace periods have impacted insurer costs and incomes. At the same time, delays in other, non-emergency care have significantly reduced insurer spending in the first part of 2020, and many are looking at, and some have announced, premium holidays. The Families First Act and the CARES Act, complementing the Affordable Care Act, requires insurers to waive all cost-sharing, including deductibles, for medical services provided to people with any type of private health coverage related to medically necessary COVID-19 testing and associated visits. In addition, any preventive services, which include any future vaccine, must be covered by the principle of no cost-sharing. The new Act also enables states to provide free coverage for coronavirus testing for uninsured residents. However, the Act does not impose any federal requirement to waive cost-sharing for COVID-19 related medical treatments, and thus individuals may be subjected to significant out-of-pocket costs.

Property & casualty insurance

Most business interruption clauses included in commercial property insurance policies are only triggered in case of physical damage to the property of the policyholder due to a covered peril. There are differing views on whether the contamination of a property by a virus would be considered physical damage. Policies that more generally provide coverage for business interruption due to physical damage or loss of use may be more likely to be determined to provide coverage of pandemic-related business interruption losses. Many commercial policies apply exclusions that could apply to a viral contamination such as COVID-19. For example, the standard Insurance Services Office commercial property policy used in the U.S. applies an exclusion for “loss or damage caused by or
Box 2. COVID-19 Impact on the Insurance Industry (concluded)

resulting from any virus, bacterium or other microorganism that induces or is capable of inducing physical distress, illness or disease.” Yet it is unclear how many commercial policies do have such a clear inclusion or exclusion.

**Major legal and regulatory risks may emerge.** For example, in New Jersey, a legislative proposal has been put forward to require that all commercial property policies providing coverage for business interruption or loss of use of property also provide coverage for interruption resulting from COVID-19. As proposed, insurers that incur claims as a result of this legislation could seek reimbursement from the Commissioner of Banking and Insurance who would then recover those costs from all insurers writing business in New Jersey. While this legislation is on hold at the time of this report’s finalization, a similar legislation has been introduced in Ohio and Massachusetts. At the federal level, a group of members of the House of Representatives has requested insurers to consider retroactively covering financial losses from COVID-19 under business interruption coverage provided in commercial policies, suggesting that containment measures should be considered as civil authority orders that trigger coverage. The NAIC has written to Congress noting that such a measure would result in substantial solvency risks for P&C insurers and significantly undermine the ability of insurers to pay other types of claims.75

**Travel insurance is affected through coverage of medical treatments and trip cancellation.** The overall industry exposure to trip cancellation claims is not significant relative to other lines of business. Some insurers have changed the terms of travel insurance policies or stopped selling new travel insurance policies. For existing policies, medical treatment during travel would be covered in most cases, unless a travel advisory was in place. Insurance coverage for trip cancellation will usually only reimburse expenses after all attempts for refunds have been exhausted and only when there are no official advisories against travel at the time of booking.

**Claims can arise from liability insurance, including workers compensation.** Employees may claim compensation for lost wages and medical expenses if they believe they were infected at workplace, which could invoke coverage under workers compensation insurance. They could also make claims for distress, bodily injury, discrimination or financial losses due to isolation that could potentially be covered by employment practices liability insurance. For businesses whose premises are accessible to the public or to their customers, claims could be made in case of infections provided a proof of negligence regarding the spread of the virus is obtained.

**Motor insurance is contributing to an overall resilience of the P&C sector.** Individual traffic has declined as a result of public health measures and lower economic activity results in reduced commercial road use. In the longer term, however, it is likely that renewals will reset and underwritten volumes will shrink.

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74 In U.S. individual life insurance, almost 30 percent is reinsured. The market for life reinsurance is highly concentrated both globally and, in the U.S., with the largest five reinsurers having a market share in the U.S. of around 90 percent. Of these five companies, four are part of European groups, and one is a domestic group. See Munich Re, 2018 Life Reinsurance Survey Results.

F. Stress Test: Results

158. In the adverse scenario, the life sector experiences a substantial hit on its statutory capital, though it is overall largely shielded by the current valuation and capital framework (Figure 43). The aggregated reduction in statutory capital of US$226 billion equates to 30.9 percent of the sample’s statutory capital and 3.9 percent of consolidated balance sheet assets—this equates to 1.1 percent of the U.S. GDP. Sizable parts of the balance sheet are not sensitive to market price fluctuations which would be different under a fully market-consistent valuation regime. The absence of a group capital framework in the U.S. makes it difficult to estimate the stress test outcome in terms of a risk-based solvency regime. Solvency ratios of U.S. solo companies tended to be well above the regulatory thresholds recently, so that based on the current calibration of the risk-based capital, it can be expected that even in this adverse scenario the vast majority would still continue to be adequately capitalized.

159. Stress test results are very heterogenous in the life and P&C sector. In the life sector, capital declines by US$74.3 billion (-35.7 percent), in P&C by US$149.8 billion (-31.7 percent), and in the health sector by only US$1.4 billion (-2.8 percent). Depending on the business model and investment allocation, the capital impact can differ significantly both within the life and the non-life sector. Among the 21 life insurance groups, the decline in capital ranges from 14 to more than 60 percent, with the median company recording a decline of 32 percent and 50 percent of companies ranging between -21 and -36 percent. In the P&C sector, the median company loses 19 percent of its capital, and results across the sample range from -5 to -53 percent. Only in the health sector, companies’ risk profiles are very similar, resulting in a low affectedness by the market stress scenario for all sample firms—for the median company, capital declines by just 1 percent, and even the most affected company sees its capital shrinking by only 8 percent.

160. Shocks to other investment assets, non-investment grade corporate bonds and stocks contribute most to reductions in statutory capital. In the life sector, the shock to other investment assets (Schedule BA) contributes most to the overall reduction in statutory capital, while in the P&C sector, the stock price decline is more relevant on aggregate. For most P&C firms, however, the equity exposure is relatively small, and the sector-wide impact is a bit overstated and driven by a very small number of larger companies with sizable investments. Mortgage defaults contribute 10 percent of the overall impact in the life sector, as companies in the other two sectors barely engage in such lending activities.

76 Some groups are active both in life and non-life business, so that some outliers in each respective sector can be explained by relatively large activities in the other sector.
Figure 43. United States: Insurance Stress Test Results

Statutory capital of the median life company declines by 32 percent, and by 19 percent for the median non-life insurer. Health insurers with their high pre-stress capital are barely affected by the market shock, while results in the other two sectors are very heterogenous.

Reduction in Statutory Capital

In the life sector, the shock to other investment assets (Schedule BA) contributes most to the overall reduction in statutory capital, while in the non-life sector, the stock price decline is more relevant (though a bit overstated as many non-life companies have only small exposures to the stock market, and the aggregated result is driven by a very small number of larger companies).

