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# JAPAN

## FINANCIAL SECTOR ASSESSMENT PROGRAM

September 2017

## TECHNICAL NOTE—SYSTEMIC RISK ANALYSIS AND STRESS TESTING THE FINANCIAL SECTOR

This Technical Note on Systemic Risk Analysis and Stress Testing the Financial Sector on Japan was prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed on September 2017.

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# TECHNICAL NOTE

## SYSTEMIC RISK ANALYSIS AND STRESS TESTING THE FINANCIAL SECTOR

Prepared By
**Monetary and Capital Markets Department**

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program in Japan. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP can be found at http://www.imf.org/external/np/fsap/fssa.aspx

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# Glossary

| | |
|---|---|
| AFS | Available for sale |
| BMA | Bayesian Model Averaging |
| BOJ | Bank of Japan |
| BPS | Basis Points |
| BU | Bottom-up (stress test) |
| CAR | Capital adequacy ratio |
| CCB | Capital Conservation Buffer |
| CCR | Counterparty credit risk |
| CDS | Credit Default Swap |
| CET1 | Core Equity Tier 1 |
| CFR | Core Funding Ratio |
| CRE | Commercial real estate |
| DSGE | Dynamic stochastic general equilibrium |
| EAD | Exposure at default |
| EDF | Expected default frequency |
| EL | Expected loss |
| ESR | Economic Solvency Ratio |
| FG | Financial Group |
| FSAP | Financial Sector Assessment Program |
| FSR | Financial Stability Report |
| FSSA | Financial System Stability Assessment |
| FX | Foreign Exchange |
| GDP | Gross domestic product |
| GFC | Global Financial Crisis |
| G-SIB | Global Systemically Important Bank |
| HFT | Held for trading |
| HQLA | High-quality liquid assets |
| HTM | Held to maturity |
| IAIS | International Association of Insurance Supervisors |
| ICS | International Capital Standards |
| IRB | Internal ratings-based (approach) |
| JFSA | Japan Financial Services Authority |
| J-GAAP | Japanese Generally Accepted Accounting Principles |
| JPY | Japanese Yen |
| LCR | Liquidity coverage ratio |
| LGD | Loss given default |
| LIBOR | London Interbank Offered Rate |
| LTV | Loan-to-value (ratio) |
| NII | Net interest income |
| NIM | Net interest margin |

| | |
|---|---|
| NPL | Nonperforming loan |
| NSFR | Net-Stable Funding Ratio |
| ORSA | Own Risk and Solvency Assessment |
| PCA | Principal component analysis |
| PD | Probability of default |
| PiT | Point-in-time |
| Pps | Percentage points |
| PTB | Price-to-book (ratio) |
| RAM | Risk Assessment Matrix |
| ROA | Return on assets |
| ROE | Return on equity |
| RWA | Risk-weighted assets |
| SMR | Solvency Margin Ratio |
| STeM | Stress test matrix (for FSAP stress tests) |
| TD | Top-down (stress test) |
| TTC | Through-the-cycle |
| VAR | Vector autoregression |
| VaR | Value at risk |
| VIX | Volatility index |
| WEO | World Economic Outlook |
| YoY | Year-on-year |
| YTM | Yield to maturity |

# EXECUTIVE SUMMARY

**A comprehensive set of stress tests and interconnectedness were conducted to assess the resilience of Japan's financial system and shed light on linkages and potential vulnerabilities.** Japan has one of the largest and most sophisticated financial systems in the world. Financial conglomerates have a significant presence in the financial system. Banks play a major role in financial intermediation, but Japan's highly concentrated insurance sector is also very sizeable. Similarly, Japanese securities markets rank among the largest in the world, and the system includes a heterogeneous set of securities firms. Various quantitative tools and models were used to examine the impact of short- and medium-term macrofinancial shocks on banks and insurers, and assess connectedness risks within and outside of the financial sector.

**The Japanese financial system appears generally resilient to short-term risks, but pockets of vulnerability exist.** Overall, banks appear to have sufficient capital and liquidity buffers to cope with a scenario of severe recession due to disruptions in global trade, and accompanied by a sharp increase in interest rates and risk premiums, and a decline in equity prices. Spillovers within the system also appear to be limited (but the analyses do not capture all potential effects during stress times). At the same time, resilience is not equal among all institutions included in the analysis: some life insurance companies and regional banks may need to strengthen their capital buffers.

**Equity and other market risk losses represent the most important risk factor for the large banks included in the stress tests.** The top-down (TD) banking sector stress test covered up to 20 of the largest banks, representing 90 percent of banking system assets. The results of these tests point to a broadly stable banking system, but some vulnerabilities exist among regional banks—three regional banks would need additional capital to meet the 8 percent total capital requirement, although the number is very small in terms of ratio to GDP. Under the Severe Adverse Scenario, Japanese banks' solvency ratios would be significantly affected, and the aggregate Common Equity Tier 1 (CET1) ratio would drop to 8.3 percent at its lowest point within the five-year stress horizon. The main drivers of this fall in capitalization would be equity- and market related losses (bond valuation effects due to increase in interest rates), credit losses, lower profitability from overseas lending due to higher U.S. dollar funding costs, and the change in risk-weighted assets.

**The stress tests show that credit-related-losses represent the highest risk for regional banks.** Regional banks without international exposure, which have relative higher overhead costs and less diversified loan portfolios, exhibit a slow decline in profitability and capital levels even under the baseline scenario.

**Loans to companies represent the most important exposure class after sovereign exposure, and many banks also carry common name credit concentration risk.** Loan portfolio concentration tests reveal that no bank fails to meet minimum CAR in case of default of the single largest borrower, even under extreme loss-given-default assumptions. However, many large exposures are connected; that is, multiple banks are exposed to common credit risks from the same large borrowers.

**Internationally active banks rely heavily on wholesale sources for foreign currency funding.** In contrast to their yen funding, most of banks' funding in U.S. dollars and euros comes from unsecured wholesale funding, repos, and foreign exchange (FX) swaps, although banks have been shifting towards stable and longer funding sources to reinforce their resilience under latent stressed funding conditions in FX markets. Banks' funding sources are also more concentrated in foreign currencies, particularly in the euro, than those in yen.

**Compared to ample liquidity in yen and in all-currency basis, potential vulnerabilities exist in foreign currency positions, particularly for internationally active regional banks.** Although no bank fails in the yen liquidity stress testing, a few internationally active regional banks would experience negative cumulative funding gaps in U.S. dollars in the severe stress scenario. However, since these funding gaps are relatively small compared to their excess yen liquidity, no bank fails in the combined liquidity stress testing of both yens and U.S. dollars. All-currency liquidity coverage ratios also suggest robust overall liquidity, with ratios above 100 percent in all banks in the sample. However, the system-wide liquidity coverage ratio (LCR) in U.S. dollars stands below 60 percent, and the ratio for regional banks is lower on average.

**TD and bottom-up (BU) stress tests were conducted for seven life and six non-life companies covering 73 and 92 percent of the respective sectors.** The two macrofinancial scenarios formed the basis for the stress tests, but were slightly adjusted by front-loading the shock for the financial market variables. The impact was measured in terms of instantaneous changes in the solvency margin ratio (SMR), with the statutory requirement of a 200 percent as the hurdle rate.

**Life insurance companies experience a substantial decline in their solvency position, given their strong sensitivity to interest rates, while non-life companies are more resilient.** In the life sector, TD stress test results show that the average SMR drops from 949 percent before stress to 708 percent in the moderate adverse scenario and to 419 percent in the severe adverse scenario. Six out of seven companies remain above the statutory requirement under the current regime. Being less sensitive to higher interest rates, the non-life sector performs better, with a less-marked decline in average SMRs. BU stress tests broadly confirm these results, but SMRs in this exercise are on average slightly higher, and all companies stay above the 200 percent hurdle rate. For the nonlife sector, the analyses reveal resilience of the non-life sector toward large natural catastrophes if modeled as single events. Domestic perils like earthquakes and typhoons are the most relevant risks.

**However, insurance stress test results need to be interpreted cautiously in the current valuation and solvency regime.** Economic solvency ratios (ESR) as tested in a recent JFSA field test are considerably lower than the statutory SMRs—on average, the life sector had an ESR of only 104 percent as of March 2016. In particular, an economic solvency regime makes life insurers less vulnerable to an interest rate increase, but more so to a prolonged period of low rates.

**The analysis of spillovers based on market- and balance sheet data suggests that the propagation of financial shocks occurs primarily through the client and investor bases.** Direct exposures seem to play only a modest role in the transmission of funding shocks, while strong links between financial and nonfinancial firms underpin market-based spillovers. Possibly, changes in market sentiment associated with credit and/or funding shocks may magnify the transmission of these shocks. Japan's nonfinancial firms and city banks are the main source of financial spillovers. Behind some of these spillovers are common exposures to foreign markets and a dense web of cross-shareholding.

**Financial firms with stronger balance sheets tend to be less sensitive to financial spillovers.** An empirical analysis suggests that among Japanese banks, institutions that rely less heavily on wholesale funding or for whom credit accounts for a larger fraction of their assets are less vulnerable to shocks from other banks. Finally, financial firms with higher shares of institutional ownership—a proxy for better corporate governance—are also less sensitive to financial spillovers.

**Losses to the financial system stemming from a credit shock would be significantly larger than those coming from a funding shock.** Amon funding shocks, those emanating from large city banks have the relatively more important consequences for the financial system, especially for securities firms. However, in the case of a default by a large city bank, average capital losses would be six times larger than under a funding shock, and life insurers would suffer most. Overall, the high levels of capital held by many financial institutions in Japan help dampen credit and funding contagion throughout the financial system.

**Stress test and other quantitative risk assessment results should be interpreted with caution.** Stress test scenarios are based on historical events or expert judgments to shed light on extreme but plausible "tail events," even though crises tend to feature unanticipated shocks and unexpected interrelationships about which history might offer limited guidance.

**Table 1. Japan: FSAP Main Recommendations on Stress Testing and Systemic Risk Assessment**

| Recommendations | Time[1] |
| --- | --- |
| Continue assessing the impact of default by largest borrowers on the whole banking system (JFSA). | I |
| Implement an in-house multi-year top-down scenario stress testing framework for banks and insurance companies (JFSA). | NT |
| Continue improving data consistency, especially between FX maturity mismatch and LCR (JFSA). | I |
| Continue conducting liquidity stress testing regularly with significant foreign currencies and require banks to hold sufficient counterbalancing capacity, particularly HQLA (JFSA). | I |
| Intensify supervision on FX funding liquidity risk by i) considering caps on funding concentration for significant foreign currencies; and ii) deducting from HQLA the assets subject to ringfencing by foreign jurisdictions (JFSA). | NT |
| Collect data and adopt analysis of interconnectedness as toolkit of financial supervision (JFSA). | I |
| The collection of data about exposures between financial firms should continue on a regular basis (JFSA). | I |
| Use insurance stress test results also to validate and benchmark ORSA reports and to gain further insights into the economic solvency regime (JFSA). | NT |

# INTRODUCTION[1]

## A. Financial System Structure

**1. Japan has one of the largest and most sophisticated financial systems in the world.** As of September 2016, total financial assets held by the financial sector reached about 620 percent of GDP in 2016, compared to 675 percent in the Euro Area and 462 percent in the United States (U.S.).[2] Financial conglomerates have a significant presence in the financial system. The twenty conglomerates make up about one third of total financial assets or about 170 percent of GDP. The four largest financial groups (FGs) hold banks, trust banks, and securities firms, and account for 136 percent of GDP. Twelve regional bank holding companies have combined assets of 21 percent of GDP. Other than Japan Post Insurance, none of the large insurers is part of a group that also includes significant banking activities. More than half of total financial assets are held by commercial banks. The remainder is mainly shared among insurance companies (15 percent of total assets), pension funds (8 percent), securities firms (5 percent), and investment trusts (6 percent) (Figure 1).

**2. Banks play a major role in financial intermediation in Japan.** The Japanese banking sector mainly consists of city banks—three of which are mega banks classified as G-SIBs[3]—trust banks, regional banks, and *Shinkin* banks (credit unions), credit associations, and credit cooperatives[4] (Figure 1). The three mega banks account for about 18 percent of assets, while regional banks and *Shinkin* banks make up 14 percent and 5 percent, respectively. Credit associations and credit cooperatives accounts for about 5 percent. Japan Post Bank accounts for about 8 percent. City banks and other large banks have nationwide networks and overseas operations, but regional and *Shinkin* banks serve a mainly domestic client base. Deposits represent the largest source of funding for banks. Foreign banks have a very small market share and are mostly involved in investment- and private banking and financial derivatives trading.[5]

**3. Japan's highly concentrated insurance sector is the world's second largest after the U.S.** Life insurance accounts for about 90 percent of the sector, with total financial assets of about 75 percent of GDP.[6] The five largest life insurers—three of which are mutual in structure—account for almost 70 percent of life insurance sector assets, while the four largest non-life insurers represent

[1] This Technical Note was prepared by Luis Brandão Marques (IMF), Timo Broszeit (IMF expert), Fei Han (IMF), Dyna Heng (IMF), and Mindaugas Leika (IMF).

[2] Bank of Japan, Flows of Fund 2016.

[3] Mizuho FG, Sumitomo Mitsui and Mitsubishi UFJ FG. Japan also has four D-SIBs (Sumitomo Mitsui Trust Holdings, Inc., The Norinchukin Bank, Daiwa Securities Group Inc., and Nomura Holdings, Inc.). No insurance company has been designated as GSII

[4] The cooperatives are regulated by the Ministry of Agriculture, Forestry, and Fisheries.

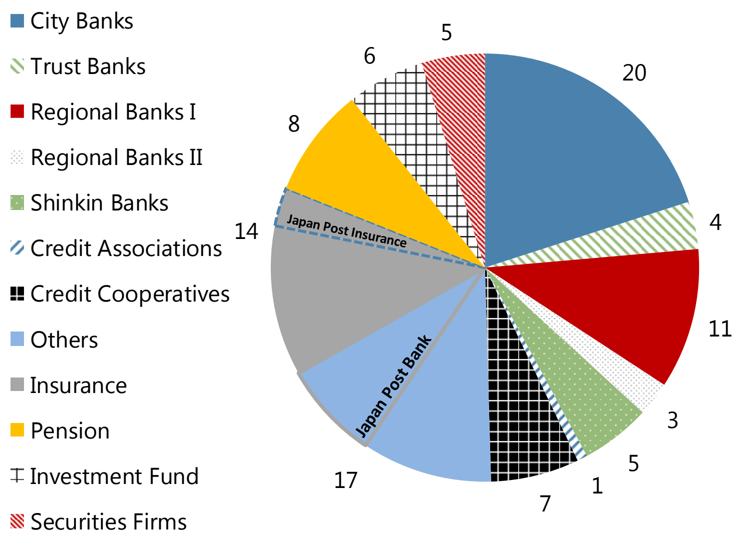
[5] Japan Post Bank (7 percent of total financial assets) takes deposits and primarily invests in Japanese Government Bonds and other government and corporate bonds

[6] Based on data from JFSA, published data from each company, and IMF staff calculations.

near 90 percent of non-life insurance sector assets.[7] In the life insurance sector, as of March 2016, annuities and medical insurance comprised 28 and 23 percent of total new business premium, respectively—a result of consumers shifting from savings products to products offering living benefits in light of the demographic developments and prevailing low interest rates.[8] In the non-life sector, motor insurance is the dominant line of business with 43 percent of total premium income, followed by fire insurance which contributes 17 percent.

**Figure 1. Japan: Structure of the Financial System, March 2016 1/**

(In percent of financial assets)




Source: IMF staff calculations.
1/ Other banks include Japan Post Bank (JPB).

**4. Japanese securities markets rank among the largest in the world.** With its equity market capitalization of about 100 percent of GDP, the Japan Exchange Group's (JPX) Tokyo Stock Exchange (TSE) is the third largest exchange in the world after the U.S. New York Stock Exchange and NASDAQ. Derivatives trading is less significant, with Osaka Exchange (also part of JPX) ranking as number 16 in the world in 2015 with about a tenth of the trading volume of the largest derivatives exchange, CME Group in the U.S. Corporate bond market remains relatively small (17 percent of GDP) although Japanese companies have issued increasing amounts of corporate bonds in recent years. Stock investment trust has increased in recent years from a very small base.[9]

**5. Japanese securities firms comprise a very heterogeneous group of companies.** The largest five firms—three of which are subsidiaries of the megabanks—are major players in global capital markets, investment banking, and asset management. Many other commercial banks have

[7] Japan Post Insurance is the largest life insurer, with 22 percent market share by assets.

[8] The numbers are based on JFSA data as of March 2016. More than 80 percent of annuities are fixed-term annuities, entailing little longevity risk for life insurers.

[9] The stock investment trust fund increased from 3 percent of GDP in 2013 to 7 percent in 2017.

securities subsidiaries, to be able to conduct trading or other specialized activities, but the market share of these firms is small. Securities firms that are part of global banking groups also have a significant presence in Japan.

## B. Stress Testing Under the FSAP Program

**6. The aim of the FSAP stress test is to assess the resilience of the whole financial sector rather than the capital adequacy of individual institutions.** The FSAP approach to stress testing is essentially macroprudential: it focuses on the resilience of the broader financial system to adverse macrofinancial conditions rather than on the resilience of individual banks to specific shocks. The FSAP stress test ensures consistency in macroeconomic scenarios and metrics across firms. The stress test analysis is intended to help identify key sources of systemic risk in key sectors and inform macroprudential policies to enhance its resilience to absorb shocks.

## C. Stress Testing Approach for the Japan FSAP

**7. The resilience of the Japanese financial system is assessed under a wide range of stress tests (Table 1).** Analyses of systemic solvency, liquidity, and contagion risks in banking and insurance sectors were conducted to examine the systemic risks that adverse economic and financial conditions could pose to domestic financial stability. The exercise followed a macroprudential approach, with risks evaluated at an individual firm level on a stand-alone basis, and from a systemic risk perspective, using both a bottom-up (BU) (selected financial institutions) and a top-down (TD) approach by the IMF and the BoJ. The exercise included both banking and insurance sectors (Figure 2 and Appendix Table 6).

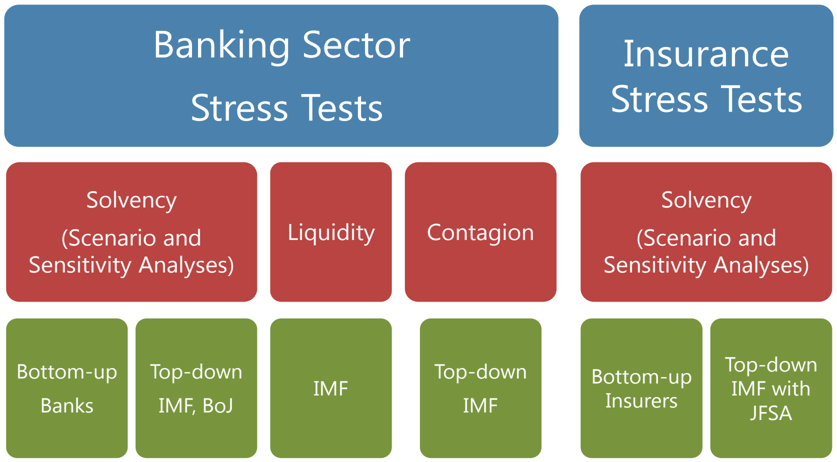
**8. The TD banking sector stress test covered 20 large banks, comprising 90 percent of banking system assets.** The IMF bank solvency stress test involves TD calculations by the FSAP team using supervisory and market-based data, with the collaboration of the JFSA. The reported results comprise five-year projections of earnings, costs, and balance sheets, and the impact of the assumed shock on (risk-weighted) assets and capital. The BoJ conducted a separate TD stress test using its own models, but following IMF scenarios.[10] The BoJ TD results are based on three-year projections of banks profitability, balance sheet, and capital. Liquidity and contagion analyses were based on IMF TD approaches and models, and used supervisory (liquidity), market (equity prices based contagion) and firms' proprietary (balance-sheet based contagion) data. FSAP team also conducted additional simulation by integrated liquidity stress tests results into solvency stress testing.

**9. TD and BU stress tests were conducted for seven life and six non-life companies, covering 73 and 92 percent of the respective sectors.** The two macrofinancial scenarios formed the basis for the stress testing exercise, but were slightly adjusted by front-loading the shock for the financial market variables. The impact was measured in terms of instantaneous changes in the

[10] Due to timing issues (BoJ TD used March 2016 data, IMF—September 2016) results are comparable with respective caution.

solvency margin ratio (SMR) with the statutory requirement of a 200 percent SMR being the hurdle rate.

**Figure 2. Japan: Stress Testing Framework**




Sources: Bank of Japan; Japan Financial Services Agency; and IMF staff.

# BANKING SECTOR SOLVENCY STRESS TESTS

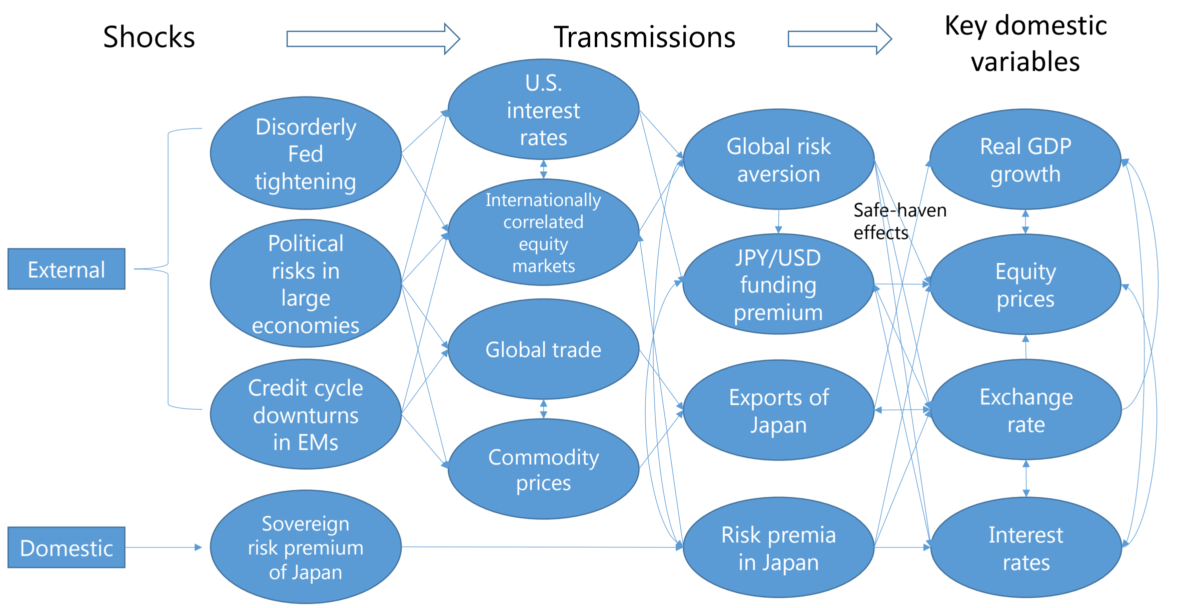
## A. Macroeconomic Scenarios

**10. The Risk Assessment Matrix (RAM, Appendix I) is the basis for stress testing scenarios.**[11] The stress testing exercise assesses Japan's financial system's resilience to three five-year macroeconomic scenarios—one baseline, one moderate adverse ("De-Globalization"), and one severe adverse ("Accelerated U.S. Monetary Policy Normalization")—for banks and insurers. The external and domestic risk factors underlying the two adverse scenarios are identified in the RAM, and are expanded to generate additional variables that are relevant for projecting credit risk losses. Scenarios differ in terms of risk factors included, transmission channels, and the magnitudes of the shocks (Figure 3).[12]

[11] The stress testing scenarios are also in line with the G-RAM as of July, 2016.

[12] The stress testing scenarios were simulated using the Global Macrofinancial Model—a DSGE model of the world economy disaggregated into forty national economies—documented in Vitek (2015).

**Figure 3. Japan: Transmission of Shocks to Key Macroeconomic Variables**




Source: IMF staff.

## Table 2. Japan: Overview of FSAP Stress Testing Exercise

| | Top-Down by IMF with JFSA | | | Bottom-Up by Banks | Top-Down by BoJ | Top-Down by IMF and JFSA | Bottom-Up Insurers |
|---|---|---|---|---|---|---|---|
| | Banking sector solvency stress tests | Banking sector liquidity stress tests | Contagion | Banks solvency and single factor sensitivity stress tests | Banking sector solvency stress tests | Insurance sector solvency stress tests | Banks solvency and single factor sensitivity stress tests |
| Models | Full balance sheet and P&L model with limited feedback effects (funding costs and liquidity). | IMF models based on maturity ladder and LCR data. | Balance-sheet model: Espinosa-Vega and Sole (2010); Market-based model: Diebold and Yilmaz's (2014). | Banks internal models | BOJ internal model | Full balance sheet | Insurers' internal models |
| Data Sources | Supervisory (balance sheet and P&L) and market (income, expected losses). | Supervisory (maturity ladder and LCR) data by significant currencies (yens, U.S. dollars, euros). | Authorities' data collected for FSAP, September 2016; and market data | Proprietary data | Public (accounting) and supervisory data | Supervisory data | Proprietary data |
| Scenarios | Baseline and two Adverse (IMF) | Two-week mild stress; three-month intermediate stress; and one-year severe stress (IMF). | Balance Sheet Analysis: Credit shock, funding shock, and the combination of the funding and credit shocks. Loss given default is assumed to be 100 percent. Funding rollover and asset price hair cut vary by each financial institution, depending on the balance sheet. | Baseline and two adverse (IMF) plus sensitivity tests: i) 50 percent decline in equity prices; ii) 20 percent decline in property prices; and iii)default of counterparties in derivative transactions. | Baseline and two Adverse (IMF) | Baseline and two Adverse (IMF) | Baseline and two Adverse (IMF) plus sensitivity tests: i) catastrophic events; ii) increase in longevity; iii) pandemic event. |

## Table 2. Japan: Overview of FSAP Stress Testing Exercise (concluded)

| | Top-Down by IMF with JFSA | | | Bottom-Up by Banks | Top-Down by BoJ | Top-Down by IMF and JFSA | Bottom-Up Insurers |
|---|---|---|---|---|---|---|---|
| Key risks and focus: | Market risks due to decline in equity prices, increase in JGB yields and risk premiums, including flattening of the yield curve due to abrupt monetary policy changes. Sharp increase in credit risk due to de-globalization (effects on trade) and interest rates impact on default rates. | Funding liquidity risk and market liquidity risk associated with equity fire sales; funding concentration | Contagion risks through credit and funding channel (balance sheet model) and market price movement (market-based analysis) | Market risks due to decline in equity prices, increase in JGB yields and risk premiums, including flattening of the yield curve due to abrupt monetary policy changes. Sharp increase in credit risk due to de-globalization (effects on trade) and interest rates impact on default rates. | Market risks due to decline in equity prices, increase in JGB yields and risk premiums, including flattening of the yield curve due to abrupt monetary policy changes. Sharp increase in credit risk due to de-globalization (effects on trade) and interest rates impact on default rates. | Market risks due to decline in equity prices, increase in JGB yields and risk premiums, including flattening of the yield curve due to abrupt monetary policy changes. Default of largest bank and nonbank counterparty. | Market risks due to decline in equity prices, increase in JGB yields and risk premiums, including flattening of the yield curve due to abrupt monetary policy changes. Default of largest bank and nonbank counterparty. |
| Outcome: | System shows high level of resilience, however several regional banks need additional capital buffers to stay above 8 percent of total CAR. Banks which fail solvency stress tests also have challenges in passing longer term FX liquidity tests. Total recapitalization needs compared to GDP are small. | System shows high level of resilience to yen funding shocks. However, a few internationally active regional banks which account for a small portion of U.S. dollar position in Japanese banking system, would experience negative cumulative funding gaps in U.S. dollars in the severe one-year scenario. The negative funding gaps in foreign currencies are small compared to their excess yen liquidity. | The propagation of financial shocks occurs primarily through the client and investor bases. Strong links between financial and nonfinancial firms underpin the market-based spillovers. Given the robust levels of capital, the effects of a funding or credit shock through the network of balance-sheet exposures are, for the most part, mild. | Banks results are more severe than IMF or BoJ TD assessment. The key difference lies in estimation of market risks, which are higher in banks output. Neither real estate, nor equity or counterparty risks are significant in banks estimates. | Banks are resilient to shocks, however several regional banks fail to meet 8 percent total CAR (as in IMF TD stress test results). | Insurers' solvency ratios drop substantially, with life insurers being more affected than non-life firms. However, under the current solvency regime, the vast majority remains above statutory thresholds. Largest impact comes from higher interest rates and falling equity prices, also the counterparty default contributes significantly. | Insurers' results are slightly less severe than IMF/JFSA TD assessment as companies' models are taking hedge positions, esp. for interest rate risks, more accurately into account. |

Source: Fund staffs.

**11. The key risk factors in the RAM are incorporated into the three macroeconomic scenarios in the following manner:** [1]

- **The baseline scenario** is largely based on the projections from the October 2016 World Economic Outlook (WEO). The baseline projection reflects continued weak growth supported by the recently announced fiscal stimulus package and private consumption. Meanwhile global growth uncertainty and yen appreciation are expected to pose a drag in the near term. Growth will fall below potential in 2020 as the fiscal package ends and the consumption tax hike is implemented in October 2019. Inflation will gradually pick up over the medium term, but remain below the BoJ's inflation target of 2 percent. Short-term interest rates are expected to remain close to zero, and long-term rates will only marginally rise over the medium term, reflecting the BoJ's recently introduced monetary policy framework of yield curve control.[2,3]

- **The moderate adverse scenario** of de-globalization features (i) protectionism and economic isolationism, leading to reduced global and regional policy collaboration with negative consequences for trade, capital and labor flows, sentiment, and growth; (ii) a significant credit slowdown in emerging market economies (EMEs) triggered by concerns over corporate leverage; and (iii) an initial depreciation, followed by a tightening in domestic financial conditions, including—compared to the baseline scenario—higher money market interest rates, lower equity prices, and a correction in the domestic housing market. The sharp decline in global growth (which at the peak drops by 1.6 percentage points globally on average compared to the baseline) increases banks' credit risks in both overseas and domestic loan portfolios.[4] Tightened domestic financial conditions, particularly lower equity prices, could also reduce banks' capital through their shareholdings.

- **The severe adverse scenario** features a more rapid tightening in the U.S. monetary policy (due to a reassessment of policy fundamentals or a term premia decompression), combined with severe stress in the domestic bond market and a tightening in domestic financial conditions. It assumes a 200 basis-point policy interest rate increase in the U.S. during 2017–18, leading to capital outflows and a tightening of financial conditions in Japan, including higher JGB yields, higher money market interest rates, and lower equity prices. It is also assumed that this initial JGB yield spike triggers a loss of confidence, resulting in a further increase in JGB yields.[5] The higher bond yields lead to significant valuation losses associated with their JGB holdings. A

[1] Although aging is a slow-moving and predictable process, it can have still potentially have difficult-to-predict and abrupt effects on asset prices—including those of sovereign bonds. The reason is that only living generations can trade financial assets in any given point in time and imbalances in the demand and supply of assets cannot be arbitraged away beforehand. However, these effects are beyond the stress testing horizon.

[2] The path of long-term rates broadly follows market expectations.

[3] See "New Framework for Strengthening Monetary Easing: Quantitative and Qualitative Monetary Easing with Yield Curve Control," September 21, 2016.

[4] Growth drops by 1.8 percentage points in advanced economies and by 1.0 percent in emerging market economies.

[5] The total increase in the JGB yield in this scenario is about 300 bps.

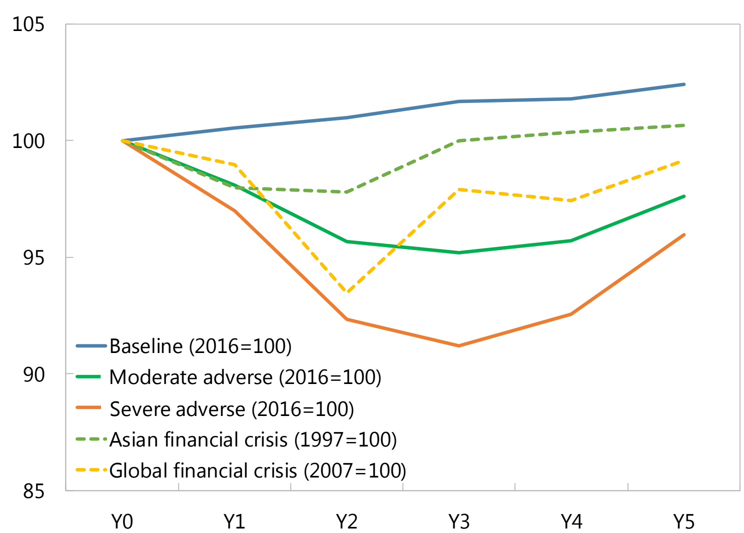
correction in domestic housing market is also assumed in this scenario. Credit risks at home and abroad also rise due to the increase in interest rates (peaking at 1.4 percentage points for long maturities globally on average).[6]

- **A combination of solvency and liquidity scenarios.** This combined tests assumes that banks which need to improve their capital buffers under the severe adverse scenario would face higher liquidity shocks (for details see pages 38−46).