Aggregated Contribution of Individual Shocks

Source: IMF staff calculations based on NAIC data.
G. Sensitivity Analysis

Low-for-Long Scenario

161. The analysis of a prolonged period of low interest rates ("low for long") focused on investment spreads and ultimately profitability. The NAIC has provided an analysis that compares the net investment yield of the life insurance sector against the average credited rate. For the years 2016–18, the resulting net investment spread averaged 1.1 percent (Figure 44). Like the 2015 FSAP, a future trend of the investment yield was projected, acknowledging that the downward trend in portfolio yields might flatten out in the future when fixed income instruments with higher coupons have already expired. The average credited rate would also decline, as new business would be issued with lower contractual guaranteed interest rates.

162. The low-for-long projection is conducted for the whole U.S. life insurance market. It is based on sector-wide aggregated data on investment yields and guaranteed rates, complemented by an approximated maturity profile based on the 21 life insurance companies of the stress test sample.

163. With continued low interest rates, the net investment spread is expected to decline further (Figure 44). The guaranteed rate in life insurance is relatively sticky but continues to decline. With about 7 percent of bond investments to be rolled over every year, the net portfolio yield is also declining, likely at a slightly higher pace than the guaranteed interest rate. By 2021, the net investment spread could therefore drop below 1 percent, only slightly above the recent minimum of 0.93 percent observed in 2017.
Lapse/Surrender Event

164. To assess potential vulnerabilities from the trend towards less liquid investment, the impact of a sudden cash outflow from the life insurance sector was modeled. The scenario assumed that policyholders are incentivized to terminate their life insurance policies after a sharp hike in interest rates. In the past decade, termination rates in the U.S. life insurance sector have been rather stable, hovering about 6 percent recently with no significant difference between individual lines and group business (Figure 45).

165. The sample for the lapse/surrender event includes the same 21 life insurance groups as the macrofinancial scenario stress test. Data for the analysis stems from the annual regulatory reporting, obtained from S&P.

166. Net cash outflows stemming from higher lapse and surrender rates were modeled for each life insurance group in the sample. It is assumed that lapse rates for life policies (general account only) which can be terminated at book value without any adjustment would double compared to the 2018 rates. Policies which foresee a surrender charge of at least 5 percent were assumed to experience an increase in lapse rates of 50 percent (Scenario 1). Various alternative paths of lapse increases were modeled to better control for each company’s own historic lapse pattern (see Figure 49 and the accompanying notes). All other policies (about two thirds of the general account) which cannot be withdrawn at the discretion of policyholders, or which are

Figure 44. United States: Life-Business: Investment Spread and Maturity of Fixed-income Assets

The net investment spread has been rather steadily declining since 2007 and will, in a scenario of persistent low rates, continue to be a drain on profitability.

Net Investment Spread
(Net portfolio yield over guaranteed rate)

Source: IMF staff calculations based on NAIC data.

Seven percent of the sample’s fixed-income assets mature within less than a year and need to be rolled over.

Maturing Bonds in Life Insurers’ Portfolios

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redeemed at fair value or with a market value adjustment, were not included in the analyses as their lapse rates are likely less sensitive to interest rate hikes. Termination of such policies might, however, increase in a recession scenario when household income shrinks.

Figure 45. United States: Life-business: Termination Characteristics

Annual termination rates were rather stable over the last decade, hovering about 6 percent.

Termination Rate
(Based on face amount)

Surrender Characteristics

Source: IMF staff calculations based on NAIC data.

167. Insurers were assumed to react to net cash outflows by liquidating investment assets. This results in the need to realize losses at distressed market levels. It is assumed that companies would sell up to 50 percent of their U.S. Treasury bonds, government-sponsored enterprises (GSEs) issues and municipals first, followed by corporate bonds starting with the highest rating category (NAIC 1). Cash positions and deposits are assumed to be kept unchanged to allow companies to make regular payments and expenses.

168. A few life insurers would need to liquidate sizable parts of their bond portfolio to meet cash outflows after a sharp increase of lapse rates (Figure 46). The sample of insurers can roughly be clustered in three categories of almost equal size. About one third is able to meet the outflow simply by selling parts of their U.S. Treasury bond portfolio which are generally seen as the most liquid asset. Another group would sell U.S Treasuries up to the assumed cap of 50 percent, and also sell some bonds of U.S. GSEs. Another four to six companies (depending on the scenario) would ultimately also have to liquidate parts of its corporate bond portfolio, even after having sold U.S. state and municipality bonds. These corporate bond holdings, despite carrying low credit risk, might be subject to (temporarily) restricted liquidity, so that large-scale sales are only possible at a discount. The total amount of U.S. Treasury bond sales in the four scenarios ranges from US$23–33 billion, while for U.S. GSEs and corporate bonds the ranges are from US$13–15 billion and from US$4–11 billion, respectively.
The need to liquidate investments after the realization of a lapse shock differs significantly among life insurers. While some companies can easily meet the cash outflows by selling moderate amounts of U.S. Treasury bonds, a few others would also need to liquidate corporate bonds in potentially less liquid markets.

Need to Liquidate Assets after Surrender Shocks:
Scenario 1

Notes: In each panel chart, the five segments denote the waterfall of asset liquidations, namely U.S. Treasuries (I), U.S. GSEs (II), U.S. Political Subdivisions (III), U.S. State bonds (IV), and corporate bonds in the NAIC 1 rating category (V). Scenario 1 assumes an increase of the 2018 lapse rate by 100 percent for life policies which can be terminated at book value without any adjustment, and an increase by 50 percent for policies which foresee a surrender charge of at least 5 percent. Scenario 2 assumes lapse shocks which correspond to the maximum termination rate observed in the period from 2009 to 2018, and the 75th percentile observed in the same period, for the two types of policies respectively. Scenario 3 assumes an increase of the lapse rate by two standard deviations and one standard deviation, respectively. Finally, scenario 4 assumes an increase of the lapse rate equal to 200 and 150 percent of each company’s mean lapse rate between 2009 to 2018, respectively.

Source: IMF staff calculations based on NAIC data.
Weather-Related Catastrophes

169. The impact of more frequent or more severe weather-related natural catastrophes might potentially be uneven across the P&C sector, with smaller and regionally active insurers being more exposed. The 2015 FSAP found overall a manageable impact of a severe hurricane on the solvency position of P&C insurers which could be explained by the diversification of risks the large insurers of the sample have underwritten. Smaller P&C companies which are active only in one or a few states tend to be more vulnerable as their exposures to tail risks are more concentrated. While the overall risk is unlikely to be nationwide systemic, conclusions could be drawn on regional vulnerabilities and—from a microprudential point of view—risk management practices in these smaller institutions.

170. Vulnerable lines of business were identified based on their coverage in the event of natural disasters and the observed volatility of loss ratios. NAIC data provides the necessary insights (Figure 47). Based on gross premiums, the most relevant line of business is homeowners’ multiple peril, followed by commercial multiple peril and allied lines—amongst these three, loss ratios are most volatile for allied lines business with peaks above 150 percent in 2005 (hurricanes Katrina, Rita and Wilma) and 2017 (hurricanes Harvey, Irma and Maria).

171. The analysis uses a bifurcated sample of (a) 538 solo entities being part of the 22 large and diversified P&C groups in the stress test sample as well as (b) 44 entities of small and regionally concentrated P&C insurers focused in nine Southeastern jurisdictions (Table 4). Those regionally active P&C insurers with concentrated exposures towards hurricanes and
windstorms were identified based on the NAIC Market Share Report 2018, considering the distribution of their business across states and vulnerable lines of business.

### Table 4. United States: Sample of Regionally Concentrated P&C Insurers

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<th>State</th>
<th>Premiums, P&amp;C ($ millions)</th>
<th>% of premiums, P&amp;C (maximum)</th>
<th>% of premiums, P&amp;C (minimum)</th>
<th>Share of vulnerable states and lines (minimum; pct)</th>
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<td>0.04</td>
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<td>FL</td>
<td>1.19</td>
<td>0.94</td>
<td>79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR</td>
<td>0.03</td>
<td>0.02</td>
<td>45</td>
<td>2/</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1/ Total premiums as of 2017
2/ Total premiums sourced from AM Best
3/ Subsidiary of Company I

Source: IMF staff calculations based on NAIC data.

**172. A proper modeling of increased frequencies and varying degrees of severity would require detailed policy and exposure information from companies.** As a workaround, the one-off effect of a very severe event simultaneously hitting all “vulnerable” states equally is modeled instead of assuming a higher frequency. Hence, the analysis cannot directly provide an estimate for the cumulated impact of a series of multiple events, e.g., a full hurricane season. Furthermore, the...

---


78 Alternatively, each insurer is individually hit by a very severe event in the same year.
analysis does not take into account any physical damage to an insurer’s own properties or any second-round effects of a (regional) economic downturn after the hurricane.

173. **The analysis draws on companies’ own estimates of the impact of hurricanes on its coverage of the risk-based capital (RBC) requirement.** As part of their regular reporting, insurers have to submit the impact of hurricanes at various occurrence probabilities, which include 1-in-50, 1-in-100, 1-in-250, and 1-in-500-year events. By design, the actual assumptions about which type of hurricane constitutes one of these events differ among companies—a 1-in-500-year hurricane in Puerto Rico will typically be different from a 1-in-500-year hurricane in Texas. Still, one hurricane might affect insurers in different states.

174. **The NAIC has provided aggregate statistics for the RBC coverage ratios before and after stress.** The dataset also includes the impact on the available capital with and without the mitigating effect from existing reinsurance contracts.

175. **Large and diversified P&C insurers are relatively resilient to individual disasters, even of a larger scale** (Figure 48). A single event which can be expected to occur every 50 years and assumed to hit all insurers simultaneously would result in an 8.1 percent reduction of available capital (gross)—taking into account recoverables paid by a reinsurer or recovered from alternative risk transfer instruments, the reduction is only 3.9 percent (net). For hurricanes with an occurrence expected every 250 and 500 years, the net capital impact increases to 5.8 and 8.6 percent, respectively. In the 1-in-250-year event, the capital of four out of 538 insurers would drop below the regulatory minimum, triggering supervisory action.

176. **Smaller and more concentrated P&C companies would be severely affected by major hurricanes in their respective home markets.** Smaller insurers rely substantially more reinsurance for more frequent hurricanes than larger firms. For a 1-in-50-year hurricane, that hit each insurer in this sample simultaneously, available capital in the sample of smaller P&C insurers would decline by 81.4 percent—taking reinsurance recoverables into account, the net impact amounts to only 5.7 percent. Excessive costs seem to prevent small companies from buying the same level of reinsurance coverage for more remote events. In case of a 1-in-250 and 1-in-500-year hurricane, the net impact on available capital is 58.6 and 164.3 percent, respectively. Already in the less severe of these two events, ten out of the 44 companies in the sample would record a shortfall in their capital adequacy.

177. **The impact of insurance failures on policyholders is mitigated through various protection schemes.** Insurance guarantee funds and, in states where those exist, dedicated catastrophe funds, funded by the P&C insurance sector as a whole would ensure that policyholder claims are paid out, however delays and disruptions in renewing contracts could occur and would require close attention by state supervisors.
**Figure 48. United States: Impact of Major Hurricanes**

The claims stemming from a simultaneous 1-in-500 year hurricane would decrease the capital of large and diversified insurers by 9 percent (net, after reinsurance)...

...while for small and concentrated insurers, the same event would result in claims which equate 164 percent of statutory capital.

**Impact on available capital:**

- **Large, diversified insurers**
- **Small, concentrated insurers**

**A significant share of small companies would record a negative capital after a 1-in-500-year hurricane, and...**

**25th percentile of the RBC distribution**

<table>
<thead>
<tr>
<th>Event</th>
<th>1-in-50</th>
<th>1-in-100</th>
<th>1-in-250</th>
<th>1-in-500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event</th>
<th>1-in-50</th>
<th>1-in-100</th>
<th>1-in-250</th>
<th>1-in-500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Percent of companies triggering RBC action**

<table>
<thead>
<tr>
<th>Event</th>
<th>1-in-50</th>
<th>1-in-100</th>
<th>1-in-250</th>
<th>1-in-500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large, diversified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small, concentrated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: IMF staff calculations based on NAIC data.
Banking Counterparty Default

178. A further asset-side shock centered around a default of the largest banking counterparty. Like the natural disaster event, this analysis did not imply a homogenous scenario as the largest banking counterparty differs for each insurance company in the sample. Furthermore, this type of analysis can only show the direct impact of one isolated default—second-round effects or a more widespread contagion after a major bank’s default are not factored in.

179. The sensitivity analysis was performed for the 50 insurance groups which were also subject to the macrofinancial stress test. The NAIC provided detailed asset exposures based on Schedule D, which allowed for the identification of relevant equity and bond exposures towards individual banks.

180. Shocks were applied as haircuts on investment assets. According to the nature of exposure, different haircut levels were applied. Equity exposures were assumed to lose their entire value, while the LGD for unsecured bond exposures was assumed to be 50 percent. Subordinated bonds would suffer from a 100 percent haircut, and the market value of secured bonds would decline by 15 percent.

181. The vast majority of insurance companies would experience a limited capital impact if the largest banking counterparty defaults (Figure 49). The median life company would lose 1.2 percent of its capital, and half of the sector’s firms range between 0.8 and 1.8 percent. In the P&C and health sector, the concentration towards the largest banking counterparty is even lower—in both sectors, the median insurer would experience a 0.5 percent loss in capital. Outliers exist, in particular in those cases where an insurer holds a participation in a large bank.