**12. In the moderate and severe adverse scenarios, the real GDP growth in Japan follows a U and V shape, respectively.** In particular, real GDP growth falls less and takes longer to recover after the initial shocks in the moderate adverse scenario, but it falls more and recovers relatively quicker in the severe adverse scenario. Japan's real GDP declines more in the severe adverse scenario than in the moderate adverse scenario, primarily due to the higher JGB yields triggered by the accelerated U.S. monetary policy normalization.

**13. The two adverse scenarios lead to significant cumulative GDP losses.** The initial declines in real GDP levels in the moderate and severe adverse scenarios are comparable to those during the Asian financial crisis (1997–98) and the global financial crisis (2007–09). The cumulative losses in the two adverse scenarios over the five-year horizon are larger than those in the two historical crises, when the recovery in real GDP growth was relatively faster than in the scenarios (Figure 4).

**Figure 4. Japan: Scenario Severity from a Historical Perspective**



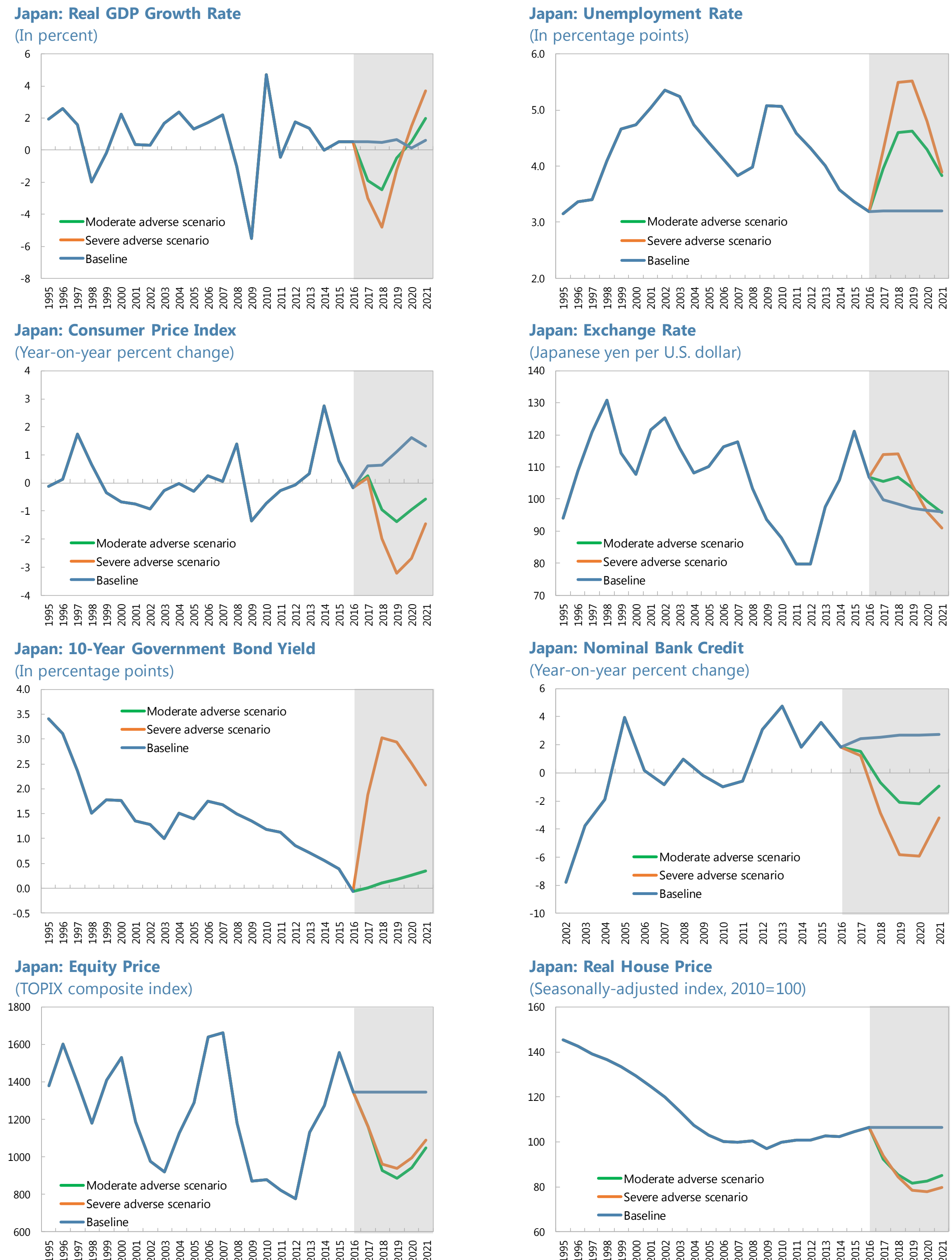

Sources: IMF's WEO database; and IMF staff calculations.
1/ The projections for GDP were made before the National Accounts revision.

[6] The increase in long-term rates peaks at 1.6 percentage points for advanced economies on average, and at 0.8percentage points for emerging market economies.

**14. The projections of key macroeconomic and financial variables in all three scenarios capture the macrofinancial feedback effects between the real economy and financial sector.** The Global Macrofinancial Model (GFM) used in the simulation can effectively capture the linkages between the real economy and financial sector developments (particularly developments in the banking sector and capital markets). In particular, the interactions between credit cycle and business cycle lead to a deleveraging by banks and hence lower credit growth in both adverse scenarios. The projections for key macroeconomic and financial variables (including real GDP, real GDP growth, CPI inflation, 10-year government bond yield, exchange rate, unemployment rate, equity price, and real house price) are shown in Figure 5.[7]

[7] A few key financial variables that are not projected by the WEO database including equity price and real house price are assumed to remain constant in the baseline scenario.

## Figure 5. Japan: Macroeconomic Baseline and Adverse Scenarios



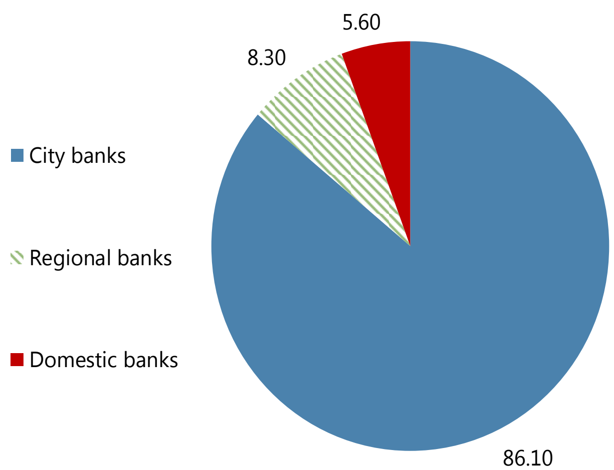

Sources: OECD Statistics; IMF's WEO and Global Assumptions databases; and IMF staff estimates.
Note: The projections for GDP were made before the National Accounts revision.

## B. Coverage of Banks and Modeling Approach

**15. The stress test scenarios were applied to a wide range of diverse group of banks.** To highlight differences among several groups of banks, they were grouped into three categories: city (seven banks), regional (nine banks), and domestic.[8] Japan Post Bank was treated as a separate entity due to its size (almost 18 percent of banking system assets), business model (low risk weights density due to large investments in domestic government securities, cash, and other liquid assets) and only public data were used for its analysis. Figure 6 highlights the relative share of each group of banks in the sample.

**Figure 6. Japan: Banks Included in the Solvency and Liquidity Stress Testing Exercises 1/**

(In percent)




Source: IMF staff calculations.
1/ Excludes Japan Post Bank.

**16. An array of satellite models were used to project banks' income, expenses, expected losses, and balance sheet adjustments, which fed into the final solvency template.** The FSAP team used both market- and supervisory data to estimate income and losses. Data were based on September 2016 balance sheets, and March 2016 for income statements. Historical data on various risk factors, income, and balance sheet data went back as far as 2002, and included the Global Financial Crisis (GFC) period (2008–09). Outputs of various models, together with behavioral adjustments were used in IMF's proprietary Solvency stress testing tool which projected banks' balance sheet, losses, RWAs, and capital evolution for the next five years (2017–21).

## C. Methodological Assumptions for Balance Sheet and Profit Projections

**17. In all the scenarios, several adjustments and assumptions were made to track the change in individual banks' balance sheets and profits over time**:

[8] Based on accounting and capital regulations and not on ownership or geographical exposures of these banks.

- **Growth of banks' balance sheets.** Banks' balance sheet size was projected to grow in line with macroeconomic scenario projections, albeit with a cap on deleveraging. This assumption has two advantages. First, it aligns macroeconomic projections (GDP, inflation, interest rates, equity prices, etc.) with credit growth rates. At the same time, the macro forecasting model does not put constraints on the amount of deleveraging.[9] A cap thus guarantees that banks do not meet capital requirements simply by excessively shrinking their balance sheets[10]—which could also reduce their RWAs (i.e., the denominator of the CAR ratio)—in adverse scenarios. Second, it ensures that banks that pass the test remain sufficiently capitalized to support lending in a severe downturn. For this reason, this assumption reduces the need to quantify the second-round effects triggered by banks' behavioral responses to the initial shocks. In case a given bank faces liquidity problems (in scenario which incorporates liquidity and solvency risks)—assumptions were made about the bank's asset liquidation strategy and respective shrinkage of the balance sheet.

- **Composition of balance sheet assets and liabilities.** It was assumed that the composition of assets and liabilities might change due to different growth rates between Japanese banks' domestic and foreign investments. The rate of growth was linked to the credit growth rate (same for each bank), and further decomposed based on relative shares of foreign assets in the balance sheet. The focus was on two key markets: Japan (domestic) and U.S. (foreign). Values of foreign exposures also changed due to changes in yen/U.S. dollar exchange rate. Balance sheet liabilities grow in line with growth rate of assets, assuming that the amount of non-interest bearing assets and liabilities remains constant.

- **Projection of risk-weighted assets**. Since most of the largest banks in Japan operate under the Basel II/III Internal Rating-Based approach, risk weights are projected using the corresponding Basel II formulas for credit risk, whereby the capital requirement ratio depends on the value of probability of default (PD), loss give default (LGD), maturity, and asset correlation.

- **Loan portfolio loss projections include projections for expected losses**. The analysis uses shocked exposure weighted average TTC PDs, shocked downturn LGDs, and adjusted EADs to project expected losses. Further details are provided in section D and in Appendix II.

- **Evolution of profits.** The income statement, non-interest profit items, and lines such as operational and administrative expenses and net fee and commission income were projected to change according to the outputs of satellite models (see Appendix III for further details).

[9] For example, the macro forecasting model might generate level of negative credit growth which would be not optimal from macroprudential policy perspective or feasibility from banks perspective given the fact that banks optimize income and risks and might consider negative feedback effects from excessive deleveraging.

[10] Due to the quasi-dynamic adjustments, the balance sheet in the ST model can shrink if credit growth is negative. Also, model-simulated deleveraging rates might not be feasible in practice. Thus, the maximum limit of deleveraging is capped at negative GDP (real or nominal, whichever is lower) growth rate.

- **Distribution of dividends.** Banks were assumed to distribute their after-tax profits according to the following rules:

  (i) Undercapitalized banks in any year of a given scenario were not allowed to distribute dividends;

  (ii) Banks that pass all minimum requirements distribute their dividends according to a 30 percent rule, which was the average dividends rate calculated from the BU stress testing submissions.

Table 1 in Appendix II provides a full summary of various assumptions used in different scenarios.

**18. Hurdle rates.** Three hurdle rates were used to calculate potential recapitalization needs, namely CET 1 of 4.5 percent (applied to City- and Regional banks with international exposure) and total capital ratio of 4 percent applied to other regional banks without international exposure. According to regulations, regional banks without international exposure are not subject to further capital requirements. Tier 1 ratio of 6 percent, as well as 8 percent of total capital ratio were further applied as additional thresholds for City- and Regional banks with international exposure. A 3 percent leverage ratio (Tier I capital to total assets) was used to test whether banks meet this potential benchmark.[11]

## D. Credit Risks in the Scenario Analysis

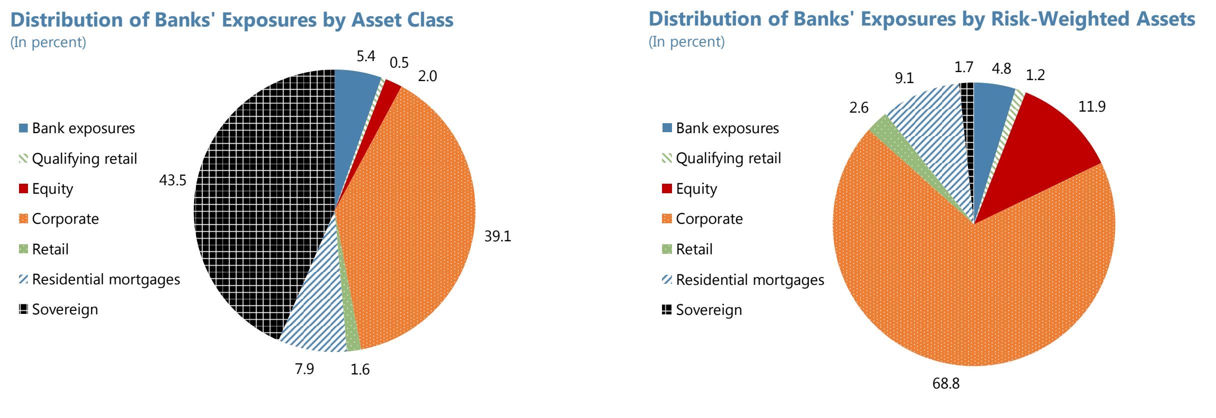
**19. Credit risk in the loan book, along with the market risk in securities portfolio, are key risk factors for the banking system.** Loans represent around half of total banking sector assets. Debt securities (20 percent), most of which are marked to market, come next. Exposures in loan books are still predominantly domestic, but recent trends show a significant increase of loan activity in foreign markets, mostly in the U.S., the European Union, and Emerging Asia. Therefore, the stress tests scenarios included macrofinancial developments in these key markets. At the same time, due to consolidation and data availability issues, IMF TD stress testing focused on aggregated loan portfolio data without separating exposures in Japan, the U.S., and Emerging Asia. BoJ's TD model and the BU STs included all key regions.

**20. The IRB approach with most of the capital allocated to corporate, equity and mortgage exposures, is dominant within banks included in the sample.** The banks apply the IRB approach for most of their exposures. Even though banks use the IRB model for sovereigns, own sovereign risk is exempted and has zero risk weight treatment (as in many other jurisdictions). The use of this exemption leads to very low capital requirements, especially for some smaller banks which have large investments in JGBs, hold high shares of cash and other very liquid assets, and are subject to low regulatory capital requirements (4.5 percent). Retail mortgages constitute a relatively

[11] Leverage ratio is not officially required; moreover, only a proxy for this ratio was used since off-balance sheet items, derivatives etc., were not included.

small item in sample banks' loan books, and associated capital requirements are low due to low PDs and LGDs (Figure 7). Capital requirements associated with equity risk are relatively high, and almost all banks use the IRB approach with fixed 90 percent LGD.[12] The size of banks' exposure to equities is a particularity of the Japanese banking system: banks might provide credit to the corporate customer and also invest into the borrower's equity. Cross-shareholding and equity holdings are recognized risks, and banks are obliged to gradually reduce equity exposure. Moreover, most of the banks use a 50 percent drop in equity prices scenario to calculate stressed losses and respective capital needs.

**Figure 7. Japan: Distribution of Banks' Exposures**




Source: IMF staff calculations.

## Credit risk stress testing methodology

**21. The transmission of macroeconomic shocks to probabilities of default and loan loss provisions of individual banks was assessed by estimating specific satellite models of credit risks.** Available public and supervisory data were used to build various credit risk satellite models and overcome multiple data limitations with the aim to replicate the regulatory approach as closely as possible. Supervisory-, as well as data provided by banks were used to construct credit risk satellite models for the six broad exposure classes, which were subsequently applied to the regulatory IRB exposure classes used by banks (see Figure 8).[13] Time series started in 2007 and cover one credit cycle when defaults increased above their means (2011–13).

[12] Basel Committee on Banking Supervision (BCBS) proposals to remove IRB option for equity risk in banking book might lead to increase in capital requirements for the banks in the sample.

[13] Exact number of regulatory IRB exposure classes used varied bank-by-bank and depended on how many of the exposure classes are under IRB in a given bank.

**22. PDs which were used for satellite models were Through-The-Cycle (TTC) without defaulted exposures.** Time series also included PDs with defaulted exposures which are more volatile compared to the pure TTC PDs.[14] The use of TTC PDs for estimation of losses has cons and pros. The biggest drawback of TTC PDs is their relative stability, though from time to time (typically annually) banks update these PDs in each rating grade to reflect changes in macro environment. Thus, TTC PDs in fact represent "hybrid" PDs with a relative weight attached to historical estimates (around 90 percent in the case of Japanese banks) and 10 percent of annual update. Without the annual update of PDs in rating grades, exposure-weighted average TTC PDs represent an annual migration of exposures within a rating matrix for the respective exposure class.[15] The biggest advantage of TTC PDs is that they can be directly used to simulate changes in RWAs.

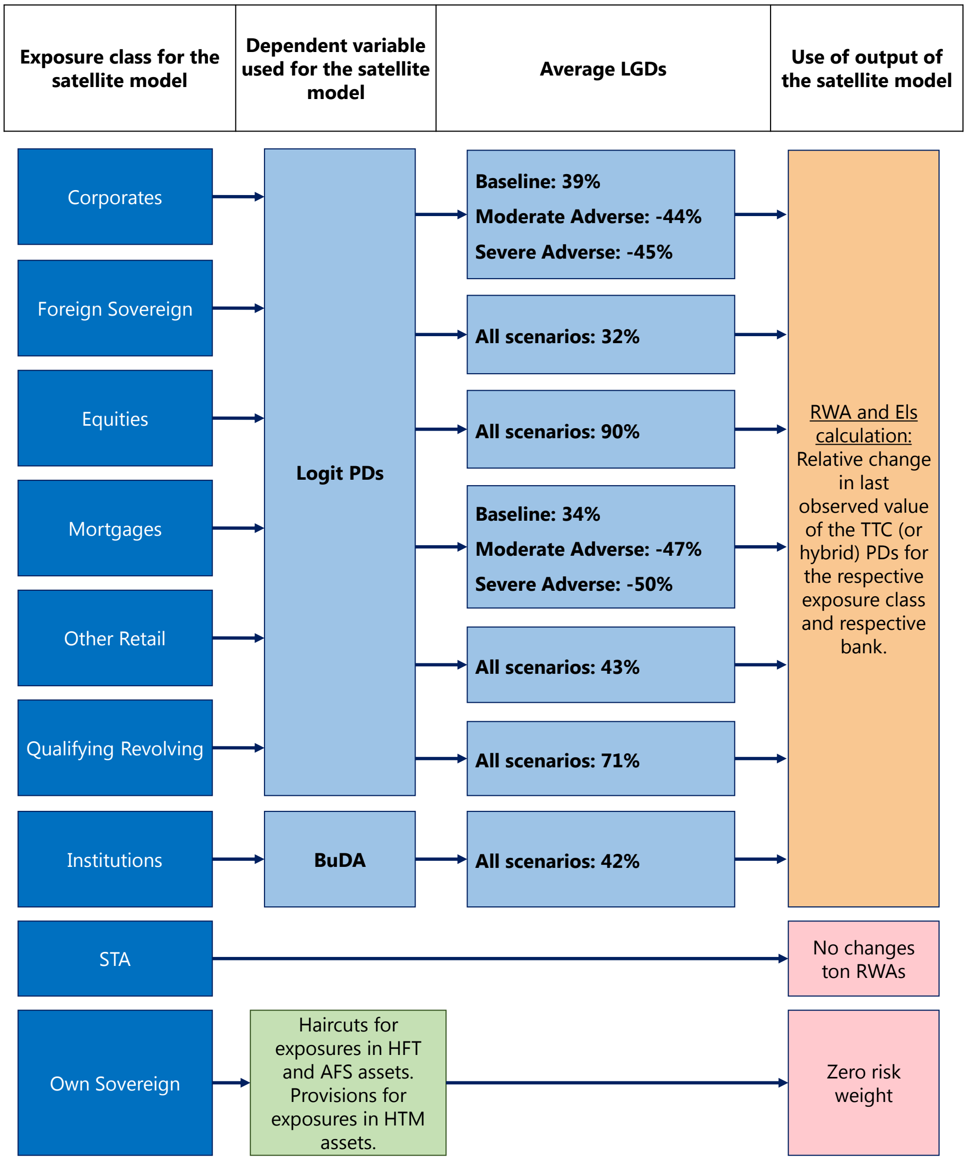
**23. PDs for certain exposure classes (Figure 9), such as foreign sovereigns and institutions are calculated for so called "low default portfolios," and thus macroeconomic variables are typically not very useful to model such defaults.** Historical PDs data for the institutions exposure class show little correlation with macroeconomic developments in Japan or key foreign regions included in the macro forecast scenarios (Euro zone, United Kingdom, U.S., Emerging Asia). To overcome this problem, an alternative approach was used: PDs for institution asset class were forecasted using the BuDA methodology (see Chan-Lau et al. (2017). This model projects one-year PDs for up to five years using the same macroeconomic scenarios. In the baseline scenario, it was assumed that PDs would remain constant. BuDA PDs behave very similarly to EDFs. The estimation uses equity prices and risk free rates (3-month Japan Treasury bill rates) as regressors. Both scenarios reveal similar outcomes: in the moderate adverse scenario, the increase in PDs is driven by a decline in equity prices, negative risk free rates (this reduces banks profitability), and in the severe adverse one by a decline in equity prices, a decline in GDP and a flattening of the yield curve, which reduces banks' profits. For the sovereign exposure class, data showed extremely low PDs, which is consistent with historical observations. In most of the cases, PDs were below 0.03 percent, which is the Basel II/III minimum PD for certain exposure classes. At the same time, a panel model showed

[14] The historic PD data series provided included defaulted exposures and PDs without defaulted exposures. PDs for each exposure class are exposure-weighted averages of PDs across all rating grades, including the last rating grade–default. Defaulted exposures are typically provisioned, hence there is no need to calculate additional expected losses and capital requirements for them. Therefore, the inclusion of defaulted exposures into PDs leads to double counting of losses and is not desirable. By contrast, average PDs without defaulted exposures provide average probability of migration to the last obligor grade (default) across all non-default rating grades, they thus approximate risk of default better.

[15] If more loans default than were granted new ones, in some extreme cases, exposure weighted average PD might be even lower under a severe macroeconomic scenario. This leads to the need to estimate amount of incurred losses for a given year. In the absence of PiT PDs data, these can be approximated using market data, such as EDFs for the respective sector. EDFs represent real probabilities of default (as opposed to risk neutral ones, like derived from CDS spreads) for one year ahead and thus are suitable for incurred loss calculation. At the same time, EDFs might be more volatile than bank's portfolio PDs; they also typically represent a more diversified set of companies compared to a given bank's exposure to a specific sector.

some sensitivity toward long-term interest rates (10-year JGB yields) and it therefore was used to capture increase in risk for the foreign sovereign exposure class.[16]

**Figure 8. Japan: Reconciliation of Exposure Classes and Satellite Models**

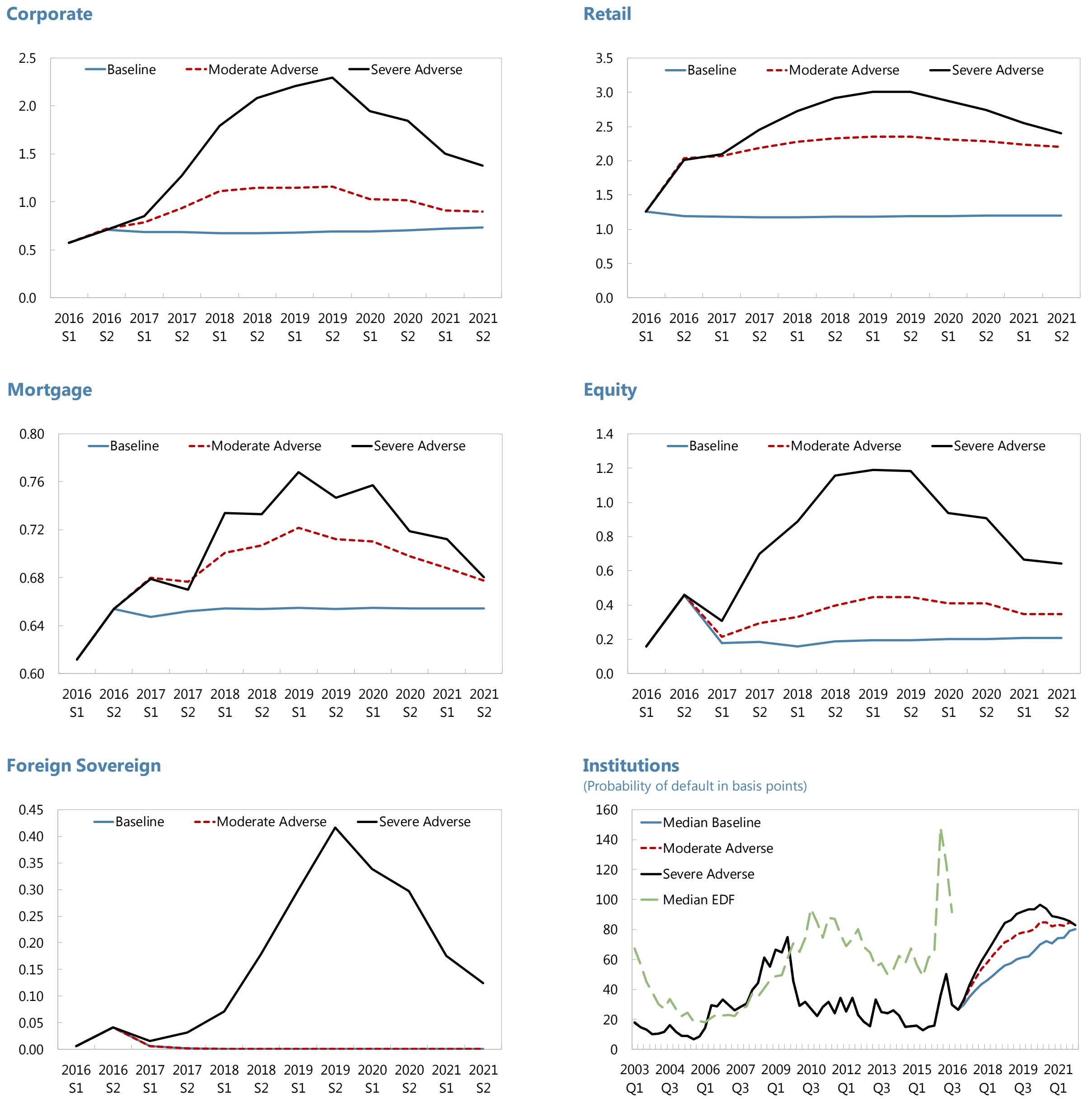



Source: IMF staff estimates.

[16] Sovereign exposure class can be very diverse and developments in Japanese economy might not be correlated to increase in foreign yields, however panel model captures historical increase in risk premiums due to the GFC in 2008–09 because most of these historic increases in PDs are attributed to increase in foreign and not domestic sovereign default risks.

**Figure 9. Japan: Median PD Projections in the Baseline and Adverse Macroeconomic Scenarios—IMF Model**

(In percentage points, unless noted otherwise)




Source: IMF staff estimates.

24. **Corporate PDs are sensitive to real GDP, equity prices and interest rate developments, while retail portfolios—to unemployment, GDP and interest rates.** For the remaining exposure classes, namely, corporate, residential mortgages, retail, equities separate satellite models were estimated. Estimation results show that the low interest rate environment supports historically low corporate and retail PDs, and that an abrupt rise in interest rates would lead to significant increase in defaults among corporates. At the same time, mortgage loans remain less sensitive to a

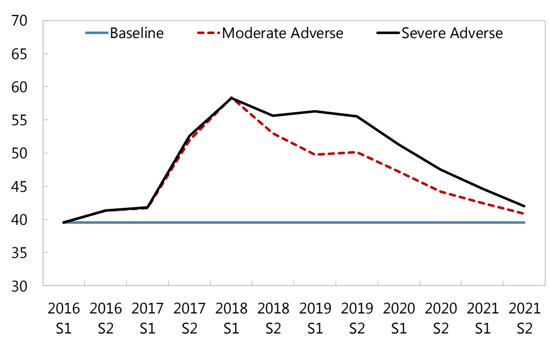
macroeconomic downturn, mostly because of relatively sticky unemployment and little impact from a decline in real estate prices. This was broadly corroborated in the BU stress testing exercise and in discussions with selected banks.

**25. LGD models used historical time series of downturn LGDs for corporate and residential mortgage exposure classes.** The selection of these exposure classes was based on their importance among total exposures as well as their dependency on asset prices. Other exposure classes, like sovereigns and financial institutions are so-called low default portfolios, and their LGDs do not depend much on real estate prices or GDP. LGDs for some exposure classes, like equities and retail loans are very high, and the FSAP team assumed no further shocks on them in adverse scenarios. Average LGDs and estimated shocked LGDs are provided in Figure 10.

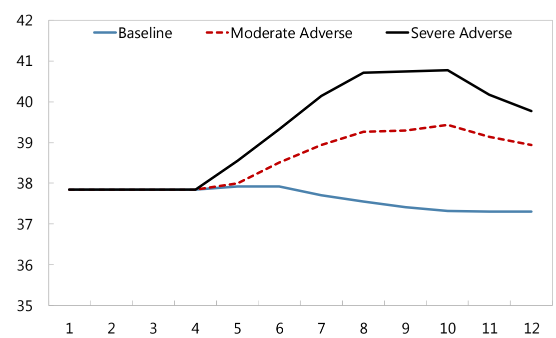
**Figure 10. Japan: LGD Projections in the Baseline and Adverse Macroeconomic Scenarios—FSAP Team Model**

(In percentage points)

**Residential Mortgages**




**Corporate**




Source: IMF staff estimates.

**26. Expected losses and RWAs were estimated based on supervisory requirements.** Estimation of expected losses was based on shocked TTC PDs, LGDs, and EADs. RWAs for exposures under IRB approach were calculated using the respective Basel II/III formulas, while RWAs under STA approach were assumed constant.

**27. To avoid the problem of "handpicked" equations and minimize selection bias, PDs were estimated using several econometric approaches.** In the first case, a Bayesian Modeling Averaging (BMA) method was used to estimate which macrofinancial variables and which lags were the most significant in explaining changes in PDs. In the second step, variables which were significant under the initial BMA estimation[17] were used to construct separate equations. These were estimated using panel data OLS and GMM methods. In the third stage, PD/LGD forecasts were made

[17] That is, the ones which have posterior probability of inclusion higher than the prior probability of inclusion. Prior probability of inclusion is simply calculated by dividing the model size over the total number of potential explanatory variables. In this case, it was assumed that each variable has the same prior probability by limiting the maximum size of the model to three explanatory variables.

for each bank. In the third stage, estimates across multiple model were averaged to obtain average PD/LGDs for each bank. In the fourth step, median PDs/LGDs were calculated and respective multipliers constructed. Finally, in the last step, PD/LGD multipliers were used to project the evolution of risk factors for each bank by multiplying the last observed PD/LGD value from each bank by obtained multiplier. Further explanations are provided in Appendix II.

**Results of credit risk estimation**

**28. While most banks have adequate amounts of capital reserves, potential credit risk losses, especially related to corporate loans, represent a vulnerability for some smaller regional banks.** IMF TD stress test results suggest that banks are likely to experience significant increases in PDs under the severe stress scenario (Figure 9), in contrast with the baseline scenario in which PDs remain almost flat. The combined effects of GDP, interest rates, and equity prices increase the banking system's median corporate PD from 0.5 percent in 2015 to 2.3 percent in 2019 under the severe adverse scenario, compared to a peak of 1.1 percent under the moderate adverse stress scenario. The effect differs from bank to bank, reflecting differences in loan portfolio risks. Large City banks experience smaller shocks to their corporate PDs, while regional banks experience larger ones. Expected losses in the adverse scenario are mostly driven by losses in the corporate portfolio. Contrary to corporate loans, PDs for residential mortgage loans do not exhibit a sharp increase. This is partially explained by the fact that banks typically have full recourse on these loans, implying little opportunities for strategic defaults.

**29. The rise in PDs requires additional provisions that worsen bank profitability in the stress scenarios.** Credit losses over the five-year horizon in the loan book amount to ¥12 trillion in the severe stress scenario, equivalent to 1.2 percent of total banking system assets, because of the credit risk increase caused by the severe macroeconomic conditions. By contrast, in the baseline scenario, the flow of new provisions is limited to ¥4 trillion, equivalent to 0.4 percent of total banking system assets. These new provisions in the baseline scenario are more than offset by net income before losses (1.6 percent).