![Figure 49. United States: Default of the Largest Banking Counterparty](image)

For the vast majority of insurance companies, the default of the largest banking counterparty has only a minor direct impact on the capital position. The median life company would lose 1.2 percent, and in the P&C and health sector, the loss in capital would amount to only 0.5 percent. However, outliers with much higher losses can be seen in the sample.

<table>
<thead>
<tr>
<th>Reduction in statutory capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life</td>
</tr>
</tbody>
</table>

Source: IMF staff calculations based on NAIC data.
Exposure Analysis: Carbon-Intense Investments

182. **The FSAP undertook a stock-take of carbon-intense investments of the U.S. insurance sector—it did however not assume a change in the pricing of carbon-intense assets.** While it can be assumed that global institutional investors will continue re-allocating parts of their assets from carbon-intense to less carbon-intense assets, this is expected to be more of a longer-term transitional risk. Technological shocks, like e.g., a breakthrough in battery technologies or substantial increases in the efficiency of renewable energies might speed up this transition, but unlikely impact assets prices in the very short term.79

183. **Carbon-intense assets were identified by using the “FFI The Carbon Underground Top 200 List”**80 which identifies companies based on their carbon footprint—to a large extent, the list features fossil fuel producers and mining companies. Bonds and shares issued by those companies were matched against insurers’ holdings are reported in Schedule D which was provided by the NAIC for this analysis. Additionally, further securities were included when the issuer name included terms like e.g., “oil”, “coal”, or “petroleum”.

184. **Carbon-intense assets in a very narrow sense do not represent a major asset class (Figure 50).** Taking into account the limitations of the identification process, the share of bonds issued by carbon-intense companies amounts to 3.5 percent of all corporate bond exposures. In the equity portfolio, the share is 1.6 percent. Together, the identified carbon investments account for 1.1 percent of the sample’s total balance sheet assets. Notwithstanding these small amounts, transition risks could also exist in other economic sectors, e.g., related to transport or heavy industries, which were not included in the analysis in the absence of missing data on direct or indirect carbon emissions.

185. **Repricing risks in the transition to a less carbon-intense economy are likely not only restricted to carbon-intense equity and bond exposures.** Mortgage loan exposures or mortgage-backed securities with collateral in areas becoming more frequently hit by windstorms, floods or wildfires could be repriced by investors, acknowledging more explicitly the underlying long-term risks. The same might apply to municipality bonds in such regions or to debt issued by local utility providers.

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79 A macrofinancial stress test with several different types of energy transition risks was developed and run by the Dutch Central Bank. See De Nederlandsche Bank (2018) An energy transition risk stress test for the financial system of the Netherlands, Occasional Paper, Volume 16-7.

80 See www.fossilfreeindexes.com.
SYSTEMIC RISK, INERCONNECTEDNESS, AND CONTAGION ANALYSIS

A. Scope

186. The systemic risk and interconnectedness analysis complements balance sheet stress tests and assesses the transmission of risks across the financial system. Previous sections focused on stress testing individual institutions and provided an overview of the resilience of the different sectors separately—namely, the banks, the mutual funds (including money market mutual funds), insurance companies, and nonfinancial firms. This section aims to bridge that analysis by providing a quantification of the transmission of risks and vulnerabilities across sectors of the U.S. financial and nonfinancial sectors.

187. Systemic risk assessment consists of two complementary analyses. The first one is the contagion analysis between banks, non-banks and nonfinancial companies, which accounts for the direct and indirect cross-sectoral interconnectedness in the U.S. financial landscape. The second one is the market-based analysis which aims at capturing important correlation and co-movement patterns embedded in financial asset prices across different institutions and sectors.
B. Contagion Between Banks, Non-banks, and Nonfinancial Corporates

Overview

188. The domestic cross-sectoral contagion analysis aims at capturing potential spillover risks between banks and other financial and nonfinancial institutions. Given that over half of financial intermediation takes place outside of the banking system, this analysis aims to complement the banking sector network analyses described earlier by extending the coverage to include non-bank financial institutions (e.g., mutual funds, insurance companies, etc.). Moreover, this analysis aims at quantifying how the materialization of risk in a specific segment of the system transmits and reverberates across other segments of the financial system. In other words, and in contrast to previous sections where financial institutions (or sub-segments of the financial system) were analyzed in isolation, this part of the analysis takes into account how the endogenous behavior of certain institutions can affect other institutions across different segments of the financial system.

189. The analysis centers on assessing the resilience of banks and non-banks when facing potential stress in the corporate sector. Analysis of household and nonfinancial business sector resilience showed a rapid increase in vulnerabilities in the U.S. corporate sector, most notably among highly leveraged firms. Given the rapid rise of leveraged finance (e.g., leveraged loans, high yield, and private debt markets) and related products (e.g., CLOs), combined with a growing share of intermediation by the non-bank financial sector, this analysis focus on assessing the impact of potential stress in the corporate sector on both banks and non-bank financial institutions—including through their reaction in response to stress.

190. System-wide shocks could emerge and be transmitted instantly or via gradual adjustments in exposures of the financial institutions. An instant shock, such as for example the credit rating downgrade of many leveraged borrowers at the same time, would lead to fire-sales in the market. A gradual adjustment of exposures in the financial system would be due to rebalancing of portfolios of banks, insurers, mutual funds because of an increase in credit risk related losses but would not necessarily lead to a fire sale of corporate debt securities and leveraged loans. As gradual adjustment would be less severe than asset fire sales, in the subsequent analysis we focus on an instant market shock which lasts for one month and which leads to an immediate asset liquidation.

Exposures and Risk Transmission Channels

191. Direct exposures to the U.S. corporate sector are concentrated among the non-banks. Financial institutions exposures relate mainly to investment in nonfinancial firms’ equities as well as holdings of corporate debt instruments (e.g., corporate bonds, commercial paper, etc.). Mutual funds, life insurers, and pension funds exhibit relatively large exposures to corporate securities (Figure 51), while bank holdings of these instruments are limited. Banks are exposed to the corporate sector mainly through bank term loans and revolvers (committed and uncommitted credit lines). Accordingly, non-bank financial institutions would suffer larger direct losses in case of financial stress in the corporate sector than banks.
Corporate sector risks could manifest through the complex interlinkages with bank and non-bank financial institutions. Previous sections assessed the vulnerability of mutual funds to corporate debt. However, stress in the corporate sector could translate into wider losses throughout the entire system through direct linkages (i.e., cross-sectoral exposures) among different segments of the financial system, as well as indirect linkages—similar asset holdings, market reaction, asset liquidation, and marked-to-market losses.