**Market risk**

**30. The FSAP solvency stress test assesses the impact of market risk on regulatory capital from valuation losses in bond and equity markets.** The analysis covers the impact of the debt and equity securities portfolio accounted in the trading book (HFT) and available for sale book (AFS). While the impact of shocks to HFT securities impact regulatory capital through net profits, asset mark-downs from shocks to the AFS portfolio hit capital through other comprehensive income. Rebalancing of the portfolio was not allowed which increases an implicit severity of the shock over the relatively long five-year horizon.

**31. The effect of increase in domestic and foreign (U.S. dollar) interest rates and JGB yields was applied to domestic as well as foreign debt securities.** The value of the debt securities portfolio among the nineteen major banks amounts to around ¥165 trillion or 18 percent of total assets; 76 percent of them are domestic bonds (Japan government bonds dominate) whereas the rest are foreign securities, predominantly U.S. government debt. The average duration of debt securities portfolio is relatively short at 2.5 years; however this varies across banks, with some regional banks having much longer average duration. Banks with longer average duration experienced higher valuation losses.

**32. Shocks to equity prices were instantly applied to the valuation of equity portfolios.** Equity-exposure-related risks are very important for most of the Japanese banks: the value of equity securities in banks' balance sheets is ¥16 trillion or 1.8 percent of total assets. Among individual banks, the share of equity securities to total assets ranges from as low as 0.2 percent to almost 4 percent.[18] Output from the macro forecasting model provided a scenario-conditional drop in market prices which was used to shock portfolio of equity securities. The model provided only the deviation from the baseline scenario.[19] The TOPIX and NIKKEI indices were used as benchmarks for estimations of the impact of the drop in equity prices banks' balance sheets and income. The market shock was applied as an instantaneous shock to all the equity positions for each year of the horizon. Higher RWAs for equity exposures and an increase in expected losses were the result of an increase in PDs. As a result, market valuation losses or gains were included in other comprehensive income. Significant shares of equities compared to capital and the need to mark-to-market these assets lead to significant market valuation losses and deductions from capital base in both adverse scenarios. At the same time, if a bank can hold these securities, it can offset these losses by gains when markets recover in the last years of the adverse scenarios.

**33. Market risk from shocks to other risk factors, such as commodities, is negligible.** Japanese banks do not carry material open positions in commodities or basis risk. Therefore, market risk is mostly due to fair-valuation effects on the securities portfolio from the effect of term premium shocks across debt markets as well as sharp decline in equity prices.

**34. Repricing gap analysis (interest rate risk on the banking book) was applied for the three key currencies (Japanese yens, U.S. dollars, and euros).** Full balance sheet reprising was based on changes in risk free rate. The repricing gap contributed to gains or losses in both, Japanese yen and U.S. dollar portfolios, with negligible effects from EUR portfolios (due to insignificant size of exposures). Normalization of the yield curve—that is, a larger increase in longer term interest rates compared to the increase in short term ones—was the key factor behind improvements in interest margins. In addition to this, the JPY/USD exchange rate effect also contributed to gains or losses in the respective maturities. The macro forecasting model provided only several interest rates, namely long term ones (JGB 10-year yield and 6 month Tibor interbank), hence the FSAP team used additional model based on Principal Component Analysis (PCA) to

[18] In addition, the Japanese banking system is characterized by a high degree of cross-shareholding among financial institutions. This could amplify market risk related losses. Additional details about cross shareholding are provided in part "Contagion and Connectedness Analysis."

[19] It was assumed that in the baseline scenario, stock market indices follow a random walk process and thus do not change their value (i.e., return to the initial value at the end of each year).

simulate behavior of the full yield curve, including 30-years, 5-years, 2-years and 1-year JGB yields, 12-month, 3-month, and 1-month TIBOR, long-term and short-term prime lending rates.[20]

**35. The absolute impact on banks' capital from the total stressed loss amount (credit plus market risks) is largest due to market risk losses.** Equity- and bond valuation effects during the three worst years in the stress equal to losses of around 1 percent of assets vs. 0.9 percent of assets from credit risk related losses. Against this backdrop, part of part of market valuation losses is easily offset by market gains in the equity portfolio once asset prices return to their growth path.

## E. Solvency Stress Test Results

**36. Aggregate solvency results from the IMF show that the banking system is broadly resilient, but some banks are particularly vulnerable to extreme shocks**.[21] Under the severe adverse scenario, banks' solvency ratios would be significantly affected: the aggregate Common Equity Tier 1 (CET1) ratio would drop to 8.3 percent (Figure 11), but the small capital shortfall would remain manageable at the macro level (Figure 12). Three regional banks would need additional capital to meet 8 percent total capital requirement.

**37. Equity and other market risk losses represent the most important risk factor for the large banks included in the stress tests.** Credit losses, coupled with lower profitability from overseas lending due to higher U.S. dollar funding costs, and the change in risk-weighted assets are also important. Losses stemming from equity exposures as well as bond valuation effects are also the largest drivers of the system-wide decline in capital adequacy ratios in both, BoJ TD as well as BU stress tests. That is, the banking system is vulnerable to correlated market- (equity) and credit risk shocks. These results confirm banks' still large investments into equities, the presence of interest risk related to large holdings of debt securities, and the reliance on wholesale funding in U.S. dollars to finance portfolio expansion overseas.

**38. The stress test shows that regional banks maintain the highest sensitivity towards credit risk related losses.** Domestic banks, which have relative higher overhead costs and less diversified loan portfolios, exhibit a slow decline in profitability and capital levels even under the baseline scenario (Figure 12). Recovery to banking sector profitability is based on assumptions about yield curve normalization which allows banks to improve profit over the longer-term horizon. City- as well as some regional banks do depend on U.S. dollar funding, thus higher funding costs reduce their potential profit even during the recovery stage after the three years of stress. Very low credit risk parameters, such as PDs and LGDs, in some smaller banks can potentially hide additional vulnerabilities in times of stress when capital buffers might not be adequate to cover increase in unexpected losses.

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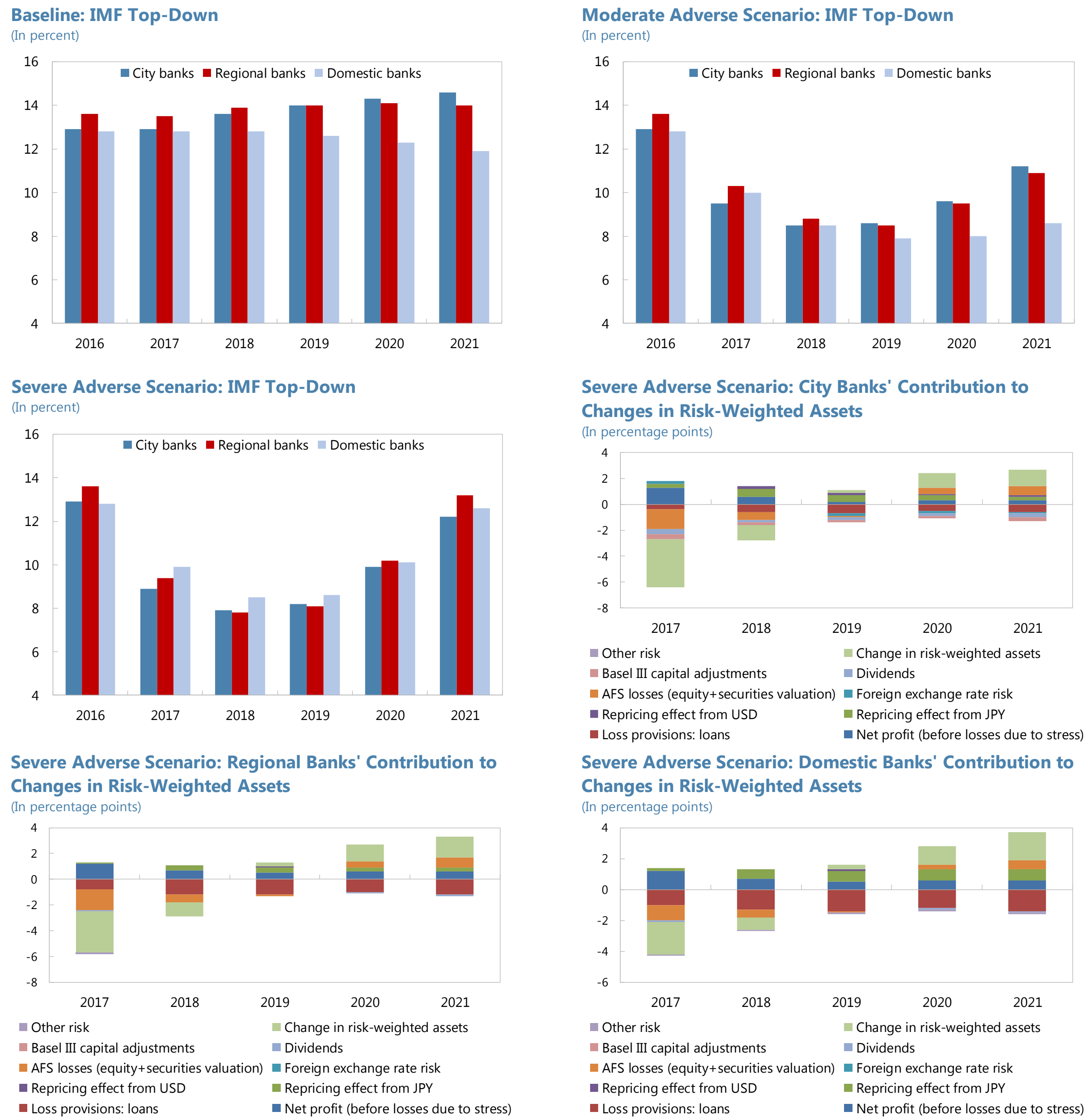
[20] PCA model linked changes in various interest rates by extracting several principal components from historic co-movements in interest rates, namely first principal component represents parallel movement of the yield curve, second—slope of the curve and third—curvature of the yield curve.

[21] Regional banks (excluding domestic banks) should maintain total capital above 8 percent. Regional banks without international exposure are not subject to total capital requirement and should maintain core capital above 4 percent.

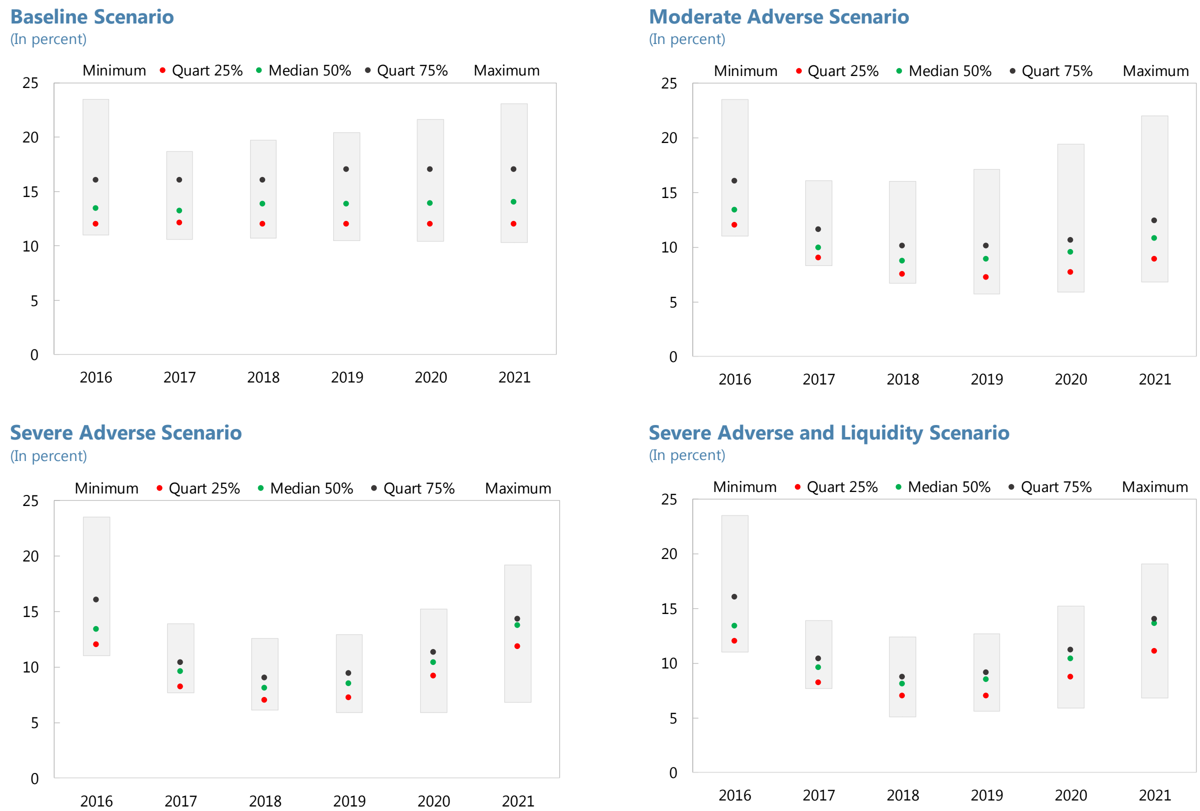
**Figure 11. Japan: Solvency Stress Tests—IMF Top-Down Results**




Source: IMF staff estimates.

**39. Total potential recapitalization needs are small due to small market share of banks which need additional capital to meet total capital requirements.** While the size of the macroeconomic shocks and their impact on CAR is large (i.e., system-wide CAR ratio drops by almost 50 percent), the banking system exhibits resilience because of the high average CAR buffers. Banks which would need additional capital are relatively small as well as would not fall below CET 1 minimal capital requirement. Against this backdrop, estimated recapitalization needs are conditional on a recovery in interest margins and a gradual increase in equity prices, which are embedded in the severe adverse scenario.

**Figure 12. Japan: Results of the IMF TD Solvency Stress Test by Quartiles**




Source: IMF staff calculations.
Note: Baseline includes JPB.

**40. Banks also carry credit concentration risk; BU sensitivity tests suggest that counterparty default risk and losses due to a decline in real estate prices are limited.** Loan portfolio concentration test reveals that no bank fails to meet the minimum CAR in case of default of the single largest borrower even under the most extreme 100-percent-LGD assumption. Only the default of five and 10 largest borrowers leads to 4 and 12 banks falling below minimum CET1 CAR.[22] Many large exposures are connected; that is, multiple banks have the same large borrower. A default of the largest borrower in the system would lead to the loss of 4.5 percent of system's total capital, though no bank would be undercapitalized. Based on the BU sensitivity stress tests by the four banks, a residential and commercial real estate price drop by 20 percent would not lead to undercapitalization of these banks (impact on their capital would be 0.14 percent of combined CET1), though these and some regional banks have large exposures to commercial real estate development companies. Japanese banks have comparatively small exposure to retail loans, including mortgages. In terms of counterparty risk, default of the two counterparties with the lowest credit rating would also lead to small losses for the four banks (less than 0.01 percent of combined

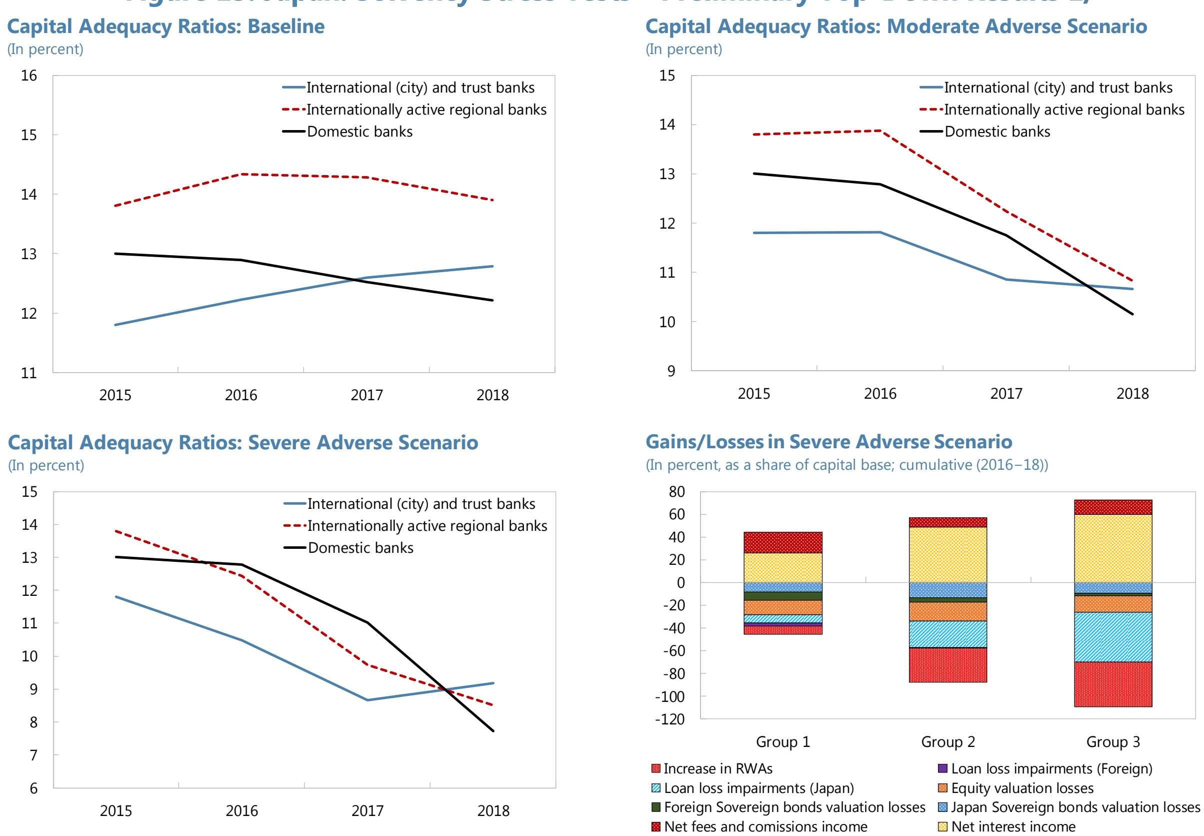
[22] The results are not much different assuming 100 percent loss, as many of the large exposures in Japan are unsecured or secured by third party guarantees.

capital). Finally, an equity price drop by 50 percent would lead to capital drop by almost two percentage points.[23]

***BoJ TD stress test results***

**41. Results from the BoJ's TD stress testing results also confirm that the banking system overall is particularly vulnerable to market (equity) and credit risk shocks.** Losses stemming from cross-shareholdings of equity securities of borrowing companies are the largest driver of the system-wide decline in capital adequacy ratios. Sovereign risk from Japanese and foreign sovereign valuations is a smaller driver in relative terms. While all banks included into BoJ's TD exercise remain above the minimum CET1 or core capital requirements, the U.S. monetary policy normalization scenario leads to the highest losses in the system (see Figure 13), with domestic banks CAR dropping from 13 percent in 2016 to 7.7 percent in 2018. Small regional banks are more vulnerable to credit risk (decline in GDP growth) than their large peers.

**Figure 13. Japan: Solvency Stress Tests—Preliminary Top-Down Results 1/**




Source: IMF staff estimates.
1/ Group 1 stands for city banks, Group 2 for international active regional bank, and Group 3 regional banks without international exposure.

[23] It is important to note, that equity losses are twofold: increase in probability of default leads to higher expected losses, RWAs and deductions from other comprehensive income. Only impairment of equities is directly included into profit and loss statement.

## Bottom-up stress testing results

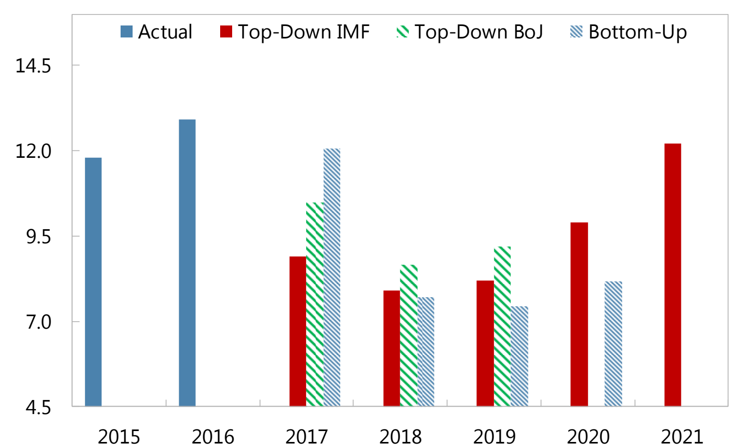
**42. BU stress test results reveal similar outcomes: most of the vulnerability lies in market and credit risk related losses.** However, the impact from market risk related losses is relatively higher in these tests. Banks' estimates of market risk related losses are more granular compared to both IMF and BoJ TD models. When it comes to equity risk, banks used TOPIX and NIKKEI equity indices as benchmarks to simulate drop of price for each individual equity security. Losses from debt securities were calculated using duration gap analysis, but contrary to the TD approach employed by the IMF, banks (as well as the BoJ) estimated the precise impact on each type of security in banks' portfolios.

**43. While the amount of losses from market and credit risk varies across all three types of stress tests, overall there are only small differences among all three sets of results.** Figure 14 below compares output from all tests. The comparison of results reveals that City banks forecast a higher impact of the severe adverse scenario on CET 1 capital. Losses from credit risk were higher in the IMF model. This is attributed to several factors, one of which is the granularity of the expected loss estimation. IMF used weighted average TTC PDs for each exposure class, while banks calculated ELs in a more granular manner.

**44. Scenario assumptions restricting changes in portfolio composition worsened the BU ST results.** The actual behavior of banks would be based on minimizing the impact of shocks and might lead to rebalancing of the portfolio. At the same time, rebalancing strategies might not be easily implementable at the times of systemic stress; thus behavioral constraints introduced in the design of the BU stress test might not overestimate losses.

**Figure 14. Japan: Comparing ST Results: CET1 CAR—Severe Adverse Scenario: City Banks**

(In percentage points)




Source: IMF and BoJ calculations.

# BANKING SECTOR LIQUIDITY STRESS TESTS

*Cash flow-based liquidity analysis and liquidity coverage ratios (LCRs) are used to test banks' resilience against funding and market liquidity shocks in yen and foreign currencies. The cash flow-based analysis uses the supervisory data of maturity mismatch and funding concentration provided by the JFSA.*

## A. Funding Structure and Concentration

**45. Banks rely heavily on wholesale sources for foreign currency funding (Figure 15, top panels).** In contrast to their yen funding, most of banks' funding in U.S. dollars and euros comes from unsecured wholesale funding, repos, and FX swaps—all of which could be more difficult to obtain in a stress environment—although banks have been shifting towards stable and longer funding sources to reinforce their resilience under latent stress in FX markets. Some of this funding has maturities longer than one year (particularly medium- to long-term FX and cross-currency swaps); however, a large share of them (CDs, repos, and short-term FX swaps) are typically rolled over and repriced every three to six months.

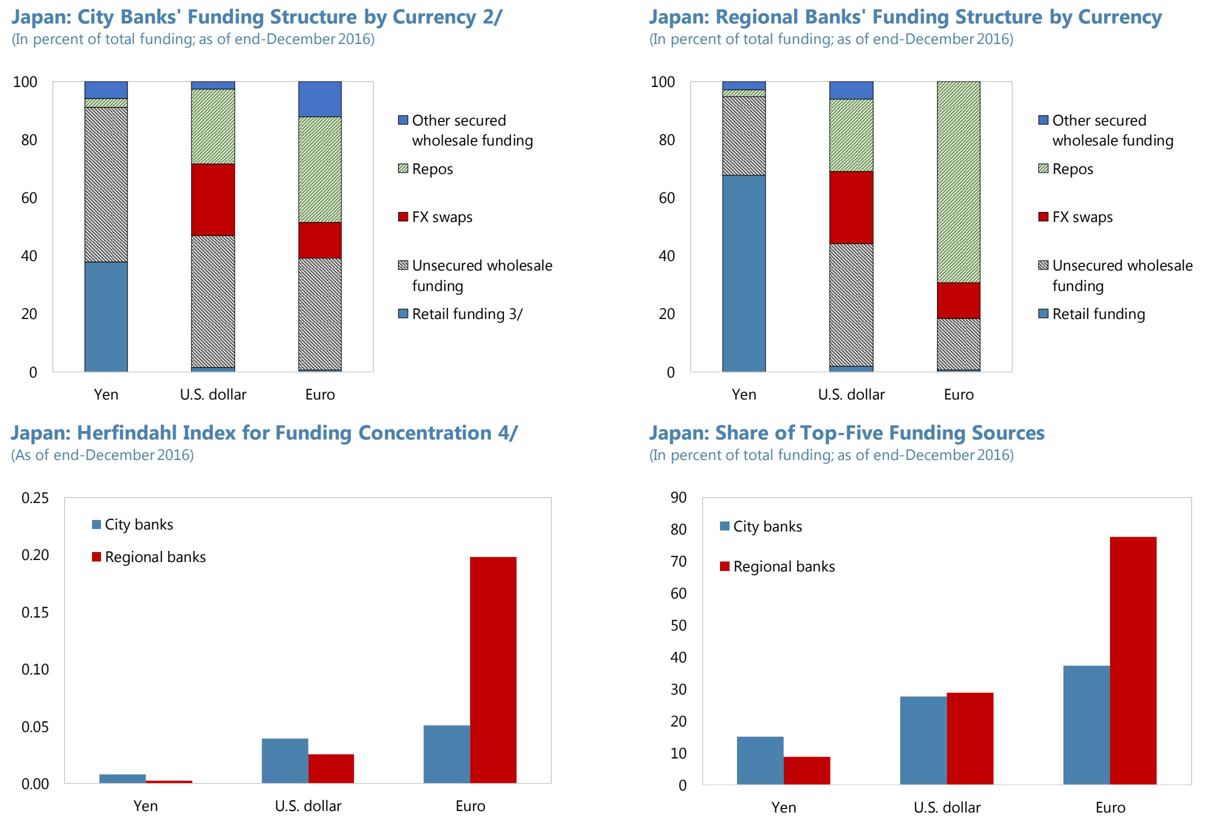
**46. Despite only accounting for a small share of total funding, banks' FX funding is more concentrated, particularly in the euro (Figure 15, bottom panels).** System wide, the amounts of bank funding in U.S. dollar and euro account for less than 25 percent and 5 percent of their total funding in all currencies, respectively. However, since most of these funding is wholesale, banks might face higher rollover risks if these wholesale sources are more concentrated. Two indicators are used to examine banks' funding concentration, i.e., (i) the Herfindahl index; and (ii) the top-five largest funding sources as a share of the total funding.[24] The index is calculated for each currency (yen, U.S. dollar, and euro) and each bank, and then aggregated for each type of banks, i.e., city banks and (internationally active) regional banks. The larger the Herfindahl index is, the more concentrated the funding sources are. Moreover, the largest five funding sources as a share of the total funding is also calculated as another indicator of funding concentration in each currency. Both indicators suggest that i) both types of banks are more concentrated in FX funding, particularly funding in euros, although this may be due to the significant shares of CCPs, and ii) regional banks are less concentrated in yen funding than city banks, but are highly concentrated in euro funding.[25]

[24] The Herfindahl index is calculated as the sum of the squared share of each of the top-20 largest funding sources in each currency (including both unsecured and secured funding) in the bank's total funding. It is implicitly assumed that the remaining funding sources are completely competitive, which seems to be reasonable because the cut-off values of the top-20 largest funding sources are very small for all banks. A caveat is that the funding concentration indicators might not be fully comparable across currencies because of the data limitation that CCPs are included and account for significant shares in banks' secured funding in foreign currencies.

[25] Since banks' euro-denominated liabilities are typically small compared to their total liabilities (less than 5 percent for all regional banks in the sample), this high concentration in euro might not be an immediate concern at this moment. However, any increase in the rollover risk of these funding for regional banks could pose higher losses to their already low (core) profitability.

The FSA could consider raising the intensity of its supervision over banks' funding concentration in significant foreign currencies.[26]

**Figure 15. Japan: Bank Funding Structure and Concentration**




Sources: Japan Financial Services Agency; and IMF staff estimates.
1/ Figures in this panel are calculated using the data on the financial group-consolidated basis.
2/ In percent of total retail and wholesale funding (not including funding through derivatives markets). City banks include the three FBs.
3/ Retail funding includes retail deposits, retail debt securities, and SME deposits.
4/ A higher Herfindahl index indicates a higher concentration.

## B. Liquidity Stress Testing Methodology and Scenarios

**47. FSAP team used two types of liquidity stress tests: LCR based analysis and fully pledged maturity ladder cash flow stress tests.**[27] LCR based analysis already embeds standardized 30-day stress period, therefore FSAP team analyzed dynamics of LCR ratio over several quarters as well as compared LCR ratios across banks and key currencies. Cash flow reporting data does not embed any scenarios itself, hence it was used to construct a battery of sensitivity tests as well as link

[26] A foreign currency is considered "significant" if the aggregate liabilities denominated in that currency amount to 5 percent or more of the bank's total liabilities.

[27] LCR reporting template is subject to Pillar I reporting standards and the maturity ladder reporting template is subject to Pillar II standards and reporting with the aim to capture liquidity risks not captured under the LCR requirement. This potentially makes maturity ladder based liquidity reports less harmonized in terms of data availability and consistency across banks.

solvency and liquidity analysis together. Contrary to solvency stress tests, liquidity stress tests face higher degree of uncertainty regarding scenario parameters, therefore FSAP team chose to design scenarios across multiple dimensions, such as timing, severity, level of support, currencies. LCR and maturity ladder cash flow based stress tests differ in terms of data granularity, timing as well as assumptions about availability of liquid assets (with LCR being more restrictive, but having relatively short time horizon).

**48. Supervisory data for the liquidity stress testing included those on the bank-solo basis and those on the FG-consolidated basis.** Data on the bank-solo basis cover 16 banks (seven city banks and nine regional banks) and include contractual cash outflows and inflows broken down by maturity buckets and counterbalancing capacity in each of the three currencies (yen, U.S. dollar, and the euro).[28] Data on the FG-consolidated basis cover 14 banks (five city banks—including three FGs—and the nine regional banks) and include similar variables of cash outflows, cash inflows, and counterbalancing capacity as in the data on bank-solo basis. The difference between the two datasets is that the three FGs are represented by five city banks on the unconsolidated bank-solo level but are only counted as three on the FG-consolidated level. Since FGs typically manage liquidity on a group level, the FG-consolidated data are likely to indicate better and more accurate liquidity positions for the three FGs. For this reason, only findings from the FG-consolidated data are presented in this note.

**49. Banks' resilience against funding and market liquidity shocks in yen and key foreign currencies was tested using maturity ladder cash flow-based liquidity data.** The cash flow approach is applied at the currency level based on the maturity ladder in yen, U.S. dollar, and euro, respectively. Market-wide stress scenarios for each currency consist of three levels of severity, i.e., low-, intermediate-, and severe stress, which are assumed to last for two weeks, three months, and one year, respectively (Figure 16).[29] Moreover, two levels of support from the BoJ are considered in the yen-liquidity analysis, i.e., no support (pure market) and support through the BoJ's discount window (lower asset haircut ratios than market). In addition, market liquidity shocks to equities are also considered to estimate the haircut ratios.[30] In the U.S. dollar-liquidity analysis, it is assumed that the run-off rate on outflows from FX swaps increases across the three severity levels to reflect different stress levels in the FX swap market and the same rates are used as the roll-off rates for yen cash inflows from FX swaps (the other leg of the U.S. dollar/yen swaps). Finally, the U.S. dollar-liquidity analysis is combined with the yen-liquidity analysis to test banks' resilience to liquidity shocks in both currencies where banks are assumed to be able to use their yen-denominated counterbalancing capacity to offset their U.S. dollar funding gap. For unconditionally callable

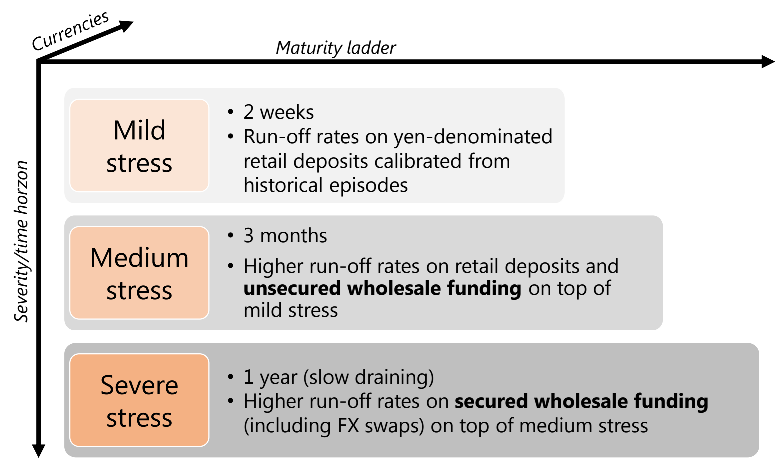
[28] Maturity buckets include overnight, 2 days to 1 week, 1 week to 2 weeks, 2 weeks to 1 month, 1 month to 2 months, 2 months to 3 months, 3 months to 6 months, 6 months to 9 months, 9 months to 1 year, 1 year to 2 years, 2 years to 3 years, 3 years to 5 years, and over 5 years. The maximum horizon of liquidity stress scenarios is 1 year.

[29] An idiosyncratic stress scenario on top of the severe stress scenario is also considered for the banks whose capital ratios fall below their regulatory levels after the first year in the solvency stress testing.

[30] The haircut ratios on equities are assumed to be dynamic and depend on the total amount of equities that all banks sell. The detailed methodology for the calculation of these dynamic haircut ratios is provided in Appendix V.

funding (stocks rather than flows), it is assumed that their run-off rates (in percent of stocks) broadly follow two-lag autoregressive (AR(2)) processes. For instance, Figure 17 illustrates the pattern of run-off rates across the three liquidity scenarios, where the cumulative run-offs of the cash outflows are the largest in the 1-year severe scenario, but the intensity over respective maturity period is the smallest among all three scenarios.

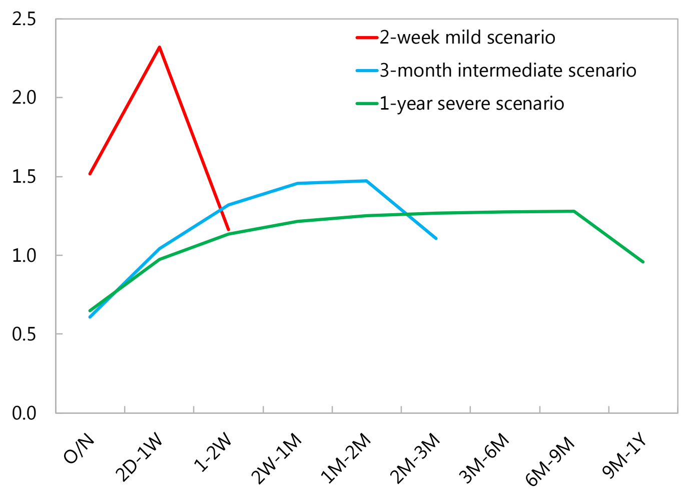
**Figure 16. Japan: Scenarios of Cash Flow-Based Liquidity Stress Testing**




Source: IMF staff.

**Figure 17. Japan: Illustration of Run-Off Rates for Unconditionally Callable Funding 1/**

(In percent)




Source: IMF staff.

1/ Assuming that the share of total cash outflows over 1 year is 5 percent in the 2-week mild scenario, 7 percent in the three-month intermediate scenario, and 10 percent in the 1-year severe scenario.

**50. The 2-week mild scenario focuses on historical episodes of run-offs from retail investors and partial closure of FX swap market.** In the mild, but more intense in terms of outflow rates, 2-week scenario, it is assumed that the run-off rates for yen-denominated retail and term deposits are the same as those calibrated from the recent historical cases of capital injection, banks' nationalization, and bankruptcy.[31] The largest run-off rate among these three cases (in the range of 3–5 percent) is used as the run-off rate for yen-denominated retail and term deposits, which is still smaller than the respective LCR run-off rates. The run-off rates for cash outflows from unsecured wholesale funding, including corporate deposits, are assumed to be 30 percent in this mild stress scenario, slightly lower than their LCR run-off rates. The run-off rates for cash outflows from secured wholesale funding are assumed to be the same as their LCR run-off rates. In particular, the run-off rate for cash outflows from secured wholesale funding from domestic central bank is assumed to be 0 percent. The run-off rates for cash outflows from secured wholesale funding from non-central bank sources are assumed to be 0 percent, 15 percent, and 50 percent for those backed by level 1, level 2A, and level 2B HQLA, respectively. Finally, in the mild scenarios for U.S. dollar and euro markets, it is assumed that the FX swap market is under mild stress and 40 percent of the contracts cannot be rolled over. Appendix V (Tables 1–4) presents the detailed assumptions of the parameters in the 2-week mild scenario.

**51. The intermediate 3-month scenario puts more stress on unsecured wholesale funding compared to the 2-week mild scenario.** The run-off rates on cash outflows from unsecured wholesale funding (particularly corporate funding, interbank borrowing, and own debt securities) and retail deposits are assumed to be 40 percent and 5–10 percent, respectively—higher than in the 2-week scenario. Meanwhile, we assume that the cash outflows from secured wholesale funding have the same run-off rates as those in the 2-week scenario (or the LCR run-off rates). Finally, this scenario assumes that 60 percent of the FX swaps cannot be rolled over—a higher roll-off rate than in the 2-week scenario (see also Appendix V, Tables 5–8 for details). The increasing pressures on different types of cash outflows (or higher run-off rates) can help identify the weak points for each bank.

**52. The 1-year severe scenario puts more stress on secured wholesale funding (particularly FX swaps) compared to the medium 3-month scenario.** In particular, the run-off rates for cash outflows from the wholesale funding that are secured by level 2A and 2B HQLA are assumed to be 30 percent and 80 percent—higher than in the 3-month scenario and the LCR run-off rates. In the severe scenarios for U.S. dollar and euro markets, it is assumed that the FX swap market is under severe stress, resulting in, on the one hand, an 80 percent run-off rate of cash outflows from U.S. dollar-denominated derivatives and, on the other hand, an 80 percent roll-off rate for cash inflows from yen-denominated derivatives. These run-off (or roll-off) rates for cash outflows (or inflows) from derivatives will be increased to 100 percent in the market and idiosyncratic liquidity scenario for those banks whose capital ratios fall below their regulatory levels after the first year in

[31] Calibration was based on the last 10 years of data, hence excludes burst of real estate bubble episode of early 90s.

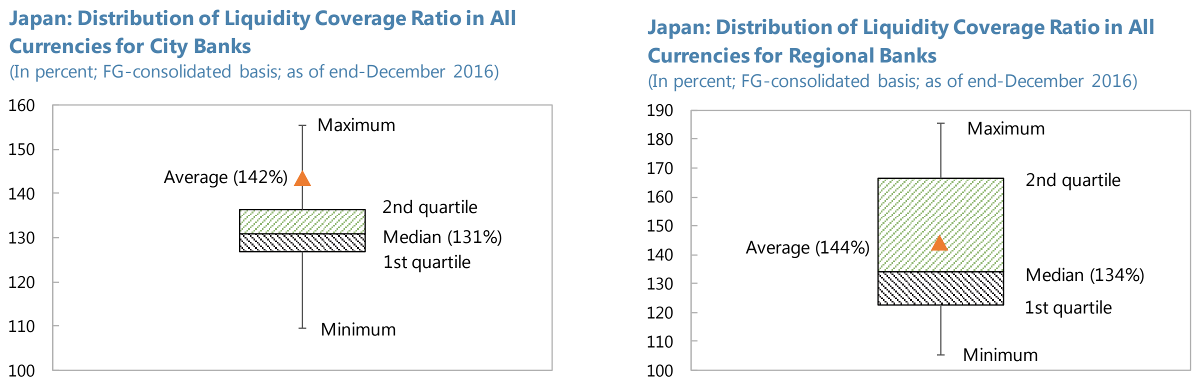
the solvency stress testing. Appendix V (Tables 9–12) present the detailed assumptions of each parameter in all the three liquidity scenarios.

## C. Liquidity Stress Test Results

**53. LCRs analysis shows that banks have ample liquidity in yen but not in foreign currencies in the one-month horizon.** All-currency aggregated LCRs suggest robust overall liquidity, with ratios above 100 percent in all banks in the sample as of end-December 2016 (Figure 18). However, the LCR in U.S. dollars stands below 60 percent (system-wide), and the ratio in regional banks is lower on average than that in city banks.

**54. The cash flow-based liquidity stress tests also find significant areas of vulnerability in foreign currency positions, particularly for regional banks, despite ample liquidity in yen.** Although no bank fails in the yen liquidity stress testing, a few internationally active regional banks would experience negative cumulative funding gaps in U.S. dollars after exhausting all their unencumbered liquid assets denominated in U.S. dollars in the severe one-year scenario (Figure 19).[32] To test whether banks would be able to offset their negative funding gaps in U.S. dollars, the analysis also combines the liquidity stress tests for yens and U.S. dollars. We assume that banks can convert their yen-denominated liquid assets to U.S. dollars in the market. The results show that, since the funding gaps in U.S. dollar are relatively small compared to their excess yen liquidity, no bank fails under the join stress conditions in both yen and U.S. dollar funding markets. Finally, all city banks can survive the 2-week mild stress at the FG-consolidated level.

**Figure 18. Japan: Liquidity Coverage Ratios**




Sources: Japan Financial Services Agency; and IMF staff estimates.

[32] However, the total amount of negative funding gaps in U.S. dollars in the severe 1-year scenario accounts for only a very small proportion of total U.S. dollar-denominated liabilities of the entire banking sector. Liquidity stress testing was also conducted for the euro (although euro-denominated liabilities only account for less than 5 percent of total liabilities for the whole banking sector). The results show negative yet very small funding gaps (relative to total funding needs) in two regional and two city banks in the severe 1-year scenario. Moreover, the results using end-March and end-September 2016 FG-consolidated data are comparable with those using end-December 2016 data in the 1-year severe scenario.

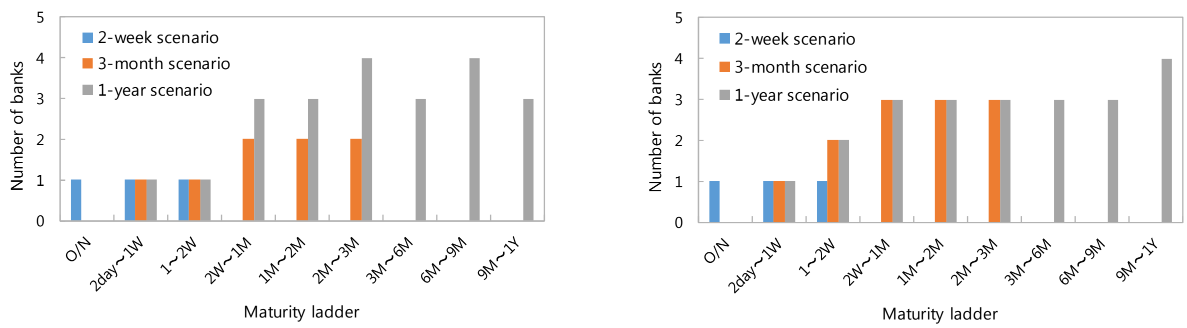
**55. The results suggest that regional banks are more sensitive towards cash outflows from unsecured wholesale funding**. Unsecured wholesale funding is typically more sensitive with respect to negative developments in the markets and in some extreme cases such source of funding might dry out completely. Applying higher run-off rates on outflows from unsecured wholesale funding leads to more failures of regional banks than applying the same run-off rates on outflows from secured wholesale funding.

**56. Findings from liquidity stress testing highlight the need to intensify banking supervision on FX funding liquidity risks.** It is important to continue to improve the consistency between the data from the FX maturity mismatch template (maturity ladder data) and the LCR data. The JFSA should continue to monitor the level of HQLAs which are not ringfenced or "trapped" in other jurisdictions (e.g., by the regulation W in the U.S.) through its ordinary supervision process. Moreover, there is merit in conducting the cash flow-based liquidity stress testing on a regular basis using the maturity ladder data, and require banks to hold sufficient counterbalancing capacity (particularly HQLAs) to survive for a certain period (e.g., three months).

**Figure 19. Japan: Liquidity Stress Tests—Cash-Flow Based Analysis**

**Japan: Number of Banks with Negative Cumulative Funding Gap in U.S. Dollar 1/**
(FG-consolidated; as of end-December 2016)

**Japan: Number of Banks with Negative Cumulative Funding Gap in Euro**
(FG-consolidated; as of end-December 2016)




Sources: Japan Financial Services Agency; and IMF staff estimates.
1/ No city bank has a negative cumulative funding gap in U.S. dollar.

## D. Integrated Solvency and Liquidity Stress Test Results

**57. Integration of both tests assumes that banks which need additional capital because of credit losses would face higher liquidity outflows due to investor concerns about solvency of these banks.** Integration of solvency and liquidity risks is not a simple exercise as it involves numerous assumptions, expert judgment and parameter calibrations. Timing and initial trigger is also important: the crisis might start due to solvency issues or due to insufficient liquidity reserves a given bank or group of banks have. The next layer of uncertainty arises from asset liquidation strategy (whether banks choose to liquidate less or more liquid assets first), feedback effects from sales to the market prices (whether fire-sale of assets would be amplified by the subsequent decline in market prices of these securities) and finally market microstructure, i.e., whether there are enough buyers which do not have liquidity constraints and able to act as a counterparts in sales transactions (like pension, insurance funds, other banks and large non-bank financial institutions). Figure 20 provides a schematic overview about various assumptions used to integrate both stress tests.

**58. The analysis followed an annual sequence and included results of both, the 1-year low intensity, severe liquidity scenario as well as severe adverse macro scenario from solvency stress test.** The solvency shock happens in 2017. Several banks are affected; hence they experience higher outflow rates and lower inflows (due to higher NPLs ratios) from credit portfolio. This liquidity stress spans over the one year horizon. Banks have a choice to liquidate assets in Japanese yen, U.S. dollars, as well as choose between liquid and less liquid assets. Choice of liquidation strategy also affects decision to use BoJ facilities. In case a bank chooses or is forced to sell portfolio of less liquid assets (such as equities, corporate bonds, commercial papers etc.) additional haircuts are applied. The haircuts are calculated using Amihud (2002) measure of stock market liquidity which captures the price impact of sales in equities (see Appendix IV for technical details). Losses due to fire-sale of assets impacted P&L as well as RWAs of banks, while loss of liabilities led to the shrinkage of balance sheets of respective banks. This lowered banks CAR.[33]

**59. The integration analysis started from a solvency trigger, mainly because Japanese banks (included in solvency and liquidity exercise) enjoy ample JPY liquidity.** Banks that fail the solvency stress testing experience higher funding liquidity shocks. These weak banks have negative funding gaps in U.S. dollars even before the additional liquidity shock due to weak solvency position is applied. After exhausting all their unencumbered assets denominated in U.S. dollars, it is assumed that the banks only liquidate JGBs or use their yen-denominated cash or central bank reserves to offset the negative funding gaps in U.S. dollars. Therefore, the losses from the fire sales of these yen-denominated assets are very small, and the losses mainly come from the fire sales of their unencumbered non-HQLA assets denominated in U.S. dollars (largely due to the haircut ratios on non-HQLA CPs, agency bonds, and corporate bonds).[34] In particular, assumptions entail higher run-off rates of certain cash outflows for the "failed" banks in the solvency stress testing—especially higher run-off rates for cash outflows from retail deposits, term deposits, wholesale corporate funding, debt securities, and secured wholesale funding (including those secured by level 2A and level 2B assets, and derivatives—particularly FX swaps).[35]

**60. Integrated stress test results show that, overall, the impact of liquidity and solvency stress scenarios on system-wide capitalization is limited due to ample liquidity in JPY.** At the same time, affected banks face higher capital shortages compared to solvency scenarios alone.

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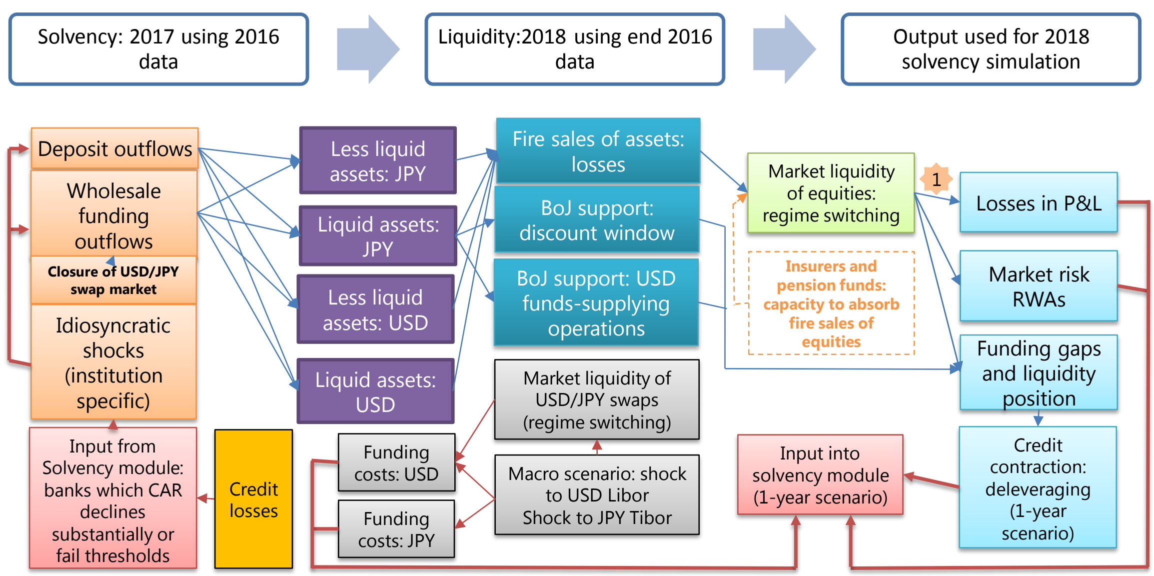
[33] Technically, the analysis could continue for the next year; however due to limited impact of the scenarios on banks CAR and liquidity positions we ended our analysis in 2018.

[34] These extra losses are relatively small compared to their excess yen liquidity.

[35] More specifically, the run-off rates for stable retail and less stable retail deposits (or term deposits) are increased from 5 and 10 percent to 10 and 20 percent, respectively; The run-off rates for cash outflows from wholesale corporate funding and debt securities are increased from 40 and 70 percent to 80 and 100 percent, respectively; The run-off rates for wholesale funding secured by level 2A and level 2B assets are increased from 30 and 80 percent to 50 and 100 percent, respectively; The run-off rate for cash outflows from derivatives is increased from 80 percent to 100 percent to reflect the closure of FX swap market for these weak banks.

Several banks which fail U.S. dollar liquidity stress tests need to liquidate their less liquid non-HQLA assets. This test explicitly assumes that banks choose to liquidate foreign assets rather than use swap market to exchange Japanese yens to U.S. dollars.[36] The liquidation generates losses around 0.02 percent in terms of GDP (or 0.05 percent of GDP to recapitalize banks up to 8 percent total CAR, see Figure 21). The overall impact on CAR ratios is limited; affected banks can remain liquidity in JPY after liquidating their portfolios in U.S. dollars, finally effects on credit contraction are negligible (due to liquidity shortages in U.S. dollars and not Japanese yens). The results are not surprising given the business models of these several banks: while they face liquidity shortages in U.S. dollars due to wholesale funding shocks, their assets denominated in U.S. dollars are relatively liquid as opposed to loans or other non-marketable assets.

**Figure 20. Japan: Integration of Solvency and Liquidity Stress Tests 1/**

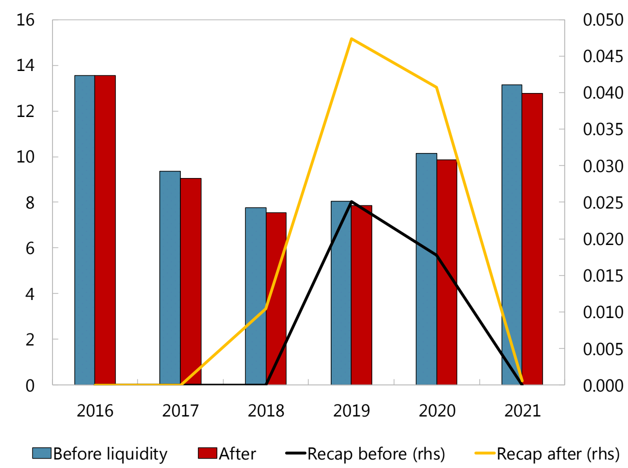



Source: IMF staff.
1/ Only fire sales of U.S. dollar assets are considered as a result of the 1-year severe liquidity scenario for U.S. dollar funding.

[36] While this scenario might be too extreme in some cases (for example, in case of idiosyncratic shock), in market wide liquidity stress scenario which includes shortage of U.S. dollar supply this liquidation strategy might happen.

**Figure 21. Japan: Solvency Stress Tests—Results of Combined Solvency and Liquidity Stress Test Under the Severe Adverse Scenario**

(In percent)




Source: IMF staff calculations.

# SOLVENCY STRESS TESTS OF INSURANCE COMPANIES

***This section explains the IMF stress test of insurance undertakings.*** *The section covers: (i) the scope of the test; (ii) the scenario specification; (iii) the modeling assumptions; (iv) the results of the TD and BU exercises; (v) additional one-factor sensitivity analyses; and (vi) recommendations.*

## A. Scope of the Test

**61. Central to the insurance sector stress test is a TD exercise which was run by the IMF in close cooperation with national authorities, complemented by a BU exercise.** It is acknowledged that such a TD stress test can usually not capture all mitigating effects, like e.g., financial hedges, profit participation, reinsurance, deferred taxes. Therefore, BU results were used to validate TD model results and to gain a deeper understanding of risk-mitigating strategies used by insurance companies.

**62. Seven life insurers and six non-life insurers participated in the exercise.** The Japanese insurance market is highly concentrated and the sample selected for the ST ensures a coverage of 73 percent and 92 percent in terms of life and non-life annualized new business premiums, respectively. Included in the non-life sample are also two reinsurance companies.

**63. The stress test was conducted at the highest level of consolidation which includes all world-wide insurance activities. Banking and other non-insurance activities were excluded.** As only eight out of the 13 ST participants form an insurance group, only those provided results at the group-level, while the others provided data at the level of the solo entity. The reference date for the stress test was the end of fiscal year 2015, i.e., March 31, 2016.

## B. Scenario Specification

**64. The macrofinancial scenarios specified by the IMF for the banking sector stress test were slightly adjusted to make them more practicable for insurance companies.** While for the banking stress test a projection horizon of five years is prescribed, for the insurance stress test all shocks are assumed to occur at the beginning of the first year (maximum drawdown as instantaneous shock). Naturally, the focus of the scenario specification for the insurance sector lies on financial market variables (Table 5):

- Shocks to government bond rates: parallel shifts of the term structure, separately for Japan, U.S., and other countries;
- Shocks to corporate bond spreads: separately per rating class;
- Shocks to equity prices: separately for Japanese and foreign stocks;
- Shocks to property prices: universal for all domestic and foreign real estate holdings;
- Shocks to foreign exchange rates: changes of the JPY/USD, JPY/EUR and JPY/AUD rates.

**65. In addition to the macrofinancial scenarios used for the banking sector stress test, the simultaneous default of the largest banking counterparty and the largest non-financial corporate counterparty was modelled, resulting in:**

- a 100 percent write-off for equity exposures, guarantees for liabilities;
- a 50 percent write-off for bonds and loans; and
- a 15 percent write-off for deposits, loaned securities, lease assets.

**66. To complement the rather short-term perspective of an instantaneous shock, undertakings were requested to provide a three-year projection of specific business developments under the baseline and the severe adverse scenario.** Reporting items included gross written premiums, net written premiums, gross claims, net claims, lapse rates, investment returns, net surplus, shareholder dividends declared, insurance liabilities, and the solvency margins. Projections were made in line with the macrofinancial scenarios (e.g., with regard to the development of the GDP and interest rates) while the market prices of investment assets were assumed to remain constant after the shocks have occurred at the beginning of the first year of the projection horizon. Interest payments received, dividends and rental incomes would therefore be the only items contributing to investment returns.

## Table 3. Japan: Market Shocks in the Insurance Stress Test

| *(Change compared to the reference date)* | | Scenario 1: "Moderate Adverse Scenario" | Scenario 2: "Severe Adverse Scenario" |
|---|---|---|---|
| Interest rates (parallel shift of the interest rate term structure) | Japan | +4bp | +296bp |
| | US | +39bp | +276bp |
| | Other | +27bp | +106bp |
| Corporate bond spreads | AAA | +30bp | +60bp |
| | AA | +40bp | +80bp |
| | A | +50bp | +100bp |
| | BBB | +70bp | +140bp |
| | BB or lower | +100bp | +200bp |
| | Unrated | +70bp | +140bp |
| Currencies | JPY/USD | -4.8% | +3.9% |
| | JPY/EUR | -3.8% | -5.5% |
| | JPY/AUD | -7.4% | -8.9% |
| Equity | Japan | -31.2% | -28.8% |
| | Other | -22.4% | -15.7% |
| Real Estate (in nominal terms) | Global | -22.0% | -22.0% |

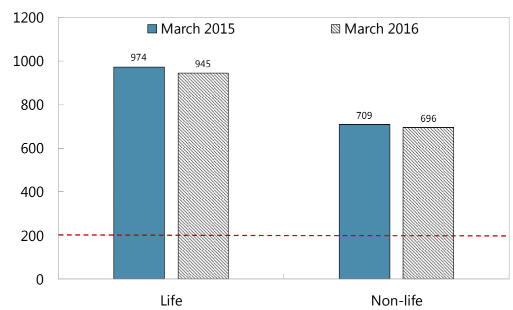
Source: IMF staff.

## Box 1. Testing an Economic Solvency Regime

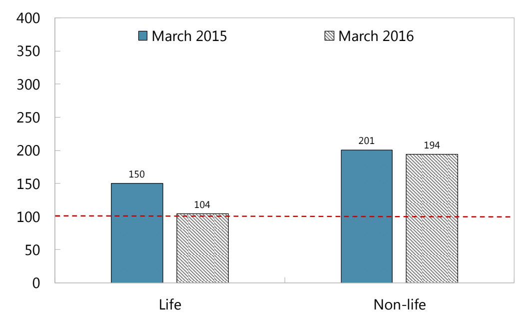
**In a recent Field Test, the JFSA tested the implications of an economic solvency regime on the Japanese insurance sector.** The JFSA published the results of its third Field Test on in March 2017. This exercise was performed in the second half of 2016 and built on the Field Test of the International Association of Insurance Supervisors (IAIS) with some smaller amendments made by the FSA. The aim was to test the impact of a regime shift towards an economic valuation of assets and liabilities and a risk-based solvency requirement with capital charges calibrated at consistent confidence levels.

**The average economic solvency ratio (ESR) was 104 percent in the life sector and 194 percent in the non-life sector as of March 2016,** down from 150 percent (for life) and 201 percent (for non-life) as of March 2015. The decline in the ESR of life insurance companies reflects mainly the downward trend in long-term interest rates during that period.

**Solvency Margin Ratio**
(In percent)




**Economic Solvency Ratio**
(In percent)




Sources: IMF staff calculations based on JFSA data.

**Translating the current solvency margin ratios into economic solvency ratios involves a detailed look into several components of available and required capital under both regimes:** On the one hand, the valuation of assets would increase to mirror fair values. On the other hand, also the value of liabilities especially for some life insurance products would go up, reflecting lower interest rates used for discounting future cash flows—however this effect is partially offset by a changed methodology to derive such future cash flows. In effect, the value of assets over liabilities which forms the basis for available capital is expected to increase. Applying capital requirements calibrated uniformly as a value-at-risk with a one-year holding period and a confidence level of 99.5 percent will considerably increase the required capital, thereby resulting in lower economic solvency ratios.

**While the JFSA has not announced a decision yet on the adoption of an economic solvency regime, some insurance companies already embrace such a regime,** e.g., by disclosing economic solvency ratios. Discussions at the global level are still ongoing and the IAIS plans to adopt the International Capital Standards (ICS) by 2019 with implementation starting in 2020. Especially for life companies conducting their business not only by adhering to the statutory regime of the SMR but also by incorporating a more economic-based perspective, the two regimes have the potential to provide different indications for risk management. While the ESR makes life insurers less vulnerable to an interest rate increase, their vulnerability caused by a prolonged period of low rates becomes more apparent.

## C. Capital Standards and Modeling Assumptions

**67. The stress test was performed by applying the current solvency regime and J-GAAP and focused on the change in available capital and the resulting coverage of the required solvency margin.** The Japanese solvency regime defines a 200 percent solvency margin ratio (SMR) as the first trigger for early remedial actions. SMR is the ratio of solvency margin (net assets and special reserves based on accounting balance sheet, excluding items such as intangible assets) to half of risk requirements calculated based on standard factors stipulated in subsidiary legislation. In other words, a 200 percent SMR means that the "margin" exactly covers the "risks."

**68. Under the current accounting regime, Japanese life insurers have piled up substantial amounts of unrealized gains.** For the life insurers in the stress test sample, fair values exceed book values by 20 percent according to JFSA data. 65 percent of unrealized gains are attributable to domestic bonds, domestic stocks and foreign securities contribute 20 percent and 14 percent, respectively. The asset valuation of non-life insurers is considerably more in line with the fair values as the hold-to-maturity classification is of lesser relevance for them.

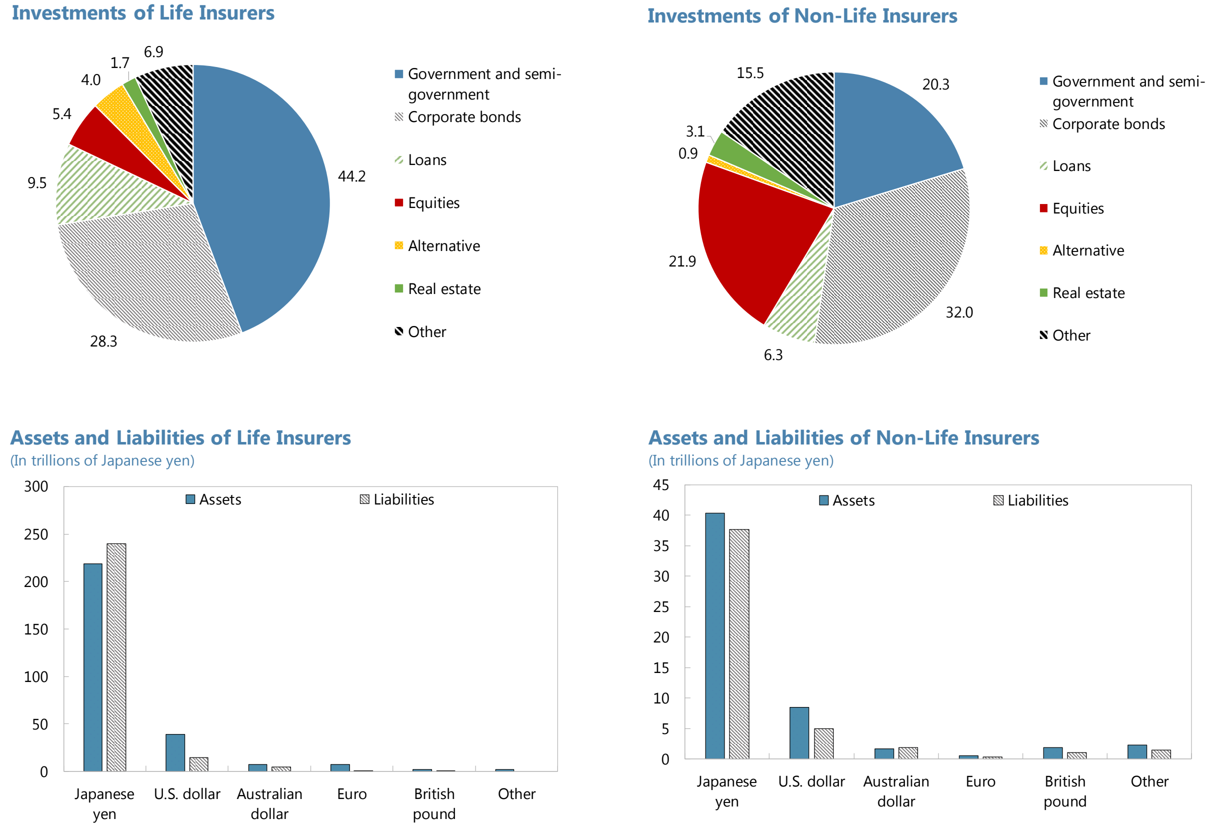
**69. Management actions were allowed to be included in the calculations only as far as they relate to non-discretionary rules already in place at the reference date.** Japanese insurance companies hedge their interest rate risks and their currency risks to different degrees.

## D. Investment Risks of Insurance Companies

**70. Life insurers hold high exposures to government bonds and non-life insurers to equities. As** of March 2016, life insurers invested 44 percent of their assets in mostly long-duration JGBs as well as bonds of municipalities and public sector entities, with another 28 percent invested in corporate bonds. Non-life insurers had a much lower exposure to government bonds at 20 percent, 32 percent of their investments in corporate bonds and 22 percent in equities.

**71. Life insurers take only moderate credit risk in their fixed-income investments but expand their holdings of FX-denominated assets.** Only a marginal share of life insurers' fixed-income portfolios is invested in non-investment grade assets, according to JFSA data. In recent years, the share of assets not denominated in JPY has increased. As of March 2016, their share amounted to 21 percent, compared to 7 percent of FX-denominated liabilities. Most companies are hedging the resulting currency risk to a large degree, mainly via forwards and options with both domestic and foreign banks as counterparties. Non-life insurers also invest in high-rated bonds but prefer shorter maturities—for them, 73 percent of assets are invested in Japanese yens which exceeds the value of Japanese yen-denominated liabilities (Figure 22).