The contagion analysis assumes that corporate stress impacts the mutual funds, which in turn lead to spillovers onto other financial institutions. Stress in the corporate sector manifests through rising corporate spreads. The shock to the BBB corporate spreads embedded in the FSAP stress scenarios is mapped into rising spreads across different credit ratings, with lower-quality rated companies experiencing a larger rise in spreads. Mutual fund returns suffer though their direct exposures to the corporate sector, which in turn may trigger redemption pressures for these funds. To meet redemptions, we assume that mutual funds will start to liquidate some of their assets, which—depending on the asset class and absorption capacity of the market—results in falling asset prices. Asset liquidations may lead to mark-to-market losses in other financial institutions, namely banks and insurance companies. These companies could also reduce funding means to the nonfinancial corporate sector, which could exacerbate the stress in that sector, feeding additional rounds of spillover. In addition to mark-to-market losses, banks might also face liquidity pressures from their committed credit lines to mutual funds (which themselves would be facing liquidity pressures). These risk transmission dynamics are presented schematically in Figure 52.

81 Conversely, if banks cut the credit lines to the mutual funds, it would exacerbate the potential liquidity stress in the mutual funds sector.

Figure 51. United States: Exposure to Nonfinancial Corporate Securities

Holdings of Corporate Assets
(In trillions of U.S. dollars; as of end-Sept. 2019)

Holdings of Corporate Assets
(In percent of assets; as of end-Sept. 2019)

Sources: FRB; and IMF staff estimates.
Note: * = includes corporate and foreign bonds
**Price Impact and Potential Losses**

194. **Based on our assumptions, asset liquidations by mutual funds could potentially lead to significant price impacts on certain asset classes.** Following the impact from stress in the corporate sector, we estimate that mutual funds would liquidate about US$97 billion (Figure 53). The liquidated amounts vary by the type of asset and the type of fund, with EM, HY, and EM funds suffering the largest redemption pressures. These asset liquidations translate to varying price impacts across asset classes (between 0.002 to 4.8 percent). Appendix XVII provides details about fire-sale haircut estimation and market size of various securities.

195. **Based on our assumptions, asset liquidations could lead to mark-to-market losses for mutual funds and reverberate through the financial system with non-negligible impact, particularly for non-banks.** The shock was calibrated based on the corporate stress tests performed by the IMF, the linkages were analyzed based on balance sheet data. Although significant, potential losses appear to be manageable for the banking system, in large part owing to banks’ limited direct exposure to the corporate sector. Assuming a market sentiment shock lasting for one month, liquidation losses for mutual funds amount to about US$0.9 billion (about 1 percent of the original value of assets sold). For banks, the resulting mark-to-market losses are close to US$10.8 billion (roughly equivalent to 0.06 percent of total assets). This would reduce banks’ CET1 ratio by about 0.1 percentage points. In the case of insurance companies, this shock may roughly

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82 Price impact for sovereign IG, sovereign HY, corporate, securitized IG, securitized HY, and municipal securities are 0.0015, 0.4, 4.8, 0.2, 1.3, and 0.45, respectively.
translate into losses at about 1 percent of insurance sector total assets. In case of a systemic credit risk-related stress (which leads to an increase of annual default rates of leveraged corporates of up to 6 percent), banks would face US$230 billion losses on commercial and industrial loans and CLO holdings.83 Five Category IV banks (Non-GSIBS) would require recapitalization. Insurance sector will be hit by around US$300 billion losses, at the same time they do not have to mark these to market given the existing regulatory treatment of their asset valuation.

### Figure 53. United States: Redemption Shock and Asset Liquidation of Mutual Funds: Price Impact Measures

<table>
<thead>
<tr>
<th>Assets Sold</th>
<th>(In billions of U.S. dollars)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Cash</th>
<th>SOV IG</th>
<th>SOV HY</th>
<th>Corp IG</th>
<th>Corp HY</th>
<th>Securitized IG (Agency)</th>
<th>Securitized HY</th>
<th>Equities</th>
<th>Muni Bonds</th>
<th>EM debt</th>
<th>Total</th>
<th>Redemption shock</th>
<th>Return shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM</td>
<td>0.4</td>
<td>2.4</td>
<td>0</td>
<td>0.3</td>
<td>1.3</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>0.0</td>
<td>2.0</td>
<td>6.4</td>
<td>-10.57</td>
<td>10.31</td>
</tr>
<tr>
<td>Global</td>
<td>0.1</td>
<td>0.4</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.7</td>
<td>12.0</td>
<td>-7.05</td>
<td>4.81</td>
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<tr>
<td>Gov</td>
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<td>-0.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-0.3</td>
<td>-0.1</td>
<td>0.0</td>
<td>-1.3</td>
<td>-1.31</td>
<td>-1.31</td>
<td>-0.50</td>
<td>-0.50</td>
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<td>HY</td>
<td>0.6</td>
<td>0.2</td>
<td>0.0</td>
<td>9.8</td>
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<td>0.1</td>
<td>0.3</td>
<td>12.0</td>
<td>24.7</td>
<td>-7.05</td>
<td>24.7</td>
<td>-1.86</td>
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</tr>
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<td>IG</td>
<td>1.2</td>
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<td>8.8</td>
<td>0.3</td>
<td>1.7</td>
<td>5.7</td>
<td>0.0</td>
<td>24.7</td>
<td>-3.06</td>
<td>24.7</td>
<td>-0.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Loan</td>
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<td>0.0</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6</td>
<td>0.6</td>
<td>-0.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Mixed</td>
<td>3.1</td>
<td>3.8</td>
<td>0.6</td>
<td>4.9</td>
<td>1.4</td>
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<td>0.9</td>
<td>28.9</td>
<td>44.8</td>
<td>-10.49</td>
<td>44.8</td>
<td>-2.84</td>
<td>2.22</td>
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<tr>
<td>Multi</td>
<td>0.4</td>
<td>0.6</td>
<td>0.1</td>
<td>0.7</td>
<td>0.3</td>
<td>0.5</td>
<td>0.8</td>
<td>0.1</td>
<td>3.4</td>
<td>-2.84</td>
<td>3.4</td>
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<tr>
<td>Muni</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>4.7</td>
<td>5.5</td>
<td>-0.76</td>
<td>5.5</td>
<td>-0.76</td>
<td>0.76</td>
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<tr>
<td>Total</td>
<td>5.8</td>
<td>13.8</td>
<td>1.5</td>
<td>15.7</td>
<td>13.5</td>
<td>3.2</td>
<td>7.6</td>
<td>29.2</td>
<td>4.7</td>
<td>2.0</td>
<td>96.9</td>
<td>-10.57</td>
<td>10.31</td>
</tr>
</tbody>
</table>

Source: IMF staff estimates.

196. **This analysis, nevertheless, warrants several important caveats.** Contagion dynamics are highly nonlinear, and thus inherently difficult to quantify. For instance, the estimation of price impacts relies on assumptions of market absorption capacity and are based on observed historical patterns. The liquidation strategy of different financial institutions is difficult to predict, as is the willingness to cut credit lines in a situation of stress by the providers of such lines. Insurance companies do not need to actively mark-to-market all assets on their balance sheets, and such losses would mainly materialize when disposing of these assets.