**Figure 22. Japan: Insurance—Characteristics of Assets and Liabilities**




Sources: IMF staff calculations based on JFSA data and company submissions.
Notes: The upper two panel charts refer to the whole life and non-life insurance sector, respectively, while the two lower charts summarize the FX breakdown of assets and liabilities of the companies included in the stress test sample.

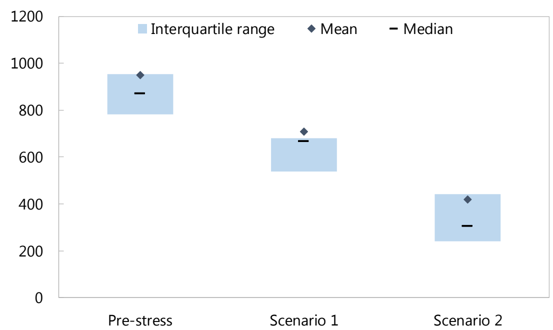
## E. Results of the Top-Down Stress Test

**72. In the TD stress test, life insurance companies experience a substantial decline in their solvency position, given their strong sensitivity to interest rates, while non-life companies are more resilient.** In the life sector, the average SMR drops from 949 percent before stress to 708 percent in the moderate adverse scenario (scenario 1) and to 419 percent in the severe adverse scenario (scenario 2). Six out of seven companies remain above the statutory requirement under the current regime. There is some dispersion in the results, given rather heterogeneous pre-stress solvency ratios, and after the materialization of the severe adverse scenario, half of the life companies would have a solvency margin ratio in a range between 241 percent and 442 percent. The aggregated available capital of the seven life insurers drops, from ¥34.4 trillion before stress, by 37 percent in the moderate adverse scenario and by 58 percent in the severe adverse scenario. Required capital would also be lower after stress as it would be calculated on the basis of a smaller investment portfolio—here the reductions are less pronounced and amount to 14 percent and 12 percent in the moderate adverse and the severe adverse scenario, respectively. Being less sensitive to higher interest rates, the non-life sector performs better, the average SMR declines from

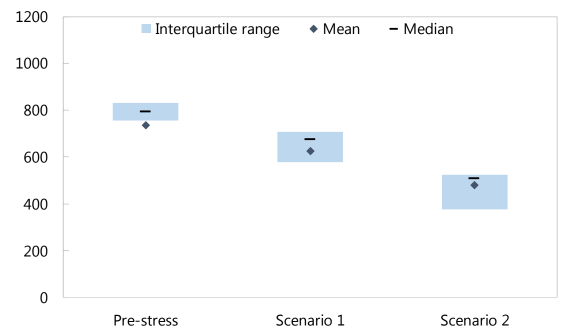
736 percent to 625 percent and 481 percent in the two scenarios, and all companies remain above the 200 percent threshold (Figure 23).

## Figure 23. Japan: Insurance Solvency Stress Test—Top-Down Results

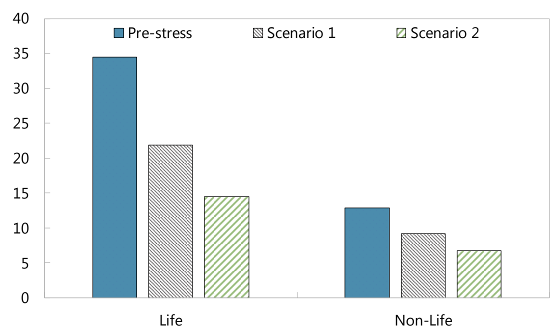
**Solvency Ratio of Life Insurers (Top-Down)**
(In percent)



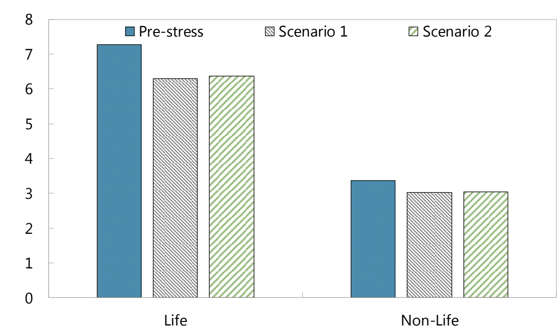

**Solvency Ratio of Non-Life Insurers (Top-Down)**
(In percent)




**Available Capital**
(Top-down, in trillions of Japanese yen)



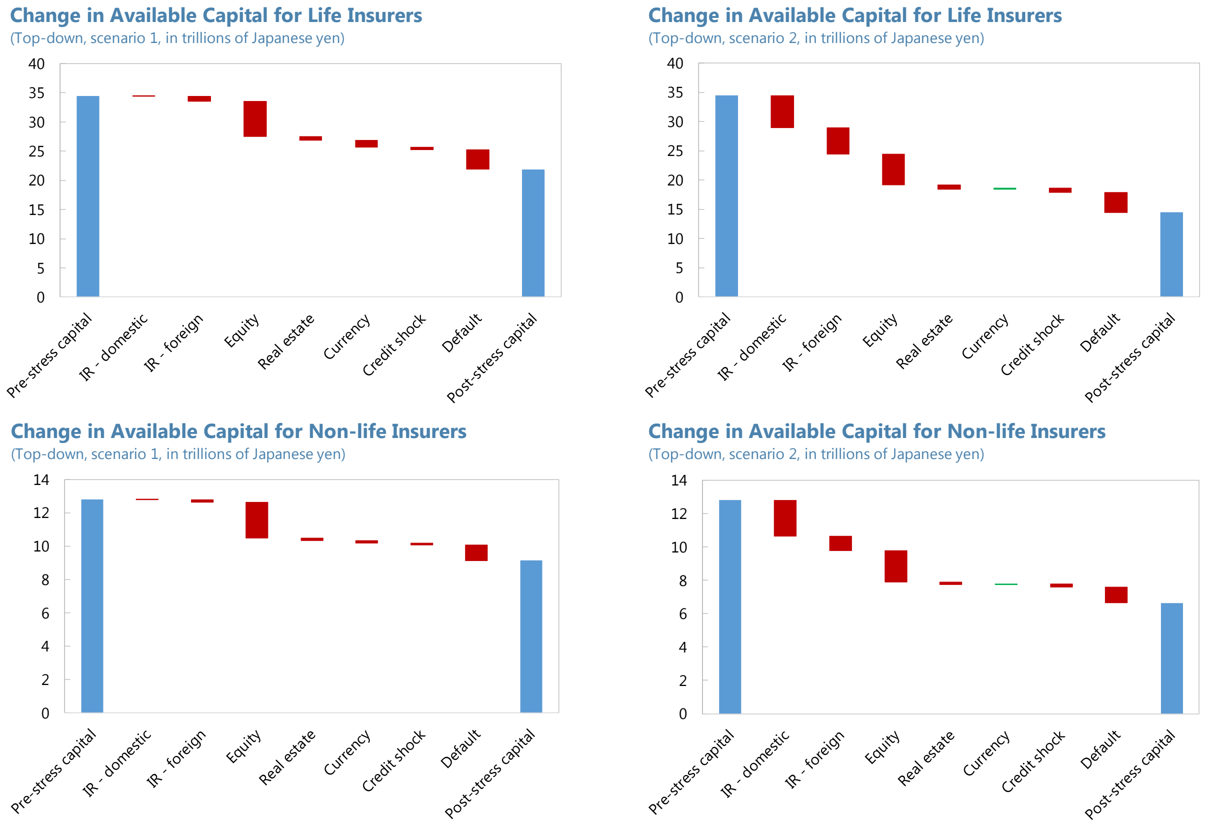

**Required Capital**
(Top-down, in trillions of Japanese yen)




Source: IMF staff calculations based on company submissions.

73. **Changes in available capital can be attributed mainly to the interest rate shocks (domestic and foreign) and the decline in equity prices (Figure 24).** In the severe adverse scenario, the assumed interest rate hikes in Japan and the U.S. as well as the equity price declines contribute more than three quarters to the decline in available capital. In addition, the assumed default of the largest banking and nonbanking counterparty has a considerable impact.

**Figure 24. Japan: Insurance Solvency Stress Test—Contribution to Change in Available Capital**




Source: IMF staff calculations based on company submissions.

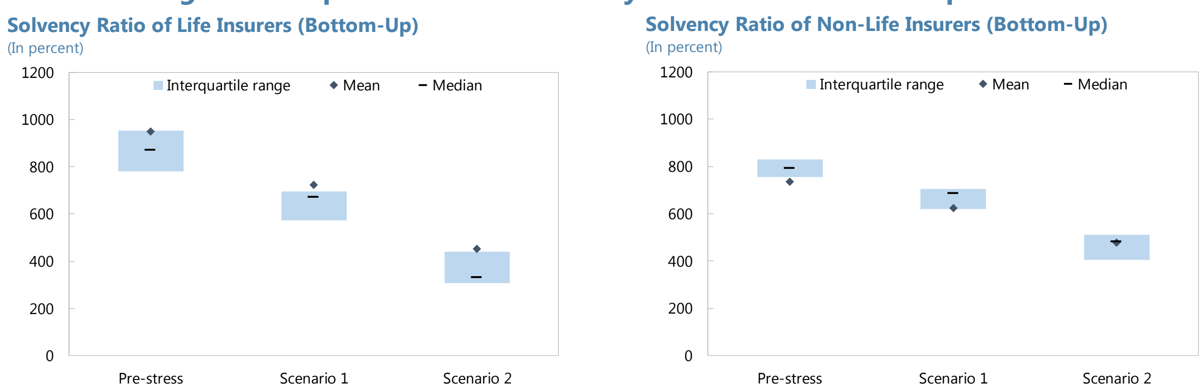
**74. The large sensitivity to interest rate hikes is typical for the current Japanese solvency regime and would be structurally different in an economic solvency regime.** In particular, an economic solvency regime makes life insurers less vulnerable to an interest rate increase, as liabilities decline in sync with the value of fixed-income assets as also the discount rate for calculating the liabilities would be higher. A prolonged period of low rates would instead be a considerably more relevant vulnerability in an economic solvency regime as the duration of liabilities usually exceeds the duration of assets for many life insurers in Japan, which results in liabilities increasing more than the value of assets when interest rates decline.

## F. Results of the Bottom-Up Stress Test

**75. Results of the BU exercise confirm broadly the results of the TD stress test (Figure 25).** Under both scenarios, life insurance companies would see a substantial decline in their capital and the solvency margin ratio, but all would remain above the statutory hurdle rate of 200 percent. Solvency margins decline, on average, from 949 percent before stress to 723 percent in the moderate severe scenario (scenario 1) and to 452 percent in the severe adverse scenario (scenario 2).

**76. Non-life insurers would be less affected by the market shocks, but also their solvency margin ratio would deteriorate.** Starting from an average solvency margin ratio of 736 percent before stress, the SMR drops to 624 percent in the moderate severe scenario and 479 percent in the severe adverse scenario. None of the six non-life insurers in the sample drops below the hurdle rate of 200 percent in either of the scenarios.

**Figure 25. Japan: Insurance Solvency Stress Test—Bottom-Up Results**

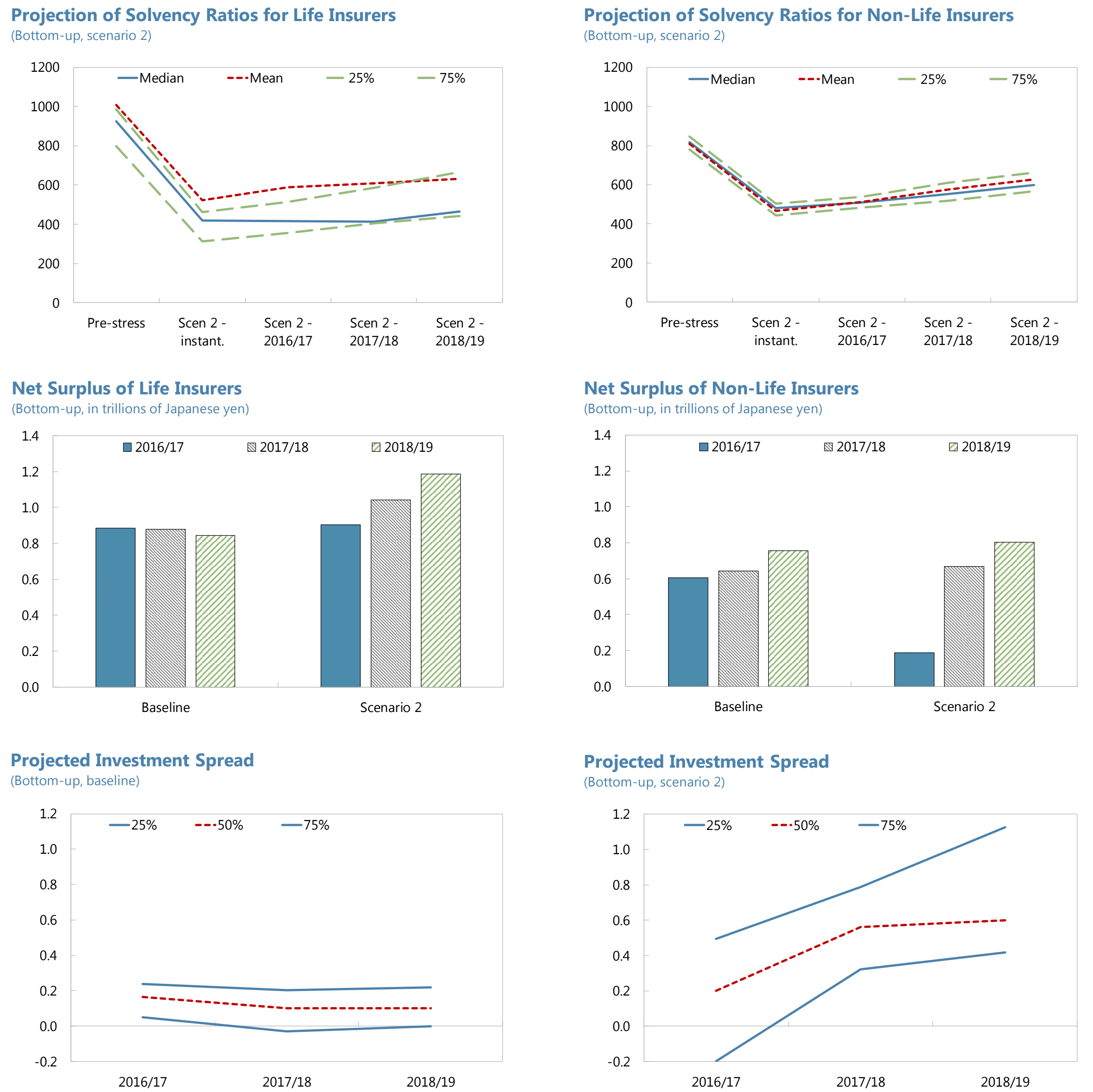



Source: IMF staff calculations based on company submissions.

**77. Insurance companies are able to recover from the severe adverse scenario mainly due to higher expected investment returns after the interest rate hike (Figure 26).** Solvency ratios recover after the materialization of the scenario as insurers would retain earnings, but the recovery is quicker and more uniformly in the non-life than in the life sector. Net surplus projections of life companies are rather flat and even slightly declining in the baseline scenario, and these projections are gradually improving in the severe adverse scenario. The spread between investment returns and guaranteed interest rates widens substantially in this scenario, contributing to higher profits for the life companies. Some non-life firms see an immediate impact of the stress scenario on their profits in the first year of the projection horizon, but also for them, the subsequent years turn out to be slightly more profitable than in the baseline. This first-year profit decline among non-life firms is mainly due to less reversal of price fluctuation reserves among non-life firms than life firms.

**78. Adjusting to a new steady state after the materialization of the severe adverse scenario is expected to result in changes in the asset allocation of insurers.** Life insurers indicated that they would invest in newly issued JGBs which pay higher coupons, however it is difficult to quantify this effect or provide estimates for the exact timing of such investments. While some companies are expected to implement such a strategy gradually by directing regular premium income into JGB investments, a few companies would also consider divestments, mainly of non-investment grade corporate bonds and equity. Life companies have further indicated that in a higher-yield scenario they would also consider reducing their duration gap by increasing their asset duration.

**Figure 26. Japan: Insurance Solvency Stress Test—Recovery of Solvency and Profitability**




Source: IMF staff calculations based on company submissions.

## G. Results of the Sensitivity Analysis

**79. Additional single-factor shocks complemented the macrofinancial stress test scenarios.** The results of these sensitivity analyses are not added to the results of the macrofinancial scenario. Such single-factor shocks cover biometric risks as well as catastrophic events. Only the direct impact from claims was reported.

**80. The sensitivity to biometric shocks like longevity and a pandemic event were calculated for the life business of ST participants.** The longevity shock was modeled as a permanent 20 percent decline in mortality rates. The pandemic event assumed temporarily higher disability and morbidity rates, i.e., a temporary 35 percent increase over one year, as well as temporarily higher mortality rates, i.e., a temporary 10 percent increase over one year.

**81. With natural disasters being a very relevant risk factor for Japanese insurers, a further sensitivity analysis for the non-life business included three historic catastrophe scenarios.** Such scenarios were assumed to occur again, based on the current exposures of insurance undertakings. Japanese exposures are covered with the modeling of the Great Kantō earthquake (1923) and Typhoon Mireille (1991). Non-Japanese exposures to catastrophe risks were assessed by calculating the effect of Hurricane Andrew (U.S., 1992). In addition, for each of the three catastrophic events, insurance undertakings provided the reinsurance recoveries from their five largest reinsurers (on a group basis).

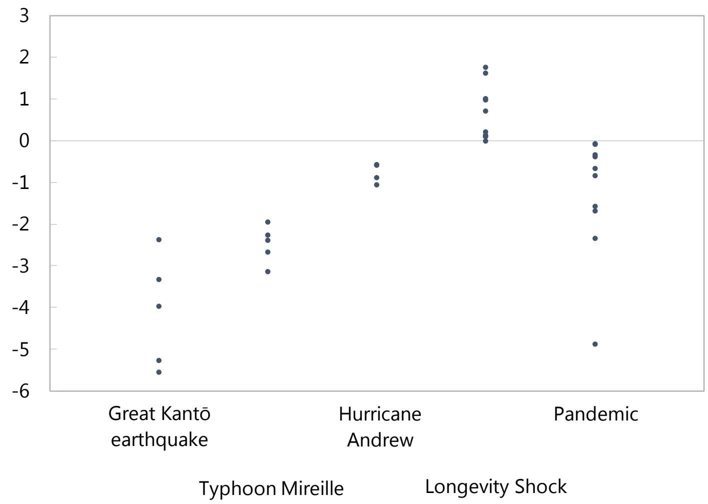
**82. While natural disasters within Japan have an impact on the available capital of non-life companies, none of the tested events in isolation would cause concerns about the solvency position.** Among the disaster events tested, an earthquake in the Tokyo metropolitan area similar to the Great Kantō Earthquake would cause the largest reduction in available capital of between 2 and 6 percent. A repetition of Typhoon Mireille would have a smaller impact of between 2 and 3 percent (Figure 27). For non-life insurers, it is nevertheless essential to model not only the direct impact of catastrophic events, but also any subsequent reactions in financial markets. Experience has shown that although financial markets are very sensitive to large catastrophes, recovery of asset prices can set in very quickly as seen after the Great East Japan Earthquake in March 2011 (see Box 2).

**83. The exposure towards catastrophic risks outside Japan is very limited.** A repetition of an event like Hurricane Andrew which was, at that time, the costliest insured event on records would cause only marginal losses of around 1 percent of the available capital of Japanese non-life insurers exposed to that region. However, the sensitivity to catastrophic risks outside Japan is likely to grow if the overseas expansion of the Japanese non-life insurance companies continues, but at this stage companies still see the overseas expansion as a means to diversify their underwriting risks.

**84. Typical life insurance products in Japan bear rather limited longevity risks for the insurer, but pandemics would hit both life and non-life insurers.** A permanent decrease of mortality rates, i.e., assuming that policyholders live longer, would have a slightly positive effect on the available capital of up to 2 percent for most life insurers. Given some heterogeneity in medical insurance products which are offered by both life and non-life insurers, a pandemic would affect companies very differently with reductions in available capital ranging between zero and five percent. As some life companies are venturing more into medical insurance, their vulnerability might increase further in the years to come.

## Figure 27. Japan: Insurance Solvency Stress Test—Sensitivity Analysis: Changes in Available Capital

(In percent)




Source: IMF staff calculations based on company submissions.
Note: The graph excludes the impact of the Great Kantō earthquake on Japan Earthquake Reinsurance.

## Box 2. Natural Disaster Risks in Japan

**Japan is vulnerable to natural disasters, in particular earthquakes and typhoons.** By far, the largest catastrophic event in recent decades has been the Great East Japan Earthquake with the subsequent tsunami which hit on March 11, 2011 and resulted in insured losses of around US$40 billion (in 2011 prices).

Large Natural Disasters (1990–2016)

| | Region | Date | Insured Losses (In billions of U.S. dollars) /1 /2 | Economic Losses (In billions of U.S. dollars) /1 /2 | Fatalities /2 |
|---|---|---|---|---|---|
| Earthquake, tsunami | Japan (Tohoku) | Mar-11 | 40 | 210 | 15,880 |
| Earthquake | Japan (Kumamoto) | Apr-16 | 6 | 31 | 69 |
| Typhoon Mireille | Japan (Hanshin) | Sep-91 | 6 | 10 | 62 |
| Typhoon Songda | Japan, South Korea | Sep-04 | 4.7 | 9.3 | 41 |
| Typhoon Bart | Japan, South Korea | Sep-99 | 3.5 | 5 | 29 |
| Earthquake | Japan (Kobe) | Jan-95 | 4 | 100 | 6,430 |

Sources: Munich Re; and NatCatSERVICE.
/1 Original values.
/2 In- and outside Japan.

**Temporarily, after the Great East Japan Earthquake in 2011, the non-life sector faced substantially higher loss rates, resulting** in a combined ratio of nearly 117 percent. The return on equity turned negative to -6.3 percent and the SMR dropped from 629 to 477 percent. However, the sector recovered quickly and was profitable again in 2012 and the years thereafter. Also, financial markets had recovered soon—the Nikkei 225 dropped by nearly 21 percent from its highest quote on March 11 to its lowest quote on March 15, but recouped more than half of its losses within two weeks after the event.

**The Japan Earthquake Reinsurance System contributes significantly to the resilience of the Japanese non-life sector.** The system centers around the Japan Earthquake Reinsurance Ltd. (JER) which was set up in 1966 and is owned by Japanese non-life companies. Insurable are losses to residential property due to earthquakes (including subsequent tsunamis) and volcanic activity. Losses are shared, in different layers, by the JER, (primary) non-life insurance companies and the government. As of April 1, 2017, beyond a loss amount of around ¥224 billion per event, the government pays 99.8 percent of any losses up to a threshold of ¥11.3 trillion. The pricing of the coverage is risk-based and incorporates the location as well as the earthquake resistance of a building. After the Great East Japan Earthquake in 2011, nearly ¥1.3 trillion were paid out, of which around three quarters within 75 days.

**Modeling catastrophe risks and especially typhoons are becoming more challenging due to the climate change.** Generally, non-life companies in Japan rely on third-party vendor models when assessing their exposure towards catastrophic risks. Earthquake models are seen as sub-optimal by some companies as they likely underestimate the impact of a tsunami which can be triggered by a seismic event. When modeling typhoon risks, the frequency and severity of such events are impacted by the climate change which poses a structural risk of mispricing and under-reserving.

# CONNECTEDNESS AND CONTAGION ANALYSIS

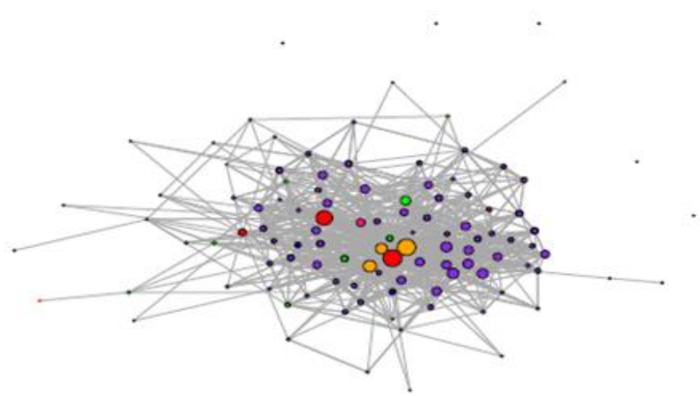
**85. Measuring financial interconnectedness sheds light on the transmission of financial stress across financial institutions.** This section analyzes financial interconnectedness using both market data and confidential balance sheet exposures. First, it analyzes the transmission of shocks to equity returns at the firm level using the method proposed in Diebold and Yilmaz (2014). It then simulates the transmission of credit and funding shocks by applying Espinosa-Vega and Solé's (2011) network approach to confidential bilateral claims data for Japanese bank and nonbank financial institutions.

**86. Spillovers between financial institutions can arise because of direct funding or counterparty risk linkages.** In Japan, banks drawing on their large deposit base provide funding to the rest of the financial system through equity investment or lending. Therefore, large banks have the potential to propagate liquidity shocks to other financial institutions such as securities firms through the withdrawal of funding. In addition, as many Japanese financial institutions—including regional banks—expand their investments overseas, access to foreign currency markets has added a new channel for the propagation of funding shocks.

**87. Cross-ownership—a common feature of Japanese financial institutions—is another possible source of interconnections.** The FGs of the three mega banks (Mitsubishi UFJ, Mizuho, and Sumitomo Mitsui), Nomura Holdings, and several major insurance companies have significant strategic equity claims in many Japanese financial institutions (Figure 28). On average, this cross-ownership accounts for 18 percent of the institutions equity capital.

**Figure 28. Japan: Cross-Ownership Among Japanese Financial Institutions**

*Large city banks and several major insurance companies have equity claims in many Japanese financial institutions but there is also a dense network of cross-ownership among regional banks.*



Sources: FactSet; and IMF staff.

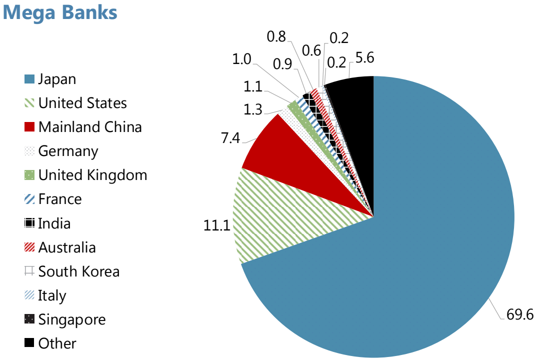
Note: The chart shows the network of shareholdings among Japanese financial institutions based on publicly reported data. The size of the nodes reflects the number of stakes held directly or indirectly in other institutions (out-degree centrality). Only insider or stakeholder ownership is considered. City banks = red, Regional banks = purple, Life insurance = blue, Nonlife insurance = orange, Securities firms = green, Finance companies = pink, Asset managers = gold.

**88. Financial interconnections can also reflect the exposure to common shocks, such as those arising from the dependence on foreign sources of revenue.** However, only mega banks and insurance companies have significant foreign exposures while regional banks for the most part rely only on domestic customers (Figure 29). This suggests that interlinkages through the foreign-exposures channel should be relevant to explain the link between city banks and insurance companies. In addition, common exposures to domestic clients could also be relevant. The significant level of cross-shareholdings also poses risks of domestic common exposure to Japanese firms and financial institutions.

**Figure 29. Japan: Business Income by Geographic Origin**

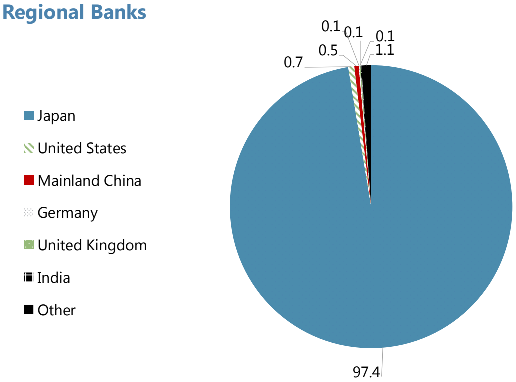
*Mega banks, on average, source almost one third of their income from abroad.*

**Mega Banks**



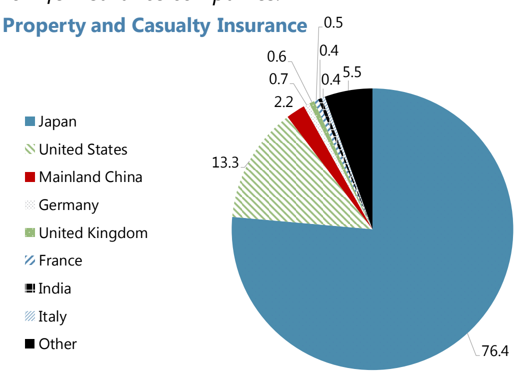

*Regional banks have almost no exposure to foreign markets.*

**Regional Banks**



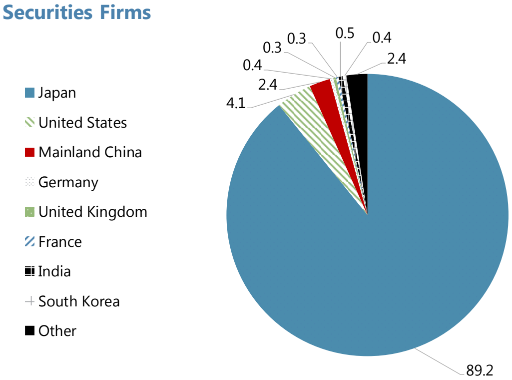

*The U.S. is the main source of foreign income for Japanese nonlife insurance companies.*

**Property and Casualty Insurance**




*Securities firms source almost 90 percent of their income from domestic clients.*

**Securities Firms**

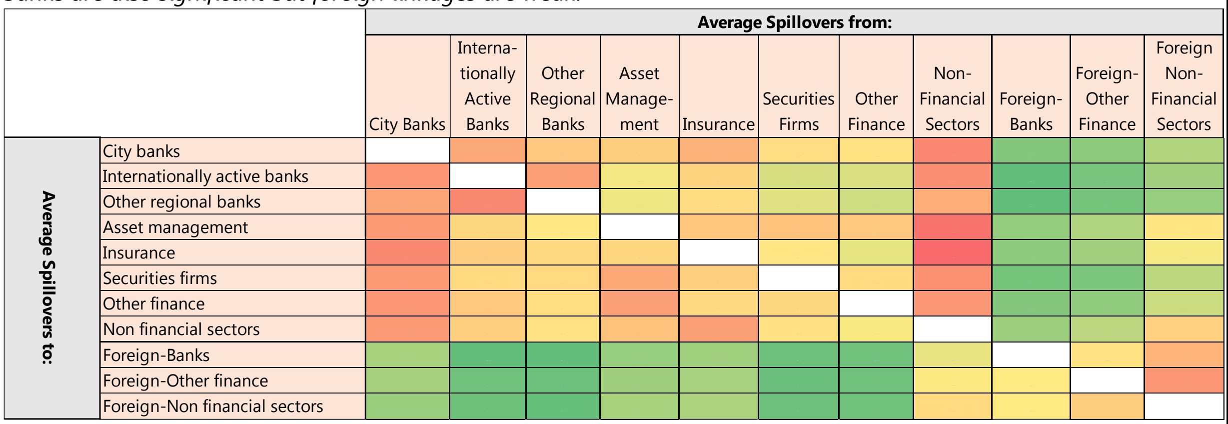



Source: FactSet.

**89. Japan's nonfinancial firms and city banks are the main source of financial spillovers measured with equity returns data.** A network analysis based on market data suggests that shocks to Japan's largest banks and largest nonfinancial firms propagate strongly to other sectors, especially to insurance companies. Links among internationally exposed and domestically-oriented regional banks are also strong. The only significant spillovers from abroad emanate from foreign nonfinancial firms. An analysis of the geographic origin of firms' revenues confirms that, except for the three largest city banks and nonlife insurance companies, foreign income accounts for a small fraction of total operating income (Figure 30).

**Figure 30. Japan: Financial Spillovers 2010–16**

*Japanese nonfinancial firms and City banks are the strongest source of financial spillovers. Spillovers among regional banks are also significant but foreign linkages are weak.*




Sources: Bloomberg LP; Thomson-Reuters Datastream; and IMF staff estimates.
Note: The heat map above shows the strength of the (unweighted) average spillover from one group of institutions (column) to another (row). Spillovers range from strong (bright red) to weak (dark green). Spillovers are calculated using firm-level weekly equity returns data (except for domestic and foreign nonfinancial firms for which the Nikkei 225 Nonfinancials and S&P 500 Nonfinancials indices are used, respectively) and Diebold and Yilmaz's (2014) generalized forecast-error variance decomposition approach. The sample starts in January 2010 and ends in December 2016.

**90. Financial firms with healthier balance sheets are less sensitive to financial shocks.** An empirical analysis of the determinants of financial spillovers among Japanese and foreign financial firms shows that firms with stronger financial statements (higher z-Scores and higher returns on assets) are less sensitive to shocks to the equity returns of other firms (Table 5). In addition, larger firms are a more important source of financial spillovers. Among Japanese banks, institutions that rely less heavily on wholesale funding or for whom credit accounts for a larger fraction of their assets (that is, those with loans-driven business models) are less sensitive to shocks from other banks. Finally, financial firms with higher shares of institutional ownership—a proxy for better corporate governance—are also less sensitive to financial spillovers.

**91. The network of overlapping equity and credit claims exposures of Japanese financial institutions provides further insight into the channels of interconnected and propagation of credit and funding shocks.** Although the spillovers analysis based on market data allows the uncovering of important connections, it has a limited ability to identify the underlying mechanisms generating the observed comovement in asset returns. For this reason, the previous analysis is complemented with an in-depth analysis of bilateral claims exposures of an important set of Japanese financial institutions organized in six sectors: large city banks, other city banks, regional banks, life insurance companies, nonlife insurance companies, and securities firms.[37]

[37] The network of claims and the simulation of shocks follows Espinosa-Vega and Solé's (2011) approach. The connections do not include exposures through derivatives. See Appendix VII.

**Table 4. Japan: Determinants of Financial Spillovers**

| Variable | All: Sign | All: SS | Japanese Banks: Sign | Japanese Banks: SS | Interpretation |
|---|---|---|---|---|---|
| Size | (-) | *** | (-) | *** | Spillovers from j to i are larger when j's size is larger than i's. |
| Revenue growth | (+) | *** | (+) | *** | Spillovers from j to i are larger when j's revenue growth is smaller than i's. |
| ROA | (-) | *** | (-) | *** | Spillovers from j to i are smaller when i's ROA is larger than j's. |
| z-Score | (-) | *** | (-) | *** | Spillovers from j to i are smaller when i's z-Score is larger than j's. |
| Credit claims | (+) | *** | (-) | *** | In the entire sample, spillovers from j to i are larger when i is more reliant on lending than j. Among Japanese banks only, banks that are more reliant on credit are less sensitive to spillovers from other banks. |
| Institutional ownership | (-) | *** | (-) | *** | Spillovers from j to i are larger when j's institutional ownership is larger than i's. |
| Wholesale funding | (-) | | (+) | *** | In the entire sample, there wholesale funding does not influence size of spillovers. Among Japanese banks, spillovers from j to i are larger when i's wholesale funding is larger than j's. |
| Distance | (-) | *** | (-) | *** | Spillovers from j to i are larger when j and i are geographically close to each other. |

Sources: Bloomberg LP; FactSet; Geospatial Information Authority of Japan (GSI); SNL; Thomson-Reuters Datastream; and IMF staff estimates.

Note: The table summarizes results of an econometric analysis of the determinants of spillovers between financial institutions. The spillover between firm *i* and firm *j* is estimated using Diebold and Yilmaz's (2014) approach and is based on equity returns data. The estimation of the determinants of these spillovers uses a gravity-model approach and is implemented with Santos-Silva and Tenreyro (2006)'s PPML method. Size is measured by total assets. The z-score—which captures the distance to default—is the sum of ratio of capital to assets and of return on assets scaled by the standard deviation of the return on assets. A higher Z-score implies lower chance of insolvency. Credit claims is the share of loans as a percentage of assets. Institutional ownership is the percentage of capital held by institutional investors. Wholesale funding is the share of funding that is not deposits or policyholders' premiums. Distance is the distance between the cities where the firms are headquartered. *** = Statistical significance at the 1 percent level. See Appendix VI for details.

**92. The central role of city banks in Japan's financial system is confirmed by firm-level bilateral exposures based on confidential balance sheet data.** A network analysis of bilateral asset exposures among Japan's financial firms shows that the largest city banks have the highest levels of connectivity, while insurance companies for the most part show the lowest levels of centrality (Table 6).[38] In particular, the largest city banks are by far the most connected providers of funding to the system (funding centrality) and have the potential to create liquidity shocks to other financial institutions through the withdrawal of funding.[39] The other city banks shows a larger relevance as providers of funding than as borrowers.

**93. The balance sheet network analysis measures interconnectedness risk arising from direct counterparty exposures across financial firms.** Counterparty exposures make firms vulnerable to the failure of other firms or to the withdrawal of funding. Following a credit or funding shock, firms experience credit losses if they are creditors, and funding shortages if they are

[38] An institution is said to be central in a network (or to have high centrality) if they have a large number of connections with the rest of the institutions in the network. Table 6 shows several measures of centrality.

[39] Funding centrality summarizes the importance of a financial institutions as a lender to other institutions in the network. In contrast, borrowing centrality summarizes its importance as borrowers and potential source of credit shocks. In network parlance, funding centrality refers to left-eigenvector centrality and borrowing centrality to right-eigenvector centrality (Glasserman and Young 2016).

borrowers. In this case, firms may have to liquidate assets at fire-sale prices. Spillovers are triggered when the capital of an institution falls below a certain level of capital. The ensuing losses could trigger a cascade of failures.

**Table 5. Japan: Connectivity in the Japanese Financial System**

| | Betweenness | | Closeness | | Borrowing Centrality | | Funding Centrality | |
|---|---|---|---|---|---|---|---|---|
| | Average | Max | Average | Max | Average | Max | Average | Max |
| Mega Banks | 45.80 | 64.30 | 0.97 | 1.00 | 0.77 | 0.89 | 0.99 | 1.00 |
| City Banks | 18.60 | 68.30 | 0.82 | 0.95 | 0.56 | 0.84 | 0.73 | 0.94 |
| Regional Banks | 12.20 | 31.60 | 0.79 | 0.84 | 0.69 | 0.89 | 0.69 | 0.86 |
| Nonlife Insurance | 20.60 | 66.00 | 0.74 | 0.93 | 0.56 | 0.82 | 0.46 | 0.90 |
| Life Insurance | 6.40 | 18.20 | 0.71 | 0.84 | 0.60 | 0.93 | 0.38 | 0.78 |
| Securities Firms | 20.60 | 34.10 | 0.84 | 0.95 | 0.76 | 1.00 | 0.67 | 0.90 |

Source: IMF staff.

Note: *Betweenness* measures how important a financial institution is for the flow of funding in the network by counting of financial institutions which are only indirectly connected to others through this institution. *Closeness* measures how far from the center of the network a node is. *Borrowing centrality* is the right-eigenvector centrality and states that a financial institution is central if it borrows (or raises equity) from other institutions that also borrow from other important institutions. *Funding centrality* is the left-eigenvector centrality and states that a financial institution is central if it lends or holds equity from other institutions that also fund other important institutions.

**94. The balance-sheet model does not take into account exposures to common clients and shareholders or the effect of financial shocks on market sentiment.** The model also assumes that bank subsidiaries are ring fenced, without considering different capitalization strategies that may take place within conglomerates. Moreover, stress events can affect financial institutions through other channels, such as changes in market sentiment or deteriorating macroeconomic conditions that adversely affect the bottom-line of nonfinancial firms and households. Still, the model can to some extent accommodate for changes in market sentiment or to macroeconomic environment shocks by appropriately calibrating key parameters such as the fire sale price discount or losses-given-default.

**95. The analysis of exposures includes three different scenarios: a funding shock, a credit shock, and a credit shock supplemented with a funding shock.** In each of the scenarios, the LGDs, withdrawal of funding, and asset fire-sale losses are calibrated at the firm-level. For every institution and under each scenario, the propensity to propagate a credit and/or funding shock is summarized by the capital buffer losses induced in all other financial institutions (as a percentage of the system's total buffer capital in the simulation.[40] Conversely, the vulnerability of each institution to shocks is summarized by the total capital buffer lost in case the other institutions fail or withdraw funding. In each scenario, it is assumed that the financial institutions cannot raise additional capital and that all losses are absorbed by capital. The shocks are modeled as follows (see Appendix VII for a more detailed explanation).

[40] An institution is assumed to be under stress if it loses its capital buffer which is assumed to be the capital amount higher than 2 percent of its asset. Total capital buffer here refers to the sum of each institution's capital after subtracting 2 percent of its asset.

- **Funding shock.** The funding shock scenario assumes financial institutions cannot rollover a given percentage of their funding. This percentage is calibrated based on the share of short-term liabilities in total liabilities vis-à-vis the firms in the network. To make up for the funding shortfall, institutions must sell assets at either the full price (liquid assets) or fire-sale prices (illiquid assets). Thus, the asset price loss is calibrated using the share of illiquid investment assets in total investment assets.

- **Credit shock.** The credit shock scenario assumes each financial institution fails on their liabilities vis-à-vis the other institutions and causes a credit loss. Since the exposures are already net of collateral and other risk mitigation measures, the LGD is assumed to be 100 percent.

- **Credit and funding shock.** The combination of the funding and credit shocks.

**96. The withdrawal of funding by large city banks would have a small effect in terms of capital losses throughout the financial system, with securities firms being the most vulnerable.** Withdrawals of funding by large city banks would cost slightly more than 2 percent of the financial system's total capital (Figure 5).[41] Securities firms are the most vulnerable to funding shocks (regardless of origin) with average capital losses equivalent to 2 percent of the total capital in the simulation.

**97. In the case of a default by a large city bank, average capital losses would be six times larger than under a funding shock and life insurers would suffer most (Figure 31).** In the event of a credit default by a large city bank, the resulting losses would absorb 12 percent of the financial system's total capital. The simulated losses in case of a default by either a smaller city bank or a securities firms would also be larger than in the scenario of a funding shock by one or two orders of magnitude and be around 7 and 5 percent of the financial system's total capital, respectively. Unlike the previous scenario, under the credit shock scenario, life insurance companies would be the most affected group because of their deposits, credit, and equity exposures. The combination of credit and funding shocks has somewhat higher effects but of similar nature. The high levels of capital held by many financial institutions in Japan help contain credit and funding contagion throughout the financial system.

**98. Focusing only on the observed direct balance-sheet exposures, scenarios of sector-specific failures would have, for the most part, mild implications for the health of the financial institutions in other sectors.** In the event of a simultaneous default all the institutions in a given sector, the approach followed in this sector simulates the capital losses incurred by all other institutions.[42] The simulation assumes an institution becomes stressed (and therefore defaults on its obligations) when its equity (or net assets) falls below 2 percent of total assets. The results of the

[41] Capital is measured as the book value of shareholders' equity for incorporated firms or the book value of net assets for mutual companies.

[42] These losses include both direct credit losses and capital losses because of fire sales induced by the withdrawal of funding. However, it does not include any possible losses caused by generalized market losses triggered by the loss of confidence that would likely come along with a hypothetical wave of important failures.

simulation show that failures by city banks cause a fair number of insurance and securities companies to become stressed (Figure 31, panel 4). Under all other scenarios, the resulting number of stressed institutions is small. However, the measured effects should be considered a lower bound and do not fully capture the cascading effects caused by changes in market sentiment and exposures to the nonfinancial sector.

**Figure 31. Japan: Capital Losses in Contagion Scenarios**


Sources: Japan Financial Services Authority; and IMF staff.
Note: CBB = Large city banks; CBS = Small city banks; RB – Regional banks; INN = Nonlife insurance companies; INL = Life insurance companies; SC = Securities firms. In panels 1 through 3, *Contagion* shows the average percent of the system's capital lost because of the failure or withdrawal of credit from any given firm in each category. In the same panels, Vulnerability shows the average percent of the system's capital lost in each category because of the failure or withdrawal of credit from any given firm. In panel 4, the instensity of stress ranges from inexistent (blue) to high (red) and reflects the number of firms under stress in the simulation.

99. **The analysis of spillovers based on market and balance sheet data suggest that the propagation of financial shocks occurs primarily through the client and investor bases.** Direct exposures seem to play only a modest role in the transmission of funding shocks, while strong links between financial and nonfinancial firms underpin the market-based spillovers. It is possible that changes in market sentiment associated with credit and/or funding shocks may magnify the transmission of these shocks. However, market participants believe the strong overall health of the Japanese financial system makes swift changes in market sentiment unlikely. In fact, the safe-haven status of the Japanese economy and financial system means that net inflows from abroad should

increase during stress period. The ensuing currency appreciation or other changes in asset prices could, over the medium term, decrease the profitability of nonfinancial firms and weaken the balance sheets of financial intermediaries.

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# Appendix I. Japan: Risk Assessment Matrix[1]

| Source of Risks | Likelihood (Over next 1–5 years) | Impact |
|---|---|---|
| ➢ **Retreat from cross-border integration** | **High**<br>A fraying consensus about the benefits of globalization could lead to protectionism and economic isolationism, leading to reduced global and regional policy collaboration with negative consequences for trade, capital and labor flows, sentiment, and growth. | **Medium/High.**<br>A backslash against global trade will have a significant growth impact and will increase market volatility. Growth potential could be adversely affected and trade growth could slow down further complicating efforts to restore public debt sustainability. The yen would appreciate due to safe-haven effects as global risk aversion rises, dragging down equity prices and further reducing exports. Japanese banks are also impacted via increase in credit losses on their overseas investments. Fall in export increases credit risk of domestic companies. The risks will be assessed via solvency analysis. |
| ➢ **Sharp growth slowdown and financial risks in China and other emerging market economies over the medium term** | **Medium**<br>Insufficient progress with reforms could lead to a continued buildup of vulnerabilities, resulting in a significant slowdown in growth over the medium term. | **High**.<br>The recovery of exports would stall not only due to close trade links with China and other emerging market economies but also because of safe-haven appreciation causing corrections in the stock market and sentiment. The fall in export revenue will hit companies and subsequently increase banks' credit losses. The risks will be assessed via solvency analysis. |
| ➢ **Abrupt normalization of U.S. monetary policy** | **Medium/High**<br>Higher than expected inflation as well as tightening labor market conditions in US prompt for higher Fed policy rates. Sharp asset price adjustment and decompression of credit spreads as investors reassess underlying risk and respond to unanticipated changes in growth prospects, Fed policy rate path, and increases in U.S. term premia, with poor market liquidity amplifying the effect on volatility. | **High**<br>Low interest rate environment and higher interest rate differentials encourage banks to invest abroad and would make their funding in U.S. dollars and other key foreign currencies more expensive. Increases in risk premia lead to declines in equity prices and depreciation in the yen.<br>Renewed stress in global wholesale funding markets would lead to FX liquidity strains and a sharp increase in funding costs for Japanese banks that rely on market funding from FX and cross-currency swaps for overseas expansion. The risks will be assessed via liquidity, funding, interconnectedness, market risk, derivatives as well as solvency analysis. |
| ➢ **Bond market stress from a reassessment of sovereign risk in Japan** | **Medium**<br>Abenomics falters, resulting in an eventual return of depressed domestic demand and deflation and leading to bond market stress. The sharp increase in long-term JGB yield leads to a further significant tightening in domestic financial conditions. | **High**.<br>A sharp increase in the domestic sovereign risk premium would worsen public debt dynamics gradually as the average maturity is about 7.7 years. But such a shock could cause distress in the financial sector with possible knock-on effects on debt. The risk will be assessed via solvency (in particular market risk) analysis. |
| ➢ **Tightening in domestic financial conditions** | **Medium**<br>Negative spillovers from global trade disruptions to Japan's export and output growth, or capital outflows from higher U.S. interest rates, lead to a rise in domestic risk premia. | **High**<br>Higher domestic risk premia lead to higher money market interest rate, lower equity prices, and a depreciation in yen. House prices could also decline as a result of the demand contraction. The risks will be assessed via solvency analysis. |

[1] The RAM shows events that could materially alter the baseline path (the scenario most likely to materialize in the view of IMF staff). The relative likelihood of risks listed is the staff's subjective assessment of the risks surrounding the baseline ("low" is meant to indicate a probability below 10 percent, "medium" a probability between 10 and 30 percent, and "high" a probability of 30 percent or more). The RAM reflects staff views on the source of risks and overall level of concern as of the time of discussions with the authorities. Non-mutually exclusive risks may interact and materialize jointly. The two adverse scenarios also include an extra domestic risk factor of housing market corrections which is not included in the RAM.

# Appendix II. Japan: IMF Credit Risk Model

**Appendix Table 1. Japan: Summary of Modeling Approaches in Different Scenarios**

| | Baseline | Moderate Adverse | Severe Adverse |
|---|---|---|---|
| **PDs** | Satellite models | Satellite models | Satellite models |
| **LGDs** | No changes | Satellite models for corporate and residential loans exposure classes | Satellite models for corporate and residential loans exposure classes |
| **Growth rates of interest bearing assets (credit growth), non-interest rate bearing assets, open positions** | In line macro forecasts (see scenario section for details) | In line macro forecasts (see scenario section for details) | In line macro forecasts (see scenario section for details) |
| **AFS/HFT own sovereign spread** | No changes | No changes | One year default probability for Japan (sovereign defaults) based on Japan CDS spread data and 40 percent recovery rate. Used for provisioning only, i.e., no application to RWAs. |
| **AFS/HFT foreign sovereign spread** | PDs/LGDs approach | PDs/LGDs approach | PDs/LGDs approach |
| **Funding risk shock** | Projected separately for JPY and USD liabilities; Regime switching and panel GMM models. | Projected separately for JPY and USD liabilities; Regime switching and panel GMM models. | Projected separately for JPY and USD liabilities; Regime switching and panel GMM models. |
| **Interest income growth** | Repricing gap model for shock to risk free interest rates; effective interest rate model for loans and other interest earning assets; shock to Euribor minus shock to risk free interest rate on loans. | Repricing gap model for shock to risk free interest rates; effective interest rate model for loans and other interest earning assets; shock to Euribor minus shock to risk free interest rate on loans | Repricing gap model for shock to risk free interest rates; effective interest rate model for loans and other interest earning assets; shock to Euribor minus shock to risk free interest rate on loans; |
| **Net fee and commission income growth** | Satellite model with fees and commissions income as a share of assets and key explanatory variables: one period lagged dependent variable, real GDP growth rate. | Satellite model with fees and commissions income as a share of assets and key explanatory variables: one period lagged dependent variable, real GDP growth rate. | Satellite model with fees and commissions income as a share of assets and key explanatory variables: one period lagged dependent variable, real GDP growth rate. |

**Appendix Table 1. Japan: Summary of Modeling Approaches in Different Scenarios (concluded)**

| | | | |
|---|---|---|---|
| | Behavioral caps: growth should not decline more than 10 percent (y-o-y) in any scenario (assuming that bank would increase fees in response to decline in interest income). | (assuming that bank would increase fees in response to decline in interest income). Behavioral caps: growth should not decline more than 10 percent (y-o-y) in any scenario (assuming that bank would increase fees in response to decline in interest income). | (assuming that bank would increase fees in response to decline in interest income). Behavioral caps: growth should not decline more than 10 percent(y-o-y) in any scenario (assuming that bank would increase fees in response to decline in interest income). |
| **Trading income** | Satellite model. Trading income ratio to total assets as a dependent variable and equity indices (Topix), exchange rate, lagged GDP, lagged dependent variable as explanatory variables. Obtained results were compared with valuation changes of HFT assets to avoid double counting. | Satellite model. Trading income ratio to total assets as a dependent variable and equity indices (Topix), exchange rate, lagged GDP, lagged dependent variable as explanatory variables. Obtained results were compared with valuation changes of HFT assets to avoid double counting. | Satellite model. Trading income ratio to total assets as a dependent variable and equity indices (Topix), exchange rate, lagged GDP, lagged dependent variable as explanatory variables. Obtained results were compared with valuation changes of HFT assets to avoid double counting. |
| **Other non-interest income growth** | Assumed as 0 growth | Assumed as 0 growth | Assumed as 0 growth |
| **Non-interest expenses growth** | Operational expenses (OPEX) were modeled using satellite model with OPEX ratio to total assets as dependent variable and lagged loan portfolio growth as explanatory. | Operational expenses (OPEX) were modeled using satellite model with OPEX ratio to total assets as dependent variable and lagged loan portfolio growth as explanatory. | Operational expenses (OPEX) were modeled using satellite model with OPEX ratio to total assets as dependent variable and lagged loan portfolio growth as explanatory. |
| **Tax rate** | Actual statutory tax rate (30 percent) | Actual statutory tax rate (30 percent) | Actual statutory tax rate (30 percent) |

***PD and LGD Models***

**1. Probabilities of Default (PDs) for credit risk estimation were projected for each individual bank using TTC PDs. The satellite models for PDs as a dependent variable were constructed as follows:**

(i) To ensure that the models only produce PD predictions between 0 and 1 (or, equivalently, between 0 and 100 percent) and to capture nonlinearities in the relationship between the dependent and explanatory variables, the following logit transformation was applied to the original PD:

$$Y = \ln\left(\frac{PD_{it}}{1-PD_{it}}\right) \tag{1}$$

(ii) To estimate impact of shocks of macrofinancial variables on PDs, the logit-transformed PDs were modeled as a linear function of different exogenous macroeconomic and financial factors (regressors).[1] Therefore, the estimated model for the PDs can be expressed as:

$$Y_{i,t} = \delta Y_{i,t-1} + \alpha + \beta X_{t-s} + \varepsilon_{i,t} \qquad \text{for } t = 1,\cdots,T \quad \text{and} \quad i = 1,\cdots,N \tag{2}$$

where $Y_{i,t}$ is the logit transform of the PD for asset class $i$ at time $t$, $X_t$ is a vector of macroeconomic and financial variables; $Y_{i,t-1}$ is the lagged dependent variable; $\varepsilon_{i,t}$ is an independent and identically distributed error-term, and $\alpha$, and vector $\beta$, $\delta$ are parameters to be estimated;

(iii) Bayesian model averaging (BMA) for panel regressions was used to test for significant explanatory variables and their lags. BMA was used for several purposes, first it helps to simulate multiple combinations of various regressors and their lags, which would be difficult to do under typical econometric procedures, as many similar variables (real, nominal GDP, various interest rates etc.) might be statistically significant and yield to some very similar equations. At the same time, stressed PDs from each equation might differ. Since TTC PDs do not vary much, impact of such a difference on a final result in terms of ELs and RWAs could be substantial. Secondly, BMA could help in choosing lags of regressors in evaluating impact of changes in

[1] In general, obtaining a robust estimate for PDs would require much longer historical time series and more observations. Thus, results of the satellite models shall be interpreted with appropriate care.

signs (for example, housing prices in short term might have negative effect on mortgage PDs and positive impact in the longer term, after housing market boom collapses. For our purposes, BMA helped to obtain several specifications of "weighted" equations and verify initial significance of regressors. Using initial results from BMA most significant regressors were included in equation specifications and run OLS, GMM, Robust Least squares based estimations.

(iv) While in multiple cases, several statistically and economically significant alternative specifications for the same assets class were obtained, the final selection of equations followed several principles. Namely, i) the specification with the lower number of lags for the macrofinancial explanatory variables was selected (with the aim of allowing the realization of shock within a relatively short three-year stress test time horizon); ii) inclusion of unemployment shock in the equation for mortgage portfolios; iii) specification with lower weight (elasticity) of lagged dependent variable to avoid long "memory" effects and PDs inertia;

(v) Finally, the PDs under stress for each type of borrowers in percent were computed according to the following formula which corresponds to the inverse of the logit function:

$$PD_{type,t}^{stress} = \frac{1}{1+\exp\{-(\alpha+\beta X_{t-s})\}} * 100 \qquad (4)$$

(vi) The same procedures were repeated for multiple alternative equations to minimize "handpicked" selection bias.

(vii) Averages for PDs multipliers for the same exposure class were obtained Median PDs from banks in the sample was used as benchmark to calculate PDs multiplier:

$$PD_{Multiplier,\,t}^{stress} = \frac{PD_{stress,\,t}}{PD_{t,0}} \qquad (5)$$

(vii) LGD models for corporate and mortgage exposure classes were obtained using similar methodology with the difference that LGDs were not converted into logit form.

**2. Specifications of selected equations are provided in Tables 2 and 3 below.**

3. **Estimation results reveal, that corporate PDs are mostly sensitive to lagged real GDP growth rate, equity indices and interest rates.** Mortgage loans are sensitive to GDP, unemployment and interest rates. Respective elasticities are small, and this is reflected in relatively small multipliers. PDs for equity exposures do depend on equity prices, interest and exchange rates. Other retail loans depend on interest rates, GDP and unemployment.

## Appendix Table 2. Japan: Examples of Equations Obtained Using OLS, GMM, and SUR Estimations

(Significance of Macro Verified Using BMA Methodology)

### Regressions for Corporate Loans

| | Corporate Loans | | | |
|---|---|---|---|---|
| | Eq1 | Eq2 | Eq3 | Eq4 |
| C | -5.09 | -9.38 | -3.83 | -9.54 |
| | (0.34) | (0.03) | (0.40) | (0.04) |
| RGDP_G(-2) | | -8.04 | -6.23 | -7.31 |
| | | (1.76) | (1.23) | (1.61) |
| RGDP_G(-3) | -4.24 | | | |
| | (0.85) | | | |
| TIBOR_3M | | 0.96 | | |
| | | (0.08) | | |
| TIBOR_6M | | | | 1.11 |
| | | | | (0.07) |
| JGBY_5Y(-1) | | | 0.50 | |
| | | | (0.05) | |
| LT_PRIME(-2) | 0.52 | | | |
| | (0.02) | | | |
| TOPIX_L | -0.69 | | -0.78 | |
| | (0.05) | | (0.06) | |
| D(TOPIX_L(-1)) | | -0.35 | | -0.29 |
| | | (0.11) | | (0.10) |
| Observations | 160 | 170 | 170 | 170 |
| R^2 | 96% | 96% | 96% | 70% |

| Bayesian Model Averaging | | | |
|---|---|---|---|
| Variable | Post Mean | Post SD | P!=0 (in %) |
| C | -9.09 | 0.34 | 100.00 |
| RGDP_G 1/ | 1.83 | 4.27 | 20.10 |
| RGDP_G(-1) 1/ | 0.78 | 2.78 | 11.10 |
| RGDP_G(-2) | 0.02 | 0.61 | 2.20 |
| TOPIX 1/ | 0.00 | 0.00 | 67.30 |
| TOPIX(-1) 1/ | 0.00 | 0.00 | 36.90 |
| TIBOR_3M | 0.00 | 0.05 | 2.30 |
| TIBOR_3M(-1) | 0.07 | 0.30 | 8.60 |
| TIBOR_3M(-2) 1/ | 0.08 | 0.28 | 11.10 |
| D(USDJPY) | 0.00 | 0.00 | 4.10 |
| D(USDJPY(-1)) | 0.00 | 0.00 | 2.20 |
| LT_PRIME | 0.01 | 0.09 | 3.60 |
| LT_PRIME(-1) 1/ | 0.09 | 0.25 | 16.30 |
| LT_PRIME(-2) 1/ | 0.37 | 0.27 | 69.70 |
| Observations | 190 | | |

Source: IMF staff calculations.

1/ Posterior probability of inclusion higher than prior.

### Regressions for Mortgage Loans

| | Mortgage Loans | |
|---|---|---|
| | Eq1 | Eq2 |
| C | -9.64 | -9.75 |
| | (0.01) | (0.02) |
| RGDP_G(-4) | -1.25 | |
| | (0.21) | |
| UNEMP(-1) | 0.05 | 0.07 |
| | (0.00) | (0.01) |
| D(USDJPY(-1)) | | 0.0019 |
| | | (0.00) |
| RHPI_QOQ | -0.01 | |
| | (0.00) | |
| Observations | 150 | 170 |
| R^2 | 99% | 97% |

| Bayesian Model Averaging | | | |
|---|---|---|---|
| Variable | Post Mean | Post SD | P!=0 (in %) |
| C | -9.47 | 0.11 | 100 |
| RGDP_G | 0.09 | 0.86 | 4.9 |
| RGDP_G(-1) | 0.08 | 0.82 | 4.7 |
| RGDP_G(-2) | 0.03 | 0.73 | 4.3 |
| RGDP_G(-3) | -0.04 | 0.74 | 4.3 |
| RGDP_G(-4) 2/ | -0.15 | 1.00 | 5.6 |
| UNEMP | 0.00 | 0.01 | 5.4 |
| UNEMP(-1) 2/ | 0.00 | 0.02 | 7.5 |
| TIBOR_3M | 0.00 | 0.05 | 4.3 |
| TIBOR_3M(-1) | 0.00 | 0.03 | 4.2 |
| DUSDJPY | 0.00 | 0.00 | 4.2 |
| Observations | 190 | | |

Source: IMF staff calculations.

1/ Most significant variables.

## Appendix Table 2. Japan: Examples of Equations Obtained Using OLS, GMM, and SUR Estimations (concluded)

(Significance of Macro Verified Using BMA Methodology)

Regressions for Equity Portfolio

| | Equity Portfolio | | Bayesian Model Averaging | | | |
|---|---|---|---|---|---|---|
| | Eq1 | Eq2 | Variable | Post Mean | Post SD | P!=0 (in %) |
| C | -8.27 | 2.30 | C | -4.80224 | 7.707412 | 100 |
| | (0.10) | (0.72) | RGDP_G | 0.551356 | 2.52139 | 7 |
| JGBY_5Y | 0.42 | | RGDP_G(-1) | -0.158704 | 1.418825 | 3.2 |
| | (0.08) | | RGDP_US_G 2/ | -0.00049 | 0.000433 | 66.7 |
| JGBY_10Y | | 0.47 | TIBOR_3M | 0.007493 | 0.086225 | 1.9 |
| | | (0.05) | DUSDJPY 2/ | 0.004138 | 0.008454 | 24.4 |
| TOPIX | 0.00 | | REER 2/ | -0.029189 | 0.043757 | 45.6 |
| | (0.00) | | NEER 2/ | 0.051714 | 0.035079 | 89.3 |
| LOG(TOPIX) | | -1.85 | NIKK_LOG | -0.009947 | 0.268377 | 5.6 |
| | | (0.10) | TOPIX | -0.0000477 | 0.000291 | 6.4 |
| DREER | | -0.02 | LIBORUSD_3M | 0.001076 | 0.010765 | 2.2 |
| | | (0.00) | JGBY_10Y 2/ | 0.15937 | 0.369455 | 19.9 |
| DREER(-3) | 0.00 | | JGBY_30Y 2/ | 0.087896 | 0.196788 | 19.9 |
| | (0.00) | | LT_PRIME | -0.075547 | 0.265711 | 10.6 |
| Observations | 150 | 180 | | | | |
| R^2 | 93% | 81% | | | | |

Source: IMF staff calculations.

1/ Most significant variables.

Regressions for LGD

| | Corporate | Mortgages 1 | Mortgages 2 |
|---|---|---|---|
| C | 0.12 | 0.43 | 0.07 |
| | (0.03) | (0.00) | (0.01) |
| LGD_CORP(-1) | 0.69 | | |
| | (0.07) | | |
| NGDP_G | | -1.37 | |
| | | (0.23) | |
| NGDP_G(-1) | -0.28 | | |
| | (0.16) | | |
| RHPI_YOY(-1) | | -0.008 | -0.002 |
| | | (0.00) | (0.00) |
| LGD_RESMORTG(-1) | | | 0.82 |
| | | | (0.02) |
| Observations | 170 | 180 | 170 |
| R^2 | 87% | 92% | 81% |

Source: IMF staff calculations.

## Appendix Table 3. Japan: Examples of Equations Obtained Using BMA Estimation

BMA: Corporate Loans

| Variable | Model1 | Model2 | Model3 | Model4 | Model5 |
|---|---|---|---|---|---|
| C | -9.03 | -9.44 | -9.43 | -8.63 | -9.51 |
| | (0.27) | (0.20) | (0.21) | (0.22) | (0.21) |
| RGDP_G | - | 11.29 | - | - | - |
| | | (4.31) | | | |
| RGDP_G(-1) | - | - | - | - | 9.27 |
| | | | | | (4.20) |
| RGDP_G(-2) | - | - | - | - | - |
| TOPIX | 0.00 | - | - | 0.00 | - |
| | (0.00) | | | (0.00) | |
| TOPIX(-1) | - | 0.00 | 0.00 | - | 0.00 |
| | | (0.00) | (0.00) | | (0.00) |
| TIBOR_3M | - | - | - | - | - |
| TIBOR_3M(-1) | - | - | - | - | - |
| TIBOR_3M(-2) | - | - | - | 0.86 | - |
| | | | | (0.17) | |
| D(USDJPY) | - | - | - | - | - |
| D(USDJPY(-1)) | - | - | - | - | - |
| LT_PRIME | - | - | - | - | - |
| LT_PRIME(-1) | - | 0.73 | - | - | - |
| | | (0.09) | | | |
| LT_PRIME(-2) | 0.49 | - | 0.63 | - | 0.70 |
| | (0.09) | | (0.08) | | (0.09) |
| No of Variables | 3 | 4 | 3 | 3 | 4 |
| R-Squared | 0.364 | 0.373 | 0.352 | 0.352 | 0.370 |
| Bayesian Info Criterion | -66.564 | -63.882 | -63.443 | -63.380 | -63.233 |
| Posterior Probability | 0.283 | 0.074 | 0.060 | 0.058 | 0.054 |

Source: IMF staff calculations.