197. **Stress losses could be compounded by systematic mispricing of risk.** During the global financial crisis, financial risk was underestimated across a range of financial instruments—as was notably the case for asset-backed security CDOs. That experience showed that it is not only the underlying risk in the individual elements of structured product that can lead to higher than expected losses, but also the default correlation across these elements. To assess the effect from underestimating this risk, we estimate default correlations based on realized defaults and compare these correlations to those implicitly used in the ratings of CLO tranches (Box 2). The estimated default correlations can then be used to adjust the holding of CLOs (based on their adjusted ratings) across the different financial institutions that invest in these products.

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83 This assumes that banks would provide at least part of their US$760 billion committed lines to corporates.
Box 3. CLO Tranches, the Pricing of Risk, and Implications for Financial Institutions

**Increased popularity of CLOs across different investors in recent years.** Together with the rapid increase in leveraged finance—most notably, the so-called ‘leveraged loans’—related structured products such as Collateralized Loan Obligations (CLO) has seen significant issuance in recent times. More than half of all leverage loan issuance ends up in CLOs. CLOs are securitized products which are in turn held by a wide range of investors, including domestic and foreign, insurance companies, mutual funds, hedge funds, among others. Different types of investors tend to invest in different CLO tranches. Banks tend to hold mainly triple-A-rated CLO tranches. Non-bank investors such as, for instance, asset managers, insurance companies, and hedge funds, tend to hold lower-rated tranches.

**Default correlations are key for the adequate pricing of risk in CLO tranches.** One of the lessons learnt from the global financial crisis is that the default correlation in structured products is a key driver of the overall creditworthiness of the bundled product. In particular, a large number of AAA-rated structured products, including several Mortgage Backed Securities (MBS) and Collateralized Debt Obligations (CDO), exhibited significantly larger than expected losses during the crisis. One of the main reasons was the systematic underestimation of default correlations. Since then, credit agencies have revised (up) some of the default correlations embedded in their ratings (see e.g., Nickerson and Griffin, 2017), but there has been limited quantitative work in estimating default correlation, particularly in the CLO market.84

**This box presents quantitative estimates of default rates as well as default correlations of corporate debt instruments.** Default correlations are estimated based on realized defaults in the spirit of Lucas (1995) and subsequent authors using a similar methodology (see Caceres et al. (2020b) for details). Default correlations are estimated for different elements within a given credit rating but also between different credit ratings. Essentially, the correlation between two elements (e.g., loan 1 and loan 2) with default events $D_1$ and $D_2$, with respective probabilities $P(D_1)$ and $P(D_2)$, is given by:

$$\rho_{D_1,D_2} = \frac{P(D_1,D_2) - P(D_1) \times P(D_2)}{\sqrt{P(D_1) (1 - P(D_1))} \times \sqrt{P(D_2) (1 - P(D_2))}}$$

The estimated default probabilities by credit ratings as well as the estimated default correlations within and between credit ratings can be seen in Table 6. As expected, lower-quality credit ratings tend to exhibit higher default correlations, suggesting that the most vulnerable elements tend to fall in distress concomitantly during periods of strain.

**Applying the estimated default correlations to adjust the credit ratings of CLO tranches enables the computation of potential equity losses across financial institutions.** Based on reported data of holding of CLOs by domestic banks and mutual funds, these holdings are repriced using the CLO tranche ratings implied from using the estimated default correlations.

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84 A few studies estimating default correlations include Lucas (1995), Nickerson and Griffin (2017), Li and Chen (2018), and Qi et al (2019).
## Box 3. CLO Tranches, the Pricing of Risk, and Implications for Financial Institutions (concluded)

### Estimation Results

**Estimated 1-year ahead default correlations, by credit rating:**

<table>
<thead>
<tr>
<th></th>
<th>A-AAA</th>
<th>BBB</th>
<th>BB</th>
<th>B</th>
<th>C-CCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-AAA</td>
<td>0.25</td>
<td>0.11</td>
<td>0.24</td>
<td>0.60</td>
<td>0.99</td>
</tr>
<tr>
<td>BBB</td>
<td>0.11</td>
<td>0.31</td>
<td>0.40</td>
<td>0.59</td>
<td>1.00</td>
</tr>
<tr>
<td>BB</td>
<td>0.24</td>
<td>0.40</td>
<td>0.63</td>
<td>1.29</td>
<td>2.19</td>
</tr>
<tr>
<td>B</td>
<td>0.60</td>
<td>0.59</td>
<td>1.29</td>
<td>2.69</td>
<td>4.54</td>
</tr>
<tr>
<td>C-CCC</td>
<td>0.99</td>
<td>1.00</td>
<td>2.19</td>
<td>4.54</td>
<td>8.69</td>
</tr>
</tbody>
</table>

**Estimated 2-year ahead default correlations, by credit rating:**

<table>
<thead>
<tr>
<th></th>
<th>A-AAA</th>
<th>BBB</th>
<th>BB</th>
<th>B</th>
<th>C-CCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-AAA</td>
<td>0.29</td>
<td>0.24</td>
<td>0.66</td>
<td>1.16</td>
<td>1.38</td>
</tr>
<tr>
<td>BBB</td>
<td>0.24</td>
<td>0.89</td>
<td>0.92</td>
<td>1.37</td>
<td>1.97</td>
</tr>
<tr>
<td>BB</td>
<td>0.66</td>
<td>0.92</td>
<td>1.79</td>
<td>3.00</td>
<td>3.96</td>
</tr>
<tr>
<td>B</td>
<td>1.16</td>
<td>1.37</td>
<td>3.00</td>
<td>4.97</td>
<td>6.50</td>
</tr>
<tr>
<td>C-CCC</td>
<td>1.38</td>
<td>1.97</td>
<td>3.96</td>
<td>6.50</td>
<td>9.70</td>
</tr>
</tbody>
</table>

**Estimated 5-year ahead default correlations, by credit rating:**

<table>
<thead>
<tr>
<th></th>
<th>A-AAA</th>
<th>BBB</th>
<th>BB</th>
<th>B</th>
<th>C-CCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-AAA</td>
<td>0.36</td>
<td>0.63</td>
<td>1.35</td>
<td>1.93</td>
<td>1.83</td>
</tr>
<tr>
<td>BBB</td>
<td>0.63</td>
<td>1.02</td>
<td>1.88</td>
<td>2.86</td>
<td>2.74</td>
</tr>
<tr>
<td>BB</td>
<td>1.35</td>
<td>1.88</td>
<td>5.83</td>
<td>5.62</td>
<td>5.43</td>
</tr>
<tr>
<td>B</td>
<td>1.93</td>
<td>2.86</td>
<td>5.62</td>
<td>8.39</td>
<td>8.48</td>
</tr>
<tr>
<td>C-CCC</td>
<td>1.83</td>
<td>2.74</td>
<td>5.43</td>
<td>8.48</td>
<td>9.90</td>
</tr>
</tbody>
</table>