## Appendix Table 3. Japan: Examples of Equations Obtained Using BMA Estimation (continued)

BMA: Corporate Loans

| Variable | Model1 | Model2 | Model3 | Model4 | Model5 |
|---|---|---|---|---|---|
| C | -9.45 | -9.69 | -9.44 | -9.60 | -9.45 |
| | (0.03) | (0.23) | (0.03) | (0.21) | (0.03) |
| RGDP_G | - | - | - | - | 1.93 |
| | | | | | (3.42) |
| RGDP_G(-1) | - | - | - | - | - |
| RGDP_G(-2) | - | - | - | - | - |
| RGDP_G(-3) | - | - | - | - | - |
| RGDP_G(-4) | - | - | -2.61 | - | - |
| | | | (3.40) | | |
| UNEMP | - | - | - | 0.04 | - |
| | | | | (0.05) | |
| UNEMP(-1) | - | 0.06 | - | - | - |
| | | (0.05) | | | |
| TIBOR_3M | - | - | - | - | - |
| TIBOR_3M(-1) | - | - | - | - | - |
| DUSDJPY | - | - | - | - | - |
| No of Variables | 1 | 2 | 2 | 2 | 2 |
| R-Squared | 0.000 | 0.008 | 0.004 | 0.004 | 0.002 |
| Bayesian Info Criterion | 0.000 | 3.818 | 4.412 | 4.462 | 4.689 |
| Posterior Probability | 0.507 | 0.075 | 0.056 | 0.054 | 0.049 |

Source: IMF staff calculations.

## Appendix Table 3. Japan: Examples of Equations Obtained Using BMA Estimation (concluded)

BMA: Equity Portfolio

| Variable | Model1 | Model2 | Model3 | Model4 | Model5 |
|---|---|---|---|---|---|
| C | 3.32 | -5.31 | -14.36 | -6.66 | -13.88 |
| | (4.01) | (1.62) | (0.38) | (1.54) | (0.37) |
| RGDP_G | - | - | - | - | - |
| RGDP_G(-1) | - | - | - | - | - |
| RGDP_US_G | 0.00 | 0.00 | - | 0.00 | - |
| | (0.00) | (0.00) | | (0.00) | |
| TIBOR_3M | - | - | - | - | - |
| DUSDJPY | - | 0.02 | - | - | - |
| | | (0.01) | | | |
| REER | -0.08 | - | - | - | - |
| | (0.03) | | | | |
| NEER | 0.09 | 0.03 | 0.04 | 0.03 | 0.04 |
| | (0.02) | (0.005) | (0.004) | (0.005) | (0.005) |
| NIKK_LOG | - | - | - | - | - |
| TOPIX | - | - | - | - | - |
| LIBORUSD_3M | - | - | - | - | - |
| JGBY_10Y | - | - | - | - | 0.52 |
| | | | | | (0.11) |
| JGBY_30Y | - | - | 0.53 | - | - |
| | | | (0.11) | | |
| LT_PRIME | - | - | - | - | - |
| No of Variables | 4 | 4 | 3 | 3 | 3 |
| R-Squared | 0.438 | 0.433 | 0.417 | 0.415 | 0.412 |
| Bayesian Info Criterion | -88.060 | -86.708 | -86.672 | -86.003 | -85.260 |
| Posterior Probability | 0.187 | 0.095 | 0.094 | 0.067 | 0.046 |

Source: IMF staff calculations.

# Appendix III. Profit and Funding Cost Projection

**1. Bank's income growth was projected using the loan interest income ratio to total loans as dependent variable (period from 2002–16) and difference between 10-year JGB yield and three-month Japan Government Treasury notes yield.** Projected interest income from overseas was also subject to conversion using changes in the Japanese yen/U.S. dollar rate. It was assumed that income from extraordinary items did not recur during the 2017–21 period in the baseline and the adverse scenarios. Moreover, non-performing loans were assumed to not provide any accrued income.

**2. Evolution of funding costs. Banks' liabilities and assets were divided into two components: funding costs U.S. dollar and funding costs in Japanese yen.** Total funding costs were calculated as a ratio of interest expenses over interest rate sensitive liabilities. The model was estimated using panel GMM model with fixed effects (annual data over 2002–16[1]) estimating Japanese banks' average annual interest expense[2] to total funding cost ratio (using interest rate sensitive liabilities as denominator). To capture market funding conditions as well as individual banks' risk profiles, explanatory variables included: the lagged dependent variable (*funding costs t-1*), Libor U.S. dollar three-month rate (proxy for funding costs in U.S. dollar), average rate of ordinary deposits ($Rate_t$; proxy for funding costs in Japanese yen) and each individual bank's capital gap ($Cap_{Gapi,t}$) difference between actual and minimum required CAR). The estimated equation was the following:

$$Funding\ cost_{i,t} = C_i + \alpha * funding\ cost_{i,t-1} + \beta * USD\ 3m\ Libor_t + \gamma * Rate_t - Cap_{Gap_{i,t}}$$

**3. The ordinary deposit rate in Japanese yen was projected using a Markov regime-switching model (using Tibor 6-month rate as switching regressor), similar to the one used for U.S. dollar Libor 3-month.** The regime switching model for U.S. dollar Libor also captures historical effects of shortage U.S. dollars in the markets, when banks' abilities to buy U.S. dollars in spot

[1] In general, obtaining a robust estimate for funding costs would require much longer historical time series and more observations. Thus, results of the satellite models shall be interpreted with appropriate care.

[2] Historical data series did not distinguish between U.S. dollar and Japanese yen funding expenses, hence the U.S. dollar rate needed to be included in the domestic funding equation to capture FX as well as foreign interest rate effects.

markets were limited due to an evaporating supply. The funding costs estimation also captured the relationship between banks' funding costs, funding availability, and banks' solvency. Banks' funding costs rise when funding evaporates (raise in interest rates), and capital adequacy ratio declines (implicit probability of default increases).

**4. Projections of U.S. dollar funding cost capture the market liquidity stress in USD/JPY swap market by using the Markov regime-switching model.**[3] Since banks' U.S. dollar funding relies heavily on FX swaps, any stress in the USD/JPY swap market could affect banks' U.S. dollar funding cost (Appendix Figure 1). Our analysis on market liquidity indicates that the deterioration in the liquidity conditions in the USD/JPY swap market in 2016 increased the liquidity risk premium and pushed up the U.S. dollar funding cost, despite some recent recovery since this year.[4] This is mainly due to the observation that liquidity risk premium can change quickly when market liquidity stress occurs (so-called "regime-switching" behavior). The Markov regime-switching model can capture two main drivers of the change in market-wide U.S. dollar funding cost, i.e., developments in the 3-month LIBOR in USD (from the macroeconomic scenarios) and the liquidity stress in USD/JPY swap market (Appendix Figure 1).[5] In particular, it is assumed that there is no deterioration in market liquidity in the USD/JPY swap market in the baseline and moderate adverse scenario, and hence the main driver of the projected U.S. dollar funding cost is the 3-month LIBOR in U.S. dollars. However, due to the more rapid tightening in U.S. monetary policy, it is assumed that liquidity risk premium in the USD/JPY swap market switches from a tranquil regime to a stress regime in the severe adverse scenario, putting significant pressures on the U.S. dollar funding cost. Markov regime-switching models are used to analyze the liquidity risk premium in the USD/JPY swap market. Following GFSR (October 2015), the Markov regime-switching models are used to estimate the impact of liquidity risk premium on U.S. dollar funding cost in both tranquil regime and stress regime. In particular, the following Markov regime-switching model is estimated for the change in U.S. dollar funding cost, $\Delta FC_t^{USD}$:[6]

[3] The use of the Markov regime-switching models to identify the regimes of liquidity risk premium follows the work in Acharya, Amihud, and Bharath (2013) and Chapter 2 of the Global Financial Stability Report (October, 2015).

[4] See Japan FSAP Background Note "Market Liquidity and Funding", 2017. The liquidity risk premium in this note is defined as the impact of market liquidity on U.S. dollar funding cost.

[5] Since most of the FX swap contracts that banks use are rolled over and repriced every 3 to 6 months, the 3-month LIBOR in U.S. dollars is used in the modeling.

[6] The U.S. dollar funding cost is calculated from the 3-month USD/JPY swap cost.

$$\Delta FC_t^{USD} = \beta_0^k + \beta_1 \cdot \Delta LIBOR_t + \beta_2^k BAS_t + \varepsilon_t^k \qquad (1)$$

where $t$ denotes time and $k$ indicates the liquidity regime. $\Delta LIBOR_t$ is the change in the 3-month LIBOR in U.S. dollar, and $BAS_t$ is the bid-ask spread of the 3-month USD/JPY swap contract—a measure of market liquidity, and is the only regime-switching variable in model (3), except the constant, $\beta_0^k$, which is also allowed to vary across regimes.

Estimation results of model (3) find a significant impact of the bid-ask spread on U.S. dollar funding cost but only in the stress regime.[7] The estimated coefficient of the bid-ask spread is statistically significant in one regime, but not significant in the other. And the impact is also much larger in the first regime than the second. Therefore, the first regime is called the "stress regime" which has a higher liquidity risk premium, and refer to the second regime as the "tranquil regime" in which the liquidity risk premium is lower. The estimated coefficient in the stress regime is used as the liquidity risk premium to project the U.S. dollar funding cost in all three macroeconomic scenarios.

Market liquidity condition is assumed to remain constant in the baseline and moderate adverse scenario, but deteriorate by two standard deviations in the severe adverse scenario. In light of the more rapid tightening in U.S. monetary policy in the severe adverse scenario, it is assumed that liquidity of the USD/JPY swap market (measured by the bid-ask spread) deteriorates by two standard deviations and fully recover by the end of the five-year horizon. Using the estimated liquidity risk premium in the stress regime from model (3) and the projected 3-month LIBOR in U.S. dollars in the adverse scenario (generated from the GFM), the paths of U.S. dollar funding costs can be projected in the severe adverse scenario. For projections in the baseline and moderate adverse scenario, the analysis assumes that the bid-ask spread remains the same as current levels and the liquidity risk premium is zero (as the estimated coefficient is insignificant).

Estimation results reveal that in the baseline scenario funding costs would increase only moderately due to small changes in short term interest rates as well higher U.S. dollar Libor rate. In the moderate adverse scenario, funding costs will remain flat. Finally, the biggest increase of funding costs is projected under the severe adverse scenario. The reason is twofold: a more-rapid-than

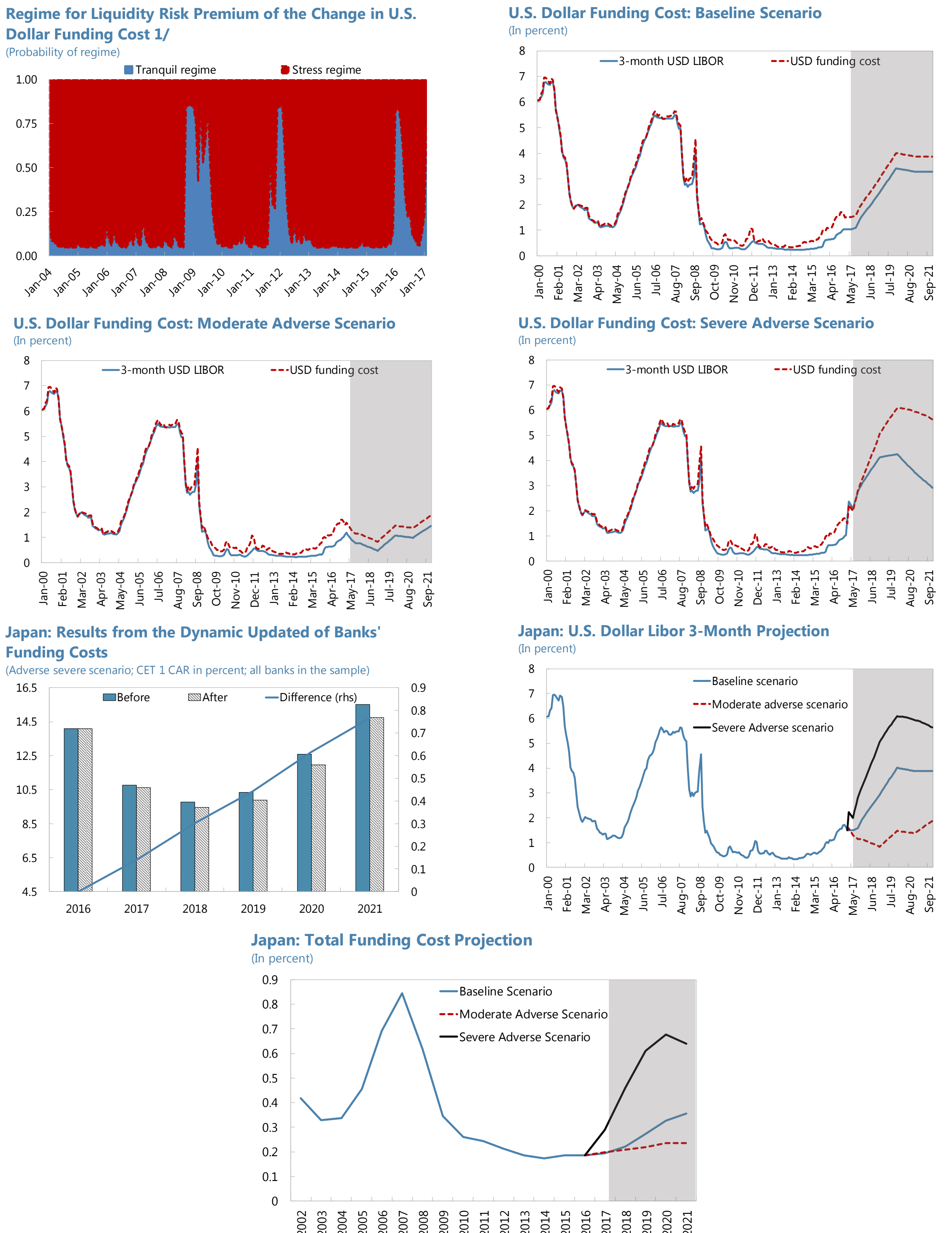
[7] Two regimes are identified for this regression, which correspond to the regime with low liquidity risk premium and the regime with high liquidity risk premium, respectively.

expected normalization of monetary policy leads to an increase in short term interest rates and respective term premiums, as well as a decline in the CAR of banks due to market and credit risk related losses. Higher funding costs affect banks' profit and loss accounts and thus possibly reduce their capitalization if the pass-through rate of increase in funding costs to lending rates is less than 100 percent. This might happen for several reasons: i) negotiating power of clients and competition within banking industry (for retail portfolios, the pass-through rate might be close to 100 percent, for wholesale lending—less); and ii) dominant type of interest rate setting in loan contracts. The absence of detailed portfolio level data prevented detailed estimations; nevertheless, the majority of loans in Japan are tied to short term rates, such as 3 or 6-month Tibor. This means that the pass-through rate of market interest rates increase is close to 100 percent. At the same time, the pass-through rate of an increase in individual banks funding risk premiums might be below 100 percent due to dominance of corporate loans in loan portfolios (assuming that companies have a stronger negotiating power than retail customers).

Individual bank's funding risk premiums were partially captured via dynamic updates of funding costs for each bank and each year to capture changes in previous year's capitalization rate. Figure 7 illustrates the impact of dynamic adjustment of funding costs compared to a static estimation. Results reveal that the decline in capital adequacy ratios would be 0.7 p.p. higher than without inclusion of this impact in the Adverse Severe scenario. The projection of liabilities growth was aligned with the credit growth and liquidity stress testing (for banks with shortage of liquidity). That way, the liquidity stress test parameters and the solvency stress test results could be integrated.[8] Figures 8 and 9 provide respectively estimation results of funding costs in U.S. dollars (U.S. Libor 3-month rate) as well as total funding costs. Overall, severity of funding costs in the adverse scenario is comparable to the levels observed during 2008–09 crisis.

[8] The change in the U.S. dollar three-month Libor was not applied (set to constant) for banks without significant foreign liabilities and exposures.

## Appendix Figure 1. Japan: Projections of Funding Cost 1/ 2/

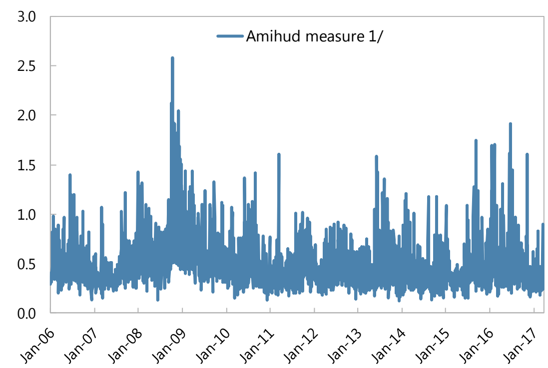



Sources: Bloomberg, L.P.; and IMF staff estimates.
1/ The USD funding cost is a market-wide measure, calculated from the 3-month USD/JPY swap cost.
2/ Shaded areas indicate the projections.

# Appendix IV. Estimation of Equity Price Haircuts

**1. The Amihud (2002) measure of stock market liquidity is used to capture the price impact of sales in equities.** The Amihud (2002) measure for market liquidity of each stock is defined as daily returns of that stock divided by its daily transaction volume, which measures the impact of one-unit transaction volume on the stock price. We calculate the Amihud measure for each stock in Nikkei 225, and the average across all stocks in Nikkei 225 is used as an indicator of the historical price impact of equity sales.

**Japan: Stock Market Liquidity**
(In percent)




Sources: Bloomberg, L.P.; and IMF staff calculations.
1/ Amihud measure is calculated for each stock in Nikkei 225 as the absolute daily return divided by daily trading volume. The measure presented here is the median across all the stocks in Nikkei 225.

**2. Due to the regime-switching behavior and high volatility of stock market liquidity, an estimate of a simple Markov regime-switching model is estimated for the historical price impact.** The model assumes that the constant is the only regime-switching variable, and hence the regimes are identified according to the level of market liquidity. In particular, the following Markov regime-switching model is estimated fur the average Amihud measure:

$$Amihud_t = \beta_0^k + \varepsilon_t^k \qquad (2)$$

The estimation results suggest that there are two regimes, a low-liquidity regime and a high-liquidity regime. The estimated constant in the low-liquidity regime is used as the average impact of equity sales on equity prices. This average price impact is used to calculate haircut ratios in a dynamic way: the change in equity price depends on the total amount of equities that all banks sell at the same time, and the haircut ratio is calculated from this price change.

# Appendix V. Liquidity Stress Testing

## Appendix Table 1. Japan: Cash Flow-Based Liquidity Analysis: Run-Off Rates (2-Week Scenario)

(In percent)

| Cash Outflows | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| Retail funding due (including small business customers but excluding SMEs) | | | | | | | | | |
| thereof: stable deposits | | | | | | | | | |
| thereof: sight deposits | 0.9 | 1.4 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: less stable deposits | | | | | | | | | |
| thereof: sight deposits | 2.1 | 3.3 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 7.0 | 7.0 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: term deposits | 5.0 | 5.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Unsecured wholesale funding due | | | | | | | | | |
| thereof: total operational deposits | | | | | | | | | |
| thereof: sight deposits | 7.6 | 11.6 | 5.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other deposits | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: certificate of deposits | | | | | | | | | |
| thereof: unconditionally callable | 7.6 | 11.6 | 5.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other certificate of deposits | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: debt securities (excluding certificate of deposits) | | | | | | | | | |
| thereof: unconditionally callable | 15.2 | 23.2 | 11.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other debt securities (excluding certificate of deposits) | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: deposits from non-financial corporates, sovereigns, centrall banks, MDBs and PSEs | | | | | | | | | |
| thereof: sight deposits | 9.1 | 13.9 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other deposits | 30.0 | 30.0 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: funding from individual group entities and central branch | | | | | | | | | |
| thereof: consolidated foreign non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 9.1 | 13.9 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 30.0 | 30.0 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: consolidated domestic non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 9.1 | 13.9 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 30.0 | 30.0 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: consolidated foreign financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 18.2 | 27.9 | 13.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 60.0 | 60.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: consolidated domestic financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 18.2 | 27.9 | 13.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 60.0 | 60.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: head office and branch accounts (only for foreign banks) | | | | | | | | | |
| thereof: unconditionally callable | 18.2 | 27.9 | 13.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 60.0 | 60.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

## Appendix Table 1. Japan: Cash Flow-Based Liquidity Analysis: Run-Off Rates (2-Week Scenario) (concluded)

(In percent)

| Cash Outflows | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| thereof: others | | | | | | | | | |
| thereof: non-consolidated financial institutions | | | | | | | | | |
| thereof: unconditionally callable | 18.2 | 27.9 | 13.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 60.0 | 60.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | | | | | | | |
| thereof: unconditionally callable | 30.4 | 46.4 | 23.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Secured wholesale funding due | | | | | | | | | |
| thereof: conducted with domestic central bank | | | | | | | | | |
| thereof: unconditionally callable | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: not conducted with domestic central bank | | | | | | | | | |
| thereof: secured by Level 1 assets | | | | | | | | | |
| thereof: unconditionally callable | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: secured by Level 2A assets | | | | | | | | | |
| thereof: unconditionally callable | 4.6 | 7.0 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: secured by Level 2B assets | | | | | | | | | |
| thereof: unconditionally callable | 15.2 | 23.2 | 11.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: secured by other assets | | | | | | | | | |
| thereof: unconditionally callable | 30.4 | 46.4 | 23.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Outflows from derivatives | | | | | | | | | |
| thereof: unconditionally callable | 12.1 | 18.6 | 9.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 40.0 | 40.0 | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Undrawn volume of committed credit/liquidity lines 1/ | | | | | | | | | |
| thereof: unconditionally callable | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Others 1/ | | | | | | | | | |
| thereof: unconditionally callable | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Source: IMF staff calculations.

1/ The run-off rates for "undrawn volume of committed credit/liquidity lines" and "others" are calculated as the size-weighted average of the Liquidity Coverage Ratio-run off rates for each subcategory of these items from the more granular data that JFSA provided.

## Appendix Table 2. Japan: Cash Flow-Based Liquidity Analysis: Roll-Off Rates (2-Week Scenario)

(For U.S. dollars, euros; in percent)

| Cash-Inflows | O/N | 2day~1W | 1~2W | 2W~1M | 1M~2M | 2M~3M | 3M~6M | 6M~9M | 9M~1Y |
|---|---|---|---|---|---|---|---|---|---|
| Secured lending (reverse repos) | | | | | | | | | |
| thereof: secured by Level 1 assets | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: secured by Level 2A assets | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: secured by Level 2B assets | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: secured by other assets | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Contractual inflows from fully performing loans | | | | | | | | | |
| thereof: loans to non-consolidated financial entities | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: unsecured loans to individual group entities and central branch | | | | | | | | | |
| thereof: consolidated foreign non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: consolidated domestic non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: consolidated foreign financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: consolidated domestic financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: head office and branch accounts (only for foreign banks) | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| thereof: loans to central banks | | | | | | | | | |
| thereof: unconditionally callable | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| thereof: others | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

## Appendix Table 2. Japan: Cash Flow-Based Liquidity Analysis: Roll-Off Rates (2-Week Scenario) (concluded)

(For U.S. dollars, euros; in percent)

| Cash-Inflows | O/N | 2day~1W | 1~2W | 2W~1M | 1M~2M | 2M~3M | 3M~6M | 6M~9M | 9M~1Y |
|---|---|---|---|---|---|---|---|---|---|
| thereof: loans to other entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Contractual inflows from securities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other contractual inflows from securities | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Inflows from derivatives | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other inflows from derivatives | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Others | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: IMF staff calculations.

## Appendix Table 3. Japan: Cash Flow-Based Liquidity Analysis: Haircuts and Sales of Assets (2-Week Scenario)

(For U.S. dollar, euros; in percent)

| Counterbalancing Capacity | Haircut Ratios | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|
| HQLA | | | | | | | | | | |
| thereof: Cash and banknotes | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: Central bank reserves | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: securities issued or guaranteed by sovereigns, central banks and PSEs | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: CP and bonds not included anywhere above | | | | | | | | | | |
| thereof: Japan | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: non-financial common equity shares | | | | | | | | | | |
| thereof: Japan | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| CP and bonds not included anywhere above | | | | | | | | | | |
| thereof: Japan | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

## Appendix Table 3. Japan: Cash Flow-Based Liquidity Analysis: Haircuts and Sales of Assets (2-Week Scenario) (concluded)

(For U.S. dollar, euros; in percent)

| Counterbalancing Capacity | Haircut Ratios | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|
| Equitiy shares not included anywhere above | | | | | | | | | | |
| thereof: Japan | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Others | | | | | | | | | | |
| thereof: Japan | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: IMF staff calculations.

## Appendix Table 4. Japan: Cash Flow-Based Liquidity Analysis: Haircut Ratios (2-Week Scenario)

(For Japanese yen; in percent)

| Counterbalancing Capacity | BoJ haircut ratios through discount window | BoJ haircut ratios for USD-funds supplying operations | O/N | 2day~1W | 1~2W | 2W~1M | 1M~2M | 2M~3M | 3M~6M | 6M~9M | 9M~1Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HQLA | | | | | | | | | | | |
| thereof: Cash and banknotes | | | | | | | | | | | |
| thereof: Japan | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: Central bank reserves | | | | | | | | | | | |
| thereof: Japan | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: securities issued or guaranteed by sovereigns, central banks, and PSEs | | | | | | | | | | | |
| thereof: Japan | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: CP and bonds not included anywhere above | | | | | | | | | | | |
| thereof: Japan | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: non-financial common equity shares 1/ | | | | | | | | | | | |
| thereof: Japan | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

## Appendix Table 4. Japan: Cash Flow-Based Liquidity Analysis: Haircut Ratios (2-Week Scenario) (concluded)

(For Japanese yen; in percent)

| Counterbalancing Capacity | BoJ haircut ratios through discount window | BoJ haircut ratios for USD-funds supplying operations | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CP and bonds not included anywhere above | | | | | | | | | | | |
| thereof: Japan | | | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Equitiy shares not included anywhere above 1/ | | | | | | | | | | | |
| thereof: Japan | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 20.7 | 20.7 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Others | | | | | | | | | | | |
| thereof: Japan | | | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Source: IMF staff calculations.

1/ The market haircut ratios on domestic equities are based on the estimated price impact of equity sales (see Appendix IV for details).

## Appendix Table 5. Japan: Cash Flow-Based Liquidity Analysis: Run-Off Rates (3-Month Scenario)

(In percent)

| Cash-Outflows | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| Retail funding due (including small business customers but excluding SMEs) | | | | | | | | | |
| thereof: stable deposits | | | | | | | | | |
| thereof: sight deposits | 0.4 | 0.7 | 0.9 | 1.0 | 1.1 | 0.8 | 0.0 | 0.0 | 0.0 |
| thereof: others | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 0.0 | 0.0 | 0.0 |
| thereof: less stable deposits | | | | | | | | | |
| thereof: sight deposits | 0.9 | 1.5 | 1.9 | 2.1 | 2.1 | 1.6 | 0.0 | 0.0 | 0.0 |
| thereof: others | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 0.0 | 0.0 | 0.0 |
| thereof: term deposits | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 0.0 | 0.0 | 0.0 |
| Unsecured wholesale funding due | | | | | | | | | |
| thereof: total operational deposits | | | | | | | | | |
| thereof: sight deposits | 2.2 | 3.7 | 4.7 | 5.2 | 5.3 | 3.9 | 0.0 | 0.0 | 0.0 |
| thereof: other deposits | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| thereof: certificate of deposits | | | | | | | | | |
| thereof: unconditionally callable | 2.2 | 3.7 | 4.7 | 5.2 | 5.3 | 3.9 | 0.0 | 0.0 | 0.0 |
| thereof: other certificate of deposits | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| thereof: debt securities (excluding certificate of deposits) | | | | | | | | | |
| thereof: unconditionally callable | 6.1 | 10.4 | 13.2 | 14.5 | 14.7 | 11.1 | 0.0 | 0.0 | 0.0 |
| thereof: other debt securities (excluding certificate of deposits) | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 | 0.0 | 0.0 | 0.0 |
| thereof: deposits from non-financial corporates, sovereigns, centrall banks, MDBs and PSEs | | | | | | | | | |
| thereof: sight deposits | 3.5 | 6.0 | 7.5 | 8.3 | 8.4 | 6.3 | 0.0 | 0.0 | 0.0 |
| thereof: other deposits | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 0.0 | 0.0 | 0.0 |
| thereof: funding from individual group entities and central branch | | | | | | | | | |
| thereof: consolidated foreign non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 3.5 | 6.0 | 7.5 | 8.3 | 8.4 | 6.3 | 0.0 | 0.0 | 0.0 |
| thereof: others | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 0.0 | 0.0 | 0.0 |
| thereof: consolidated domestic non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 3.5 | 6.0 | 7.5 | 8.3 | 8.4 | 6.3 | 0.0 | 0.0 | 0.0 |
| thereof: others | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 0.0 | 0.0 | 0.0 |
| thereof: consolidated foreign financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 8.7 | 14.9 | 18.8 | 20.8 | 21.1 | 15.8 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 |
| thereof: consolidated domestic financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 8.7 | 14.9 | 18.8 | 20.8 | 21.1 | 15.8 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 |
| thereof: head office and branch accounts (only for foreign banks) | | | | | | | | | |
| thereof: unconditionally callable | 8.7 | 14.9 | 18.8 | 20.8 | 21.1 | 15.8 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 |

## Appendix Table 5. Japan: Cash Flow-Based Liquidity Analysis: Run-Off Rates (3-Month Scenario) (concluded)

(In percent)

| Cash-Outflows | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| thereof: others | | | | | | | | | |
| thereof: non-consolidated financial institutions | | | | | | | | | |
| thereof: unconditionally callable | 8.7 | 14.9 | 18.8 | 20.8 | 21.1 | 15.8 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | | | | | | | |
| thereof: unconditionally callable | 8.7 | 14.9 | 18.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Secured wholesale funding due | | | | | | | | | |
| thereof: conducted with domestic central bank | | | | | | | | | |
| thereof: unconditionally callable | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: not conducted with domestic central bank | | | | | | | | | |
| thereof: secured by Level 1 assets | | | | | | | | | |
| thereof: unconditionally callable | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: secured by Level 2A assets | | | | | | | | | |
| thereof: unconditionally callable | 1.3 | 2.2 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: secured by Level 2B assets | | | | | | | | | |
| thereof: unconditionally callable | 4.3 | 7.4 | 9.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: secured by other assets | | | | | | | | | |
| thereof: unconditionally callable | 8.7 | 14.9 | 18.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Outflows from derivatives | | | | | | | | | |
| thereof: unconditionally callable | 5.2 | 8.9 | 11.3 | 12.5 | 12.6 | 9.5 | 0.0 | 0.0 | 0.0 |
| thereof: others | 60.0 | 60.0 | 60.0 | 60.0 | 60.0 | 60.0 | 0.0 | 0.0 | 0.0 |
| Undrawn volume of committed credit/liquidity lines 1/ | | | | | | | | | |
| thereof: unconditionally callable | | | | | | | 0.0 | 0.0 | 0.0 |
| thereof: others | | | | | | | 0.0 | 0.0 | 0.0 |
| Others 1/ | | | | | | | | | |
| thereof: unconditionally callable | | | | | | | 0.0 | 0.0 | 0.0 |
| thereof: others | | | | | | | 0.0 | 0.0 | 0.0 |

Source: IMF staff calculations.

1/ The run-off rates for “undrawn volume of committed credit/liquidity lines” and “others” are calculated as the size-weighted average of the Liquidity Coverage Ratio-run off rates for each subcategory of these items from the more granular data that JFSA provided.

## Appendix Table 6. Japan: Cash Flow-Based Liquidity Analysis: Roll-Off Rates (3-Month Scenario)

(In percent)

| Cash-Inflows | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| Secured lending (reverse repos) | | | | | | | | | |
| thereof: secured by Level 1 assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: secured by Level 2A assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: secured by Level 2B assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: secured by other assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Contractual inflows from fully performing loans | | | | | | | | | |
| thereof: loans to non-consolidated financial entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 90.0 | 90.0 | 90.0 | 90.0 | 100.0 | 100.0 | 100.0 |
| thereof: unsecured loans to individual group entities and central branch | | | | | | | | | |
| thereof: consolidated foreign non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: consolidated domestic non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: consolidated foreign financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: consolidated domestic financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: head office and branch accounts (only for foreign banks) | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

## Appendix Table 6. Japan: Cash Flow-Based Liquidity Analysis: Roll-Off Rates (3-Month Scenario) (concluded)

(In percent)

| Cash-Inflows | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| thereof: loans to central banks | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: loans to other entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 95.0 | 95.0 | 95.0 | 95.0 | 100.0 | 100.0 | 100.0 |
| Contractual inflows from securities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other contractual inflows from securities | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Inflows from derivatives | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other inflows from derivatives | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Others | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: IMF staff calculations.