**Sources:** Caceres et al. (2020b); and IMF staff calculations.

### C. Complementary Market-Based Contagion Analysis

198. A market-based analysis is performed to assess indirect spillover risks between domestic banking entities and large foreign entities due to co-movement in asset prices. The spillover risks are analyzed using publicly available daily financial market prices—i.e., equity price returns. The spillovers analysis uses Diebold and Yilmaz’s (2014) approach. This analysis evaluates the directional co-movement through equity price returns, as equity prices could—to some extent—reflect banks’ current and expected fundamentals. A financial spillover from firm A to firm B is defined as the share of the variation in firm B’s equity returns shocks that can be attributed to (contemporaneous or preceding) shocks to firm A’s equity returns. The concept stresses
idiosyncratic shocks and excludes co-movement across markets that is driven by common factors. The VAR is estimated using a lasso-estimator (see Zou and Hastie, 2005). Estimations are conducted by controlling for global conditions by using the VIX index. The specification is as follows:

\[ A(L)Y_t + B(L)X_t = \varepsilon \]

\[ D^H = [d^H_{i,j}] \]

\[ X_t = [VIX, ...] \]

\( Y \) is a vector of equity returns for all the firms in the sample, \( X \) is the Chicago Board Options Exchange Standard & Poor’s 500 Implied Volatility Index (VIX), \( A(L) \) and \( B(L) \) are lag polynomials, \( \varepsilon \) is an error term, and \( DH \) is the H-step ahead generalized forecast error variance decomposition matrix.

199. The VAR model above is used to build a generalized forecast-error variance decomposition (GVD), using Pesaran and Shin’s (1998) methodology, to identify uncorrelated structural shocks to FCIs. The GVD for each firm is aggregated in a matrix, with the non-diagonal elements capturing spillovers effects. Specifically, the spillover from firm \( i \) to firm \( j \) is the percent of \( j \)’s total inward spillovers that are coming from \( i \):

\[ s_{ij} = \frac{d_{ij}}{\sum_{l \neq j} d_{ij}} \]

The spillover therefore measures the fraction of the H-month ahead forecast error variance of firm \( j \)’s returns that can be accounted for by innovations in firm \( i \)’s returns.

200. Sample of institutions and calculations. The sample includes 160 large financial sector entities with asset size above US$100 billion in 20 countries. The analysis is performed using daily equity returns from 2015 through end-2019, estimated as log differences in equity prices. To control for the differences in trading hours in this cross-country setting, two-day averages are used (see Forbes and Rigobon, 2002). Estimations are conducted by controlling for global conditions by using the VIX index. Several sub-samples are assessed separately to explore domestic and cross-border equity return co-movement.

201. Results illustrate stronger equity return spillovers emanating from the U.S. G-SIBs. The directional co-movement—controlling for common global shocks through the vix index—shows relatively stronger co-movements in equity returns from the U.S. G-SIBs into domestic as well as foreign financial entities (Figure 54, panel 1). Inward spillovers from the U.S. G-SIBs into the U.S. Non-GSIBs are relatively high, while few Non-GSIBs with larger credit card operations reveal higher spillovers (Figure 54, panel 2). Large non-bank financial entities in the U.S. are also well connected with the domestic G-SIBs through equity return co-movement. Based on historical market conditions, spillovers emanating from Non-GSIBs and other U.S. non-bank financial entities are

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85 The GVD identification framework is order invariant by construction, hence avoids the ad hoc ordering of structural shocks characteristic of recursive identification.
relatively subdued on average, compared to the spillovers from U.S. G-SIBs. In a nutshell, given the strong market-based interconnectedness between the G-SIBs’ and other domestic financial entities as these results illustrate, monitoring market-based as well as exposure-based contagion between large domestic financial sector entities may provide room to identify potential vulnerabilities.
Market-based interconnectedness reveals higher spillovers on average from the U.S. G-SIBs to foreign non-G-SIB banks, compared to the spillovers potentially transmitted through other groups of entities. While the spillovers from the U.S. G-SIBs into foreign G-SIBs are large, potential spillovers from U.S. G-SIBs into other foreign financial and domestic financial entities on average are relatively higher (Figure 55). The analysis also reveals spillovers emanating from foreign G-SIBs into domestic financial entities, though at a relatively lower intensity compared to domestic G-SIBs. These results also reveal that many U.S. banks are closely connected with major domestic and foreign banks and therefore centrally clustered in the network (Figure 58, where closer to the center suggests larger co-movement levels). Overall, the analysis highlights the role of the U.S. G-SIBs as a potential risk transmitter, and emphasizes that vulnerabilities could potentially emanate into the domestic banks from foreign G-SIBs.

Figure 55. United States: Market-based Cross-Border Banking Sector Interconnectedness: Net Inward Co-movement of Domestic Banks and Large Foreign Banks

Sources: TR Datastream; Haver Analytics; IMF staff estimates

Note: Data as of 2019:Q4. For banks outside the US, bank names are not shown; country names are shown instead, with country names representing where the bank is domiciled. Red nodes are U.S. G-SIBs, green nodes are U.S. Non-GSIBs in the FSAPs stress testing exercise, blue nodes represent foreign G-SIBs, and orange nodes are other large foreign banks. Proximity to the center suggests greater co-movement of equity price returns.
CONCLUSIONS

203. **COVID outbreak put significant stress and amplified existing structural vulnerabilities in the financial system.** The COVID-19 represents a real-life stress event, materializing through adverse shocks to both macroeconomic and financial conditions, exposing highly leveraged borrowers and lenders to default risks. US regulatory and supervisory agencies took swift and decisive actions to mitigate the effects of the outbreak on financial markets. Nevertheless, financial system is subject to numerous uncertainties related to the future financial conditions or borrowers, policy actions and priorities. Analysis conducted during the FSAP highlighted numerous changes compared to the previous crisis episodes, such as the GFC, differences of simulated shocks as well as remaining structural vulnerabilities.

204. **After being at the epicenter of the global financial crisis, household mortgage debt has decreased substantially over the past decade, but other forms of consumer credit are on the rise.** However, certain segments of consumer credit have seen a rapid growth in recent years. Auto loans now exceed US$1 trillion, and student loan debt is on the rise. If unabated, these segments could put pressure on households’ debt servicing capacity, in light of tightened financial conditions, sharp increase in unemployment, exceeding the levels observed in the past crisis episodes. Banks stress test simulations reveal, that credit losses related to consumer credit and mortgages are the highest contributors to overall credit losses.

205. **Corporate sector leverage is at its historic peak, while leveraged finance was growing rapidly.** Increased financial risk taking, weakening underwriting standards and investor protections have allowed less creditworthy firms to access capital markets and increase their leverage. Much of this risk is distributed in the form of leveraged loans, private loans and CLOs, including abroad. Covenant protections for investors have weakened and the credit quality of new loans continues to deteriorate in light of COVID-19 shock. Important data gaps exist, particularly regarding direct and indirect exposures to leveraged and private loans across financial sub-sectors.

206. **Corporate sector vulnerabilities could further amplify the COVID-19 shock to the most leveraged part of the corporate sector and delay an economic recovery as it reverberates through other sectors.** Highly leveraged corporates already experience significant stress, leading to higher credit spreads, downgrades, inability to refinance debt, and defaults. As corporates de-lever and reduce costs, lay-offs would accelerate, consumer confidence decline, and the shock would spill to other segments of the economy. Financial institutions would suffer via direct and indirect exposures to the corporate and household sectors, resulting in funding liquidity stress, asset liquidations, and mark-to-market losses. Enhanced discretion resulting from weaker covenant protections for investors could imply delays in corporate restructurings and a subsequent economic recovery. Corporate stress test reveal, that up to 12 percent of corporates may face financial troubles in case of a prolonged recession, due to a second wave of COVID-19 infections. These results were taken into account in banking sector stress tests.
207. **The U.S. banking system entered COVID-19 crisis well prepared: with strong capital and liquidity buffers.** Observed behavior of banks at the outset of the crisis showed banks’ ability to extend credit to the real sector and thus contain further amplification of the crisis impact on cash strapped corporates and households. Part of the preparedness of the banks is attributable to the authorities’ DFAST/CCAR stress tests which are based on a conservative scenario. FSAP analysis shows, that stress test results for banks are comparable to those published by FRB (DFAST and CCAR) and use of market data proxies (EDFs) leads to only marginally more conservative estimates of loan portfolio losses compared to accounting data (also taking into account that many smaller companies are non-public). Overall, additional sensitivity analysis reveals that CET1 and leverage ratios do depend significantly on a net income and expense before credit/market risk losses.

208. **The largest loan losses in the industry are generated by the credit card-related net charge-offs, followed by residential real estate and commercial and industrial net charge-offs.** Overall, loan loss provisions contribute only a smaller fraction of the CET1 decline. Smaller domestic banks (Non-GSIBS) face most volatile CET1 and leverage ratios during stress compared to G-SIBS which have stronger market power and well diversified loan book and funding structure.

209. **Non-GSIBS do depend more on interest income from loans, have relatively higher exposure to credit card and small business loans which exhibit the highest credit loss rates in the adverse sensitivity scenarios.** Large banks (G-SIBs, Trading Banks) derive a larger share of their revenue from trading books, and thus are subject to additional losses due to marking-to-market of these trading assets and counterparty defaults. Going forward, it is important to ensure that Non-GSIBs have enough capital to support lending as well as be able to absorb losses in case of further deterioration of economic environment. This can be achieved assuming conservative capital planning and reducing or stopping shareholder payouts during the time of the crisis. Nevertheless, banks’ capital shortfalls is moderate in the Baseline and Adverse sensitivity scenarios, ranging from 0.3 to 1.3 percent of GDP. The wide range of shortfall estimates reflect uncertainty regarding duration and severity of the crisis, balance sheet growth, as well as dividend payout/share buyback policies in quarters preceding downturn.

210. **Banks maintain healthy liquidity buffers and were able to withstand severe funding outflows, at the same time, market liquidity dried out not just of mortgage and corporate but also sovereign bonds.** G-SIBs and Non-GSIBS have large amount of stable deposit funding, while some trading as well as foreign owned banks still rely on repo markets to obtain liquidity. Partial closure of the repo market (only treasury securities accepted as collateral) would not have a significant effect on liquidity of G-SIBs, except when banks are not able to sell outright large amounts of sovereign (Treasury) securities. A similar shock was observed at the outset of COVID-19 crisis but was mitigated by a swift intervention from the Federal Reserve. Banks remain significant providers of short-term funding, including liquidity to corporates, households (credit cards), other banks and non-bank financial institutions. It is important to ensure that in times of stress all large banks, including Non-GSIBs, have enough liquidity buffers to continue provide funding to their clients and counterparts.
211. **The U.S. banking system’s vulnerability to shocks emanating from other banking systems is rather contained.** The network analysis simulated a stress episode with shocks coming from credit and funding channels and evaluates the capital impairment due to contagion in the network of entities or banking systems. U.S. banking system play a larger role as a significant source of contagion. Results also suggest that capturing exposures based on different dimensions such as the level of consolidation and ownership reveal additional insights on where the pockets of vulnerabilities may arise and how the spillovers could amplify in potential stress episodes. A bank-level market-based analysis on equity return movements was also performed to complement the exposure-based analyses. The results reveal that the U.S. banks are closely connected with large foreign banks, thus centrally clustered in the network.

212. **While the banking system was strengthened since the GFC, risks migrated to non-bank financial institutions.** Highly leveraged institutions, such as investment, including hedge, funds, non-bank providers of funding such as mortgage lenders, may face higher liquidity and subsequent solvency risks during the downturn induced by COVID-19 pandemics.

213. **Mutual funds are a key part of the U.S. financial system and are highly interconnected with other financial institutions through direct and indirect exposures.** Some categories of mutual funds are subject to liquidity mismatches, as they invest in less liquid asset classes while providing daily redemptions. If significant in the aggregate, distress in the fund industry could have an important impact on financial stability.

214. **Despite some mitigating effects stemming from the current valuation regime, parts of the insurance sector are vulnerable to severe market shocks and prolonged low interest rates.** For insurance groups, analyses are complicated by the absence of a group capital requirement. The FSAP recommends the NAIC to develop and perform insurance solvency stress tests on a consolidated basis, in line with forthcoming group capital standards—also the work on liquidity stress tests should be further pursued. Public disclosures should be enhanced by requiring insurance companies to disclose market risk and interest rate sensitivities in a more harmonized manner.

215. **Systemic risk analysis results indicate that not all institutions in the financial system are equally resilient: while banks have adequate capital and liquidity buffers, some risk takers (such as some categories of mutual funds, insurers) are more vulnerable.** A marked rise in corporate stress would impact non-bank financial institutions, with a more moderate impact on banks, even though some large domestic banks are impacted more substantially. G-SIBs liquidity buffers are substantial, but high levels of utilization of credit and liquidity facilities would lead to a liquidity shortfall in some banks. Life insurers would face a significant reduction of their statutory capital in the adverse scenario, and a few less-diversified P&C insurers would face capital shortfalls after severe natural disasters. Most investment funds would be able to withstand severe redemptions, though high yield and loan funds would face significant shortfalls.