## Appendix Table 7. Japan: Cash Flow-Based Liquidity Analysis: Haircuts and Sales of Assets (3-Month Scenario)

(For U.S. dollars, euros; in percent

| Counterbalancing Capacity | Haircut Ratios | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|
| HQLA | | | | | | | | | | |
| thereof: Cash and banknotes | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: Central bank reserves | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: securities issued or guaranteed by sovereigns, central banks and PSEs | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: CP and bonds not included anywhere above | | | | | | | | | | |
| thereof: Japan | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: non-financial common equity shares | | | | | | | | | | |
| thereof: Japan | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| CP and bonds not included anywhere above | | | | | | | | | | |
| thereof: Japan | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

## Appendix Table 7. Japan: Cash Flow-Based Liquidity Analysis: Haircuts and Sales of Assets (3-Month Scenario) (concluded)

(For U.S. dollars, euros; in percent

| Counterbalancing Capacity | Haircut Ratios | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|
| Equitiy shares not included anywhere above | | | | | | | | | | |
| thereof: Japan | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Others | | | | | | | | | | |
| thereof: Japan | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: IMF staff calculations.

## Appendix Table 8. Japan: Cash Flow-Based Liquidity Analysis: Haircut Ratios (3-Month Scenario)

(For Japanese yen; in percent)

| Counterbalancing Capacity | BoJ haircut ratios through discount window | BoJ haircut ratios for USD-funds supplying operations | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HQLA | | | | | | | | | | | |
| thereof: Cash and banknotes | | | | | | | | | | | |
| thereof: Japan | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: Central bank reserves | | | | | | | | | | | |
| thereof: Japan | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: securities issued or guaranteed by sovereigns, | | | | | | | | | | | |
| thereof: Japan | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| thereof: CP and bonds not included anywhere above | | | | | | | | | | | |
| thereof: Japan | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 | 0.0 |
| thereof: non-financial common equity shares 1/ | | | | | | | | | | | |
| thereof: Japan | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |

## Appendix Table 8. Japan: Cash Flow-Based Liquidity Analysis: Haircut Ratios (3-Month Scenario) (concluded)

(For Japanese yen; in percent)

| Counterbalancing Capacity | BoJ haircut ratios through discount window | BoJ haircut ratios for USD-funds supplying operations | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CP and bonds not included anywhere above | | | | | | | | | | | |
| thereof: Japan | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| Equitiy shares not included anywhere above 1/ | | | | | | | | | | | |
| thereof: Japan | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 41.9 | 51.6 | 51.6 | 51.6 | 51.6 | 51.6 | 0.0 | 0.0 | 0.0 |
| Others | | | | | | | | | | | |
| thereof: Japan | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 |

Source: IMF staff calculations.

1/ The market haircut ratios on domestic equities are calculated based on the estimated price impact of sales of equities on equity prices (see Appendix IV for details).

## Appendix Table 9. Japan: Cash Flow-Based Liquidity Analysis: Run-Off Rates (1-Year Scenario)

(In percent)

| Cash-Outflows | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| Retail funding due (including small business customers but excluding SMEs) | | | | | | | | | |
| thereof: stable deposits | | | | | | | | | |
| thereof: sight deposits | 0.3 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 |
| thereof: others | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| thereof: less stable deposits | | | | | | | | | |
| thereof: sight deposits | 0.6 | 1.0 | 1.1 | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 | 1.0 |
| thereof: others | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| thereof: term deposits | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Unsecured wholesale funding due | | | | | | | | | |
| thereof: total operational deposits | | | | | | | | | |
| thereof: sight deposits | 1.6 | 2.4 | 2.8 | 3.0 | 3.1 | 3.2 | 3.2 | 3.2 | 2.4 |
| thereof: other deposits | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| thereof: certificate of deposits | | | | | | | | | |
| thereof: unconditionally callable | 1.6 | 2.4 | 2.8 | 3.0 | 3.1 | 3.2 | 3.2 | 3.2 | 2.4 |
| thereof: other certificate of deposits | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| thereof: debt securities (excluding certificate of deposits) | | | | | | | | | |
| thereof: unconditionally callable | 4.5 | 6.8 | 7.9 | 8.5 | 8.8 | 8.9 | 8.9 | 8.9 | 6.7 |
| thereof: other debt securities (excluding certificate of deposits) | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| thereof: deposits from non-financial corporates, sovereigns, centrall banks, MDBs and PSEs | | | | | | | | | |
| thereof: sight deposits | 2.6 | 3.9 | 4.5 | 4.9 | 5.0 | 5.1 | 5.1 | 5.1 | 3.8 |
| thereof: other deposits | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| thereof: funding from individual group entities and central branch | | | | | | | | | |
| thereof: consolidated foreign non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 2.6 | 3.9 | 4.5 | 4.9 | 5.0 | 5.1 | 5.1 | 5.1 | 3.8 |
| thereof: others | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| thereof: consolidated domestic non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 2.6 | 3.9 | 4.5 | 4.9 | 5.0 | 5.1 | 5.1 | 5.1 | 3.8 |
| thereof: others | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| thereof: consolidated foreign financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 6.5 | 9.7 | 11.3 | 12.1 | 12.5 | 12.7 | 12.8 | 12.8 | 9.6 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: consolidated domestic financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 6.5 | 9.7 | 11.3 | 12.1 | 12.5 | 12.7 | 12.8 | 12.8 | 9.6 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: head office and branch accounts (only for foreign banks) | | | | | | | | | |
| thereof: unconditionally callable | 6.5 | 9.7 | 11.3 | 12.1 | 12.5 | 12.7 | 12.8 | 12.8 | 9.6 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

## Appendix Table 9. Japan: Cash Flow-Based Liquidity Analysis: Run-Off Rates (1-Year Scenario) (concluded)

(In percent)

| Cash-Outflows | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| thereof: others | | | | | | | | | |
| thereof: non-consolidated financial institutions | | | | | | | | | |
| thereof: unconditionally callable | 6.5 | 9.7 | 11.3 | 12.1 | 12.5 | 12.7 | 12.8 | 12.8 | 9.6 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | | | | | | | | | |
| thereof: unconditionally callable | 6.5 | 9.7 | 11.3 | 12.1 | 12.5 | 12.7 | 12.8 | 12.8 | 9.6 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Secured wholesale funding due | | | | | | | | | |
| thereof: conducted with domestic central bank | | | | | | | | | |
| thereof: unconditionally callable | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: not conducted with domestic central bank | | | | | | | | | |
| thereof: secured by Level 1 assets | | | | | | | | | |
| thereof: unconditionally callable | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: secured by Level 2A assets | | | | | | | | | |
| thereof: unconditionally callable | 1.9 | 2.9 | 3.4 | 3.6 | 3.8 | 3.8 | 3.8 | 3.8 | 2.9 |
| thereof: others | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| thereof: secured by Level 2B assets | | | | | | | | | |
| thereof: unconditionally callable | 5.2 | 7.8 | 9.1 | 9.7 | 10.0 | 10.1 | 10.2 | 10.2 | 7.7 |
| thereof: others | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 |
| thereof: secured by other assets | | | | | | | | | |
| thereof: unconditionally callable | 6.5 | 9.7 | 11.3 | 12.1 | 12.5 | 12.7 | 12.8 | 12.8 | 9.6 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Outflows from derivatives | | | | | | | | | |
| thereof: unconditionally callable | 5.2 | 7.8 | 9.1 | 9.7 | 10.0 | 10.1 | 10.2 | 10.2 | 7.7 |
| thereof: others | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 |
| Undrawn volume of committed credit/liquidity lines 1/ | | | | | | | | | |
| thereof: unconditionally callable | | | | | | | | | |
| thereof: others | | | | | | | | | |
| Others 1/ | | | | | | | | | |
| thereof: unconditionally callable | | | | | | | | | |
| thereof: others | | | | | | | | | |

Source: IMF staff calculations.

1/ The run-off rates for "undrawn volume of committed credit/liquidity lines" and "others" are calculated as the size-weighted average of the Liquidity Coverage Ratio-run off rates for each subcategory of these items from the more granular data that JFSA provided.

## Appendix Table 10. Japan: Cash Flow-Based Liquidity Analysis: Roll-Off Rates (1-Year Scenario)

(In percent)

| Cash-Inflows | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| Secured lending (reverse repos) | | | | | | | | | |
| thereof: secured by Level 1 assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: secured by Level 2A assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: secured by Level 2B assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: secured by other assets | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Contractual inflows from fully performing loans | | | | | | | | | |
| thereof: loans to non-consolidated financial entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 |
| thereof: unsecured loans to individual group entities and central branch | | | | | | | | | |
| thereof: consolidated foreign non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: consolidated domestic non-financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: consolidated foreign financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: consolidated domestic financial legal entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: head office and branch accounts (only for foreign banks) | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

## Appendix Table 10. Japan: Cash Flow-Based Liquidity Analysis: Roll-Off Rates (1-Year Scenario) (concluded)

(In percent)

| Cash-Inflows | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|
| thereof: loans to central banks | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: loans to other entities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 |
| Contractual inflows from securities | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other contractual inflows from securities | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Inflows from derivatives | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: other inflows from derivatives | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Others | | | | | | | | | |
| thereof: unconditionally callable | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: IMF staff calculations.

## Appendix Table 11. Japan: Cash Flow-Based Liquidity Analysis: Haircuts and Sales of Assets (1-Year Scenario)

(For U.S. dollars, euros; in percent)

| Counterbalancing Capacity | Haircut Ratios | O/N | 2day～1W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|
| HQLA | | | | | | | | | | |
| thereof: Cash and banknotes | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: Central bank reserves | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: securities issued or guaranteed by sovereigns, central banks, and PSEs | | | | | | | | | | |
| thereof: Japan | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: CP and bonds not included anywhere above | | | | | | | | | | |
| thereof: Japan | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 15.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: non-financial common equity shares | | | | | | | | | | |
| thereof: Japan | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| CP and bonds not included anywhere above | | | | | | | | | | |
| thereof: Japan | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 25.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

## Appendix Table 11. Japan: Cash Flow-Based Liquidity Analysis: Haircuts and Sales of Assets (1-Year Scenario) (concluded)

(For U.S. dollars, euros; in percent)

| Counterbalancing Capacity | Haircut Ratios | O/N | 2day∼1 W | 1∼2W | 2W∼1M | 1M∼2M | 2M∼3M | 3M∼6M | 6M∼9M | 9M∼1Y |
|---|---|---|---|---|---|---|---|---|---|---|
| Equitiy shares not included anywhere above | | | | | | | | | | |
| thereof: Japan | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Others | | | | | | | | | | |
| thereof: Japan | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: USA | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: EU | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: UK | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| thereof: others | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: IMF staff calculations.

## Appendix Table 12. Japan: Cash Flow-Based Liquidity Analysis: Haircut Ratios (1-Year Scenario)

(For Japanese yen; in percent)

| Counterbalancing Capacity | BoJ haircut ratios through discount window | BoJ haircut ratios for USD-funds supplying operations | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HQLA | | | | | | | | | | | |
| thereof: Cash and banknotes | | | | | | | | | | | |
| thereof: Japan | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: Central bank reserves | | | | | | | | | | | |
| thereof: Japan | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: USA | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: EU | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: UK | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: others | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| thereof: securities issued or guaranteed by sovereigns, central banks, and PSEs | | | | | | | | | | | |
| thereof: Japan | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| thereof: USA | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| thereof: EU | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| thereof: UK | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| thereof: others | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| thereof: CP and bonds not included anywhere above | | | | | | | | | | | |
| thereof: Japan | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| thereof: USA | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| thereof: EU | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| thereof: UK | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| thereof: others | 4.0 | 4.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| thereof: non-financial common equity shares 1/ | | | | | | | | | | | |
| thereof: Japan | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: USA | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: EU | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: UK | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: others | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| CP and bonds not included anywhere above | | | | | | | | | | | |
| thereof: Japan | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| thereof: USA | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| thereof: EU | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| thereof: UK | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| thereof: others | | | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |

## Appendix Table 12. Japan: Cash Flow-Based Liquidity Analysis: Haircut Ratios (1-Year Scenario) (concluded)

(For Japanese yen; in percent)

| Counterbalancing Capacity | BoJ haircut ratios through discount window | BoJ haircut ratios for USD-funds supplying operations | O/N | 2day～1 W | 1～2W | 2W～1M | 1M～2M | 2M～3M | 3M～6M | 6M～9M | 9M～1Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Equitiy shares not included anywhere above 1/ | | | | | | | | | | | |
| thereof: Japan | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: USA | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: EU | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: UK | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| thereof: others | | | 59.2 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| Others | | | | | | | | | | | |
| thereof: Japan | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| thereof: USA | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| thereof: EU | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| thereof: UK | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| thereof: others | | | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |

Source: IMF staff calculations.

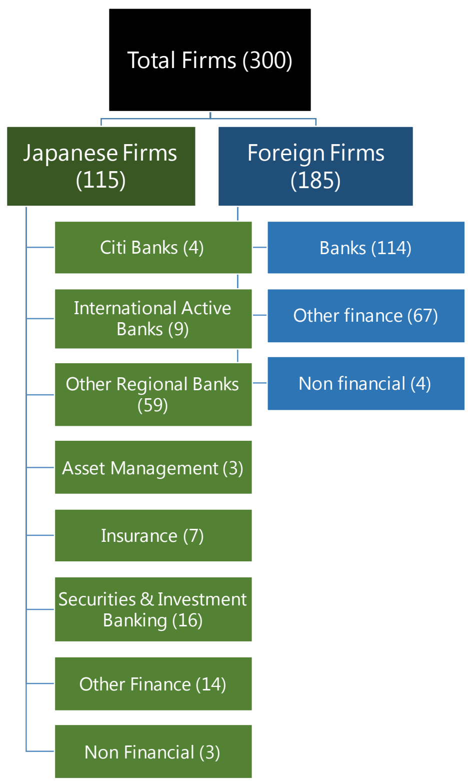
1/ The market haircut ratios on domestic equities are calculated based on the estimated price impact of sales of equities on equity prices (see Appendix IV for details).

# Appendix VI. Spillovers Based on Market Data

## Spillovers Analysis Using Equity Returns

**1. The spillovers analysis uses Diebold and Yilmaz's (2014) approach. 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.

**Appendix Figure 1. Sample of Financial Firms**




Source: IMF staff.

**2. To capture financial spillovers across financial firms the analysis relies on the estimation of a VAR of weakly equity returns.** The sample covers a large number of Japanese (115) and foreign financial firms (Figure 2). Since the number of firms is high—300—and the correlations between their equity returns, in many cases, are likely to be small, the VAR is estimated using a lasso-estimator (see Zou and Hastie 2005). As a robustness check, the VAR is also estimated with a global control variable—the VIX index—to remove comovement due to common factors. The specification is as follows:

$$A(L)Y_t + B(L)X_t = \varepsilon$$
$$D^H \equiv \left[d_{i,j}^H\right]$$
$$X_t = [VIX, \ldots]_t$$

*Y* is a vector of equity returns for all the firms in the sample, *X* is either empty or the Chicago Board Options Exchange Standard & Poor's 500 Implied Volatility Index (VIX), *A(L)* and *B(L)* are lag polynomials,[1] *ε* is an error term, and DH is the H-step ahead generalized forecast error variance decomposition matrix.

3. **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**.[2] 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:*

$$s_{ij} = d_{ij} \Big/ \sum_{i \setminus \{j\}} d_{ij}$$

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. In this application, the focus is on the 3-week ahead forecast error.

4. **The analysis above implements a series of robustness checks.** Specifically, it is augmented to include the VIX as a control and it is alternatively implemented using the weakly volatility of equity returns following the formula discussed in Diebold and Yilmaz (2009). The results are unchanged in both cases.

[1] The lag structure for the endogenous variables is chosen with the Bayesian Information Criterion (BIC) and 0 for the exogenous variable.

[2] The GVD identification framework is order invariant by construction, hence avoids the ad hoc ordering of structural shocks characteristic of recursive identification.

**Appendix Table 1. Estimates of the Determinants of Spillovers**

| | Firm-level clustering | | |
|---|---|---|---|
| | All firms (7) | Japan only (8) | Japanese banks (9) |
| Size | -0.147*** | -0.109*** | -0.124*** |
| | (0.000) | (0.000) | (0.000) |
| Revenue growth | 0.418*** | 0.168** | 0.185*** |
| | (0.000) | (0.016) | (0.009) |
| ROA | -0.104*** | -0.132*** | -0.095*** |
| | (0.000) | (0.000) | (0.000) |
| z-Score | -0.051*** | -0.049*** | -0.051*** |
| | (0.000) | (0.000) | (0.000) |
| Credit claims | -0.113*** | -0.147*** | -0.173*** |
| | (0.000) | (0.000) | (0.000) |
| Institutional ownership | 0.154*** | -0.135*** | -0.123*** |
| | (0.000) | (0.000) | (0.000) |
| Wholesale funding | -0.001 | -0.007** | 0.023*** |
| | (0.649) | (0.012) | (0.000) |
| Distance | -0.539*** | -0.001*** | -0.001*** |
| | (0.000) | (0.000) | (0.000) |
| Observations | 81,454 | 10,864 | 8,064 |

Robust pval in parentheses ***p<0.01, ** p<0.05, *<0.1

Source: IMF staff.

## Gravity Model Analysis

**5. The discussion of spillovers is deepened with a more in-depth analysis of their determinants. These determinants are modeled using a gravity equation approach.** The specification is as follows:

$$s_{ij} = \exp\left(X_{ij}\beta\right) + \varepsilon_{ij},$$

where $s_{ij}$ is the spillover from firm j to firm *i*, $X_{ij}$ is the difference between the value that a given explanatory variable takes for firm *i* and firm *j*, and e is a possibly heteroscedastic error term.

**6. The model is estimated using Santos-Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) method augmented to include firm fixed effects.** The estimation using PPML is a robust alternative to ordinary least squares (OLS) when applying log transformations. In particular, when the error terms are heteroskedastic, the log transformation of the gravity equation above generates a Jensen's inequality term which almost by construction is correlated with the explanatory variables. When this happens, unlike PPML, OLS is not consistent. In addition, PPML reduces the bias in the estimation of models using data with many zeros, which is likely to occur in the context of spillovers analysis. The full results are in Appendix Table 1.

# Appendix VII. Network Analysis of Balance Sheet Exposures

## A. Model

**1. The balance sheet network analysis is based on Espinosa-Vega and Solé (2011) who simulate the failure of a financial firm and track the spillover effects to other firms.** Larger spillovers would suggest a higher importance of potential linkages among financial sectors. This approach not only considers spillovers through direct linkages via exposures, but also through third parties by considering the "domino effect" of financial firms' failures or withdrawal of funding. The approach also tracks the spillover effects on affected counterparties from both asset and liability sides. More specifically, it considers two separate shocks:

a) The impact of a financial firm defaulting on its liabilities to other firms (credit shock); and

b) The impact of a firm deleveraging by withdrawing funding from other financial firms (funding shock), forcing the latter to deleverage as well by selling assets at a discount (fire sale). These shocks and associated assumptions may be considered tail risk scenarios but are nonetheless helpful to illustrate the relative importance of systemic linkages among firms within Japan, as well as cross-border spillovers.

## B. Calibration

### Funding Shock

**2.** The funding shock scenario assumes financial institutions cannot rollover a given percentage of their funding. This percentage is calibrated based on the share of short-term liabilities in total liabilities vis-à-vis the firms in the network. The assumptions are as follows:

a) **Short-term money placements and undrawn commitments:** The simulation assumes 0 percent roll-over or 100 percent funding withdrawal.

b) **Fixed income:** 86 percent rollover. Given the average duration of fixed income is seven years, it is assumed that 1/7 of fixed income cannot be rolled over.

c) **Uncollateralized lending:** The simulation assumes 50 percent rollover.

**3.** To make up for the funding shortfall, institutions must sell assets at either the full price (liquid assets) or fire-sale prices (illiquid assets). Thus, the asset price loss (with the loss factor of $1/(1+\delta)$) is calibrated using the share of illiquid investment assets in total investment assets.

The assumptions are as follows:

***Banks:*** On average, $\delta$ is assumed to be 0.3 for city banks and 0.4 for regional banks. $\delta$ is calibrated from the share of illiquid securities available for sale including state and municipal securities, and other investment (including equity stakes) as percent of total investment.

***Insurance:*** On average, the simulation assumes $\delta = 0.7$, which is derived from the share of corporate bonds, other securities (investment securities), shares and other variable interest instruments, and other investments (policy loans + mortgage and loans + real estate + other).

***Securities firms*****:** On average, the simulation assumes $\delta = 0.2$, which is derived from the share of equity Investments in associates and other securities as a percent of total investment.

### Credit Shock

**4.** The credit shock scenario assumes a 100 percent loss given default. The assumption is extreme, but justifiable on two grounds. First, the simulation aims at illustrating the interconnections among financial institutions in extreme stress scenarios. Second, the exposures among institutions were calculated as net of collateral and other risk mitigation measures. That is, on the one hand the simulation assumes that collateralized credit is made whole in a credit event simply by the delivery of said collateral, which is not particularly severe. On the other hand, the simulation assumes that under stress there no unencumbered assets available to partially mitigate credit losses. Alternative losses given default were used to the check robustness of the simulation.

### Credit and Funding Shocks

**5.** The credit and funding shock scenario uses the combined shocks with the same assumptions as above.

# Appendix VIII. Stress Test Matrix (STeM) for the Banking Sector: Solvency, Liquidity, and Contagion Risks

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| **Banking Sector: Solvency Risk** | | | | |
| 1. Institutional Perimeter | Institutions included | • 4 banks | • 18 banks<br>• Largest internationally active and domestic banks plus several largest regional banks, excluding Japan Post Bank and Norinchukin bank. | • 20 banks<br>• All major banks including Japan Post Bank and Norinchukin bank. |
| | Market share | • 65 percent | • 85 percent | • 90 percent |
| | Data and baseline date | • Institutions' own data as of end of March 2017.<br>• Scope of consolidation: consolidated financial group.<br>• Coverage of sovereign exposures: Domestic and foreign sovereign bonds (disaggregated, granular data) in banking and trading books. | • Supervisory data as of end of March 2016.<br>• Scope of consolidation: banking group consolidated basis.<br>• Coverage of sovereign exposures: Domestic and foreign sovereign bonds (disaggregated by maturity) in banking and trading books. | • Supervisory data as of end of September 2016.<br>• Scope of consolidation: banking group consolidated basis.<br>• Coverage of sovereign exposures: Domestic and foreign sovereign bonds (aggregated positions only) in banking and trading books. |
| 2. Channels of Risk Propagation | Methodology | • Banks' internal models, which are verified in advance by JFSA. | • BoJs Top Down stress testing model based on supervisory data (balance sheet model). | • IMF Top Down stress testing model ("workbox") modified according to the JFSA supervisory reporting requirements.<br>• Model is based on supervisory data (Balance sheet model). |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| | Satellite Models for Macro-Financial linkages | • Banks' internal models<br>• Deleveraging is not allowed. | • Models for credit losses (credit costs), pre-impairment income, credit growth.<br>• Model integrates solvency and credit growth channel via second-round effects.<br>• Results include estimation with and without deleveraging. | • Models for credit losses, pre-impairment income, credit growth; expert judgment.<br>• Models will be based on Bayesian Model Averaging (BMA) methodology to limit selection bias.<br>• Models will integrate solvency-funding liquidity feedback mechanism.<br>• Sovereign risk parameters are calculated using Vitek's (2015) DSGE model.<br>• Feedback from financial stress to real economy, second-round effects is estimated using Vitek's (2015) DSGE model.<br>• Results include estimation with and without deleveraging. |
| | Stress test horizon | • 3 years | • 3 years | • 5 years |
| 3. Tail shocks | Scenario analysis | • Macro scenarios include shocks to GDP, inflation, interest rates, exchange rate, unemployment, property prices, equity prices, haircuts on government securities.<br>• The loss of real GDP in the moderate adverse scenario is about 5.0 percent over the 5-year horizon compared to the baseline scenario, | • Macro scenarios include shocks to GDP, inflation, interest rates, exchange rate, unemployment, property prices, equity prices, haircuts on government securities.<br>• The loss of real GDP in the moderate adverse scenario is about 5.0 percent over the 5-year horizon compared to the baseline scenario, | • Macro scenarios include shocks to GDP, inflation, interest rates, exchange rate, unemployment, property prices, equity prices, haircuts on government securities.<br>• The loss of real GDP in the moderate adverse scenario is about 5.0 percent over the 5-year horizon compared to the baseline scenario, |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| | | equivalent to about 2 standard deviations of historical real GDP growth rate. The total loss of real GDP in severe adverse scenario is about 7.6 percent over the 5-year horizon compared to the baseline scenario, equivalent to about 3 standard deviations of historical real GDP growth rate. | equivalent to about 2 standard deviations of historical real GDP growth rate. The total loss of real GDP in severe adverse scenario is about 7.6 percent over the 5-year horizon compared to the baseline scenario, equivalent to about 3 standard deviations of historical real GDP growth rate. | equivalent to about 2 standard deviations of historical real GDP growth rate. The total loss of real GDP in severe adverse scenario is about 7.6 percent over the 5-year horizon compared to the baseline scenario, equivalent to about 3 standard deviations of historical real GDP growth rate. |
| | Sensitivity analysis | • Counterparty credit risk shock includes simulation of default of the two weakest counterparties (with the lowest credit rating) within the ten largest ones.<br>• Shocks to real estate prices (20 percent decline).<br>• 50 percent drop in domestic equity prices (both, Topix and Nikkei indexes). | • Not applicable. | • Shocks to real estate prices (20 percent decline)<br>• 50 percent drop in domestic equity prices (both, Topix and Nikkei indexes). |
| 4. Risks and Buffers | Risks/factors assessed (How each element is derived, assumptions.) | • Credit losses, profitability, funding costs, market risk, fixed income holdings of banks/sovereigns, counterparty risk, exchange rate, taxes. | • Credit losses, profitability, funding costs, market risk, fixed income holdings of banks/sovereigns, exchange rate, taxes. | • Credit losses, profitability, funding costs, market risk, fixed income holdings of banks/sovereigns, exchange rate, taxes. |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| | Behavioral adjustments | • A static balance sheet, i.e., no change in composition of balance sheet nor as deleveraging (negative credit growth) are allowed. This assumption applies on a solo, sub-consolidated and consolidated basis for both the baseline and the adverse scenarios.<br>• Interest expenses cannot decline under the adverse scenarios.<br>• Interest income on defaulted assets is not allowed under the adverse scenarios.<br>• Non-interest expenses are allowed to decline in the adverse scenarios, however decline, if any, is capped to the average observed in 2008–16.<br>• Dividend payout: if bank meet all regulatory requirements, dividend payout as planned by bank. | • Dynamic. No deleveraging (negative credit growth) in domestic exposures is allowed. This assumption applies on a bank-consolidated basis for both the baseline and the adverse scenarios.<br>• Interest expenses cannot decline under the adverse scenarios.<br>• Interest income on defaulted assets is not allowed under the adverse scenarios.<br>• Dividend payout: if bank meet all regulatory requirements, dividend payout as planned by bank. | • Quasi dynamic approach, i.e., no change in composition of balance sheet but deleveraging (negative credit growth) are allowed. This assumption applies on a solo, sub-consolidated and consolidated basis for both the baseline and the adverse scenarios.<br>• Dynamic balance sheet adjustment allows for deleveraging as well as asset disposal in combined liquidity and solvency scenario only.<br>• Interest expenses change under the adverse scenarios per the interest rate and funding costs projections.<br>• Funding costs are linked to macro scenarios as well as banks capital buffers.<br>• Solvency and liquidity tests are linked via funding costs and fire-sales effects.<br>• Interest income on defaulted assets is not allowed under the adverse scenarios.<br>• Non-interest expenses are allowed to decline in the adverse scenarios, however decline, if any, is capped to the average observed in 2008–16. |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| | | | | • Dividend payout: if bank meet all regulatory requirements, dividend payout as planned by bank. |
| 5. Regulatory and Market-Based Standards and Parameters | Calibration of risk parameters | • PDs and LGDs: Banks' internal models which are verified in advance by JFSA through the cycle, point in time for both credit losses and stressed RWA calculations.<br>• Separate PDs/LGDs for foreign exposures. | • Credit costs based on loan portfolio migration within the five supervisory categories.<br>• Separate estimation for foreign exposures. | • PDs and LGDs: through the cycle, point in time (without defaulted exposures) by major exposure class for both credit losses and stressed RWA calculations.<br>• EDFs for foreign exposures combined with historic credit losses. |
| | Regulatory/Accounting and Market-Based Standards | • Hurdle rate: Basel III<br>• Capital metrics: Basel III.<br>• CET1, T1, CAR.<br>• RWAs change because of change in PDs/LGDs. | • Hurdle rate: Basel III.<br>• Capital metrics: Basel III.<br>• CET1, T1, CAR.<br>• RWAs change because of change in PDs/LGDs. | • Hurdle rate: Basel III.<br>• Capital metrics: Basel III.<br>• CET1, T1, CAR.<br>• RWAs change because of change in PDs/LGDs. |
| 6. Reporting Format for Results | Output presentation | • Capital shortfall, system wide.<br>• Number of banks that pass or fail; percentage of assets that fail.<br>• Contribution to changes in RWAs.<br>• Contribution to changes in income. | • Capital shortfall, system wide.<br>• Number of banks that pass or fail; percentage of assets that fail.<br>• Contribution to changes in RWAs.<br>• Contribution to changes in income. | • Capital shortfall, system wide.<br>• Number of banks that pass or fail; percentage of assets that fail.<br>• Contribution to changes in RWAs;<br>• Contribution to changes in income. |
| **BANKING SECTOR: LIQUIDITY RISK** | | | | |
| 1. Institutional Perimeter | Institutions included | | | • 16 banks on the bank-solo basis (or 14 banks on the financial group-consolidated basis). |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| | Market share | | | • 76 percent of total banking sector assets. |
| | Data and baseline date | | | • Supervisory data<br>• Bank-solo basis or financial group-consolidated basis.<br>• Baseline date: December 31, 2016. |
| 2. Channels of Risk Propagation | Methodology | | | • LCR by currency (yen, U.S. dollar, and euro).<br>• Cash flow-based analysis using maturity buckets by currency.<br>• Link the cash flow-based liquidity analysis in U.S. dollar with solvency risk by increasing run-off rates for cash outflows including those from FX swaps, as well as funding costs and capital ratios. |
| 3. Risks and Buffers | Risks | | | • Funding liquidity risk, rollover risk (roll-off rates)<br>• Market liquidity risk: Markov regime-switching models are used to estimate the impact of market liquidity shocks on equity and JGB prices during time of stress. The estimated price impact is used to calculate the corresponding haircut ratios on these assets. In particular, haircut ratios on equities are dynamic and depend on the total amount of sales by all banks. |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| | Buffers | | | • Liquid assets/ Counterbalancing capacity, assuming HQLA in different jurisdictions can be transferred without restrictions. |
| 4. Tail shocks | Size of the shock | | | • 2-week mild stress scenario: run-off rates for yen-denominated retail deposits are calibrated based on historical cases of capital injection, nationalization, and bankruptcy.<br>• 3-month intermediate stress scenario: higher run-off rates on retail deposits, unsecured wholesale funding, and undrawn committed credit/liquidity lines on top of the mild stress scenario (comparable with LCR parameters).<br>• 1-year severe stress scenario: higher run-off rates on secured wholesale funding (particularly FX swaps) on top of the intermediate stress scenario. |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Authorities | Top-Down by FSAP Team |
| 5. Regulatory and Market-Based Standards and Parameters | Regulatory standards | | | • Threshold for cash flow-based analysis: net cumulative funding gap falls below 0.<br>• Threshold for LCRs set to 100 percent.<br>• Fail criteria for cash flow-based liquidity analysis in foreign currencies: need to use yen liquid assets (either through market or through the BoJ's U.S. dollar funds-supplying operations).<br>• Fail criteria for cash flow-based analysis in yen: need for the BoJ's emergency liquidity assistance and ratios below 100 percent of LCR (for LCR type of tests). |
| 6. Reporting Format for Results | Output presentation | | | • Number of banks with negative net cumulative funding gaps by currency and by consolidation basis.<br>• Distribution of LCRs by currency and by type of bank. |

| Domain | | Assumptions | | |
|---|---|---|---|---|
| | | Bottom-Up by Banks | Top-Down by Banks | Top-Down by FSAP Team |
| **BANKING SECTOR: CONTAGION RISK** | | | | |
| 1. Institutional Perimeter | Institutions included | | | • 10 banks and trust banks, 10 regional banks, 13 insurances, and 5 securities firms, and 10 major foreign firms. |
| | Market share | | | • About 80 percent of the financial sector. |
| | Data and baseline date | | | • Authorities' data collected for FSAP, September 2016. |
| 2. Channels of Risk Propagation | Methodology | | | • Balance-sheet model: Espinosa-Vega and Sole (2010).<br>• Market-based model: Diebold and Yilmaz's (2014) generalized forecast error variance decomposition approach. |
| 3. Tail shocks | Size of the shock | | | • Pure contagion: default of institutions, 80 percent loss given default, 50 percent funding roll-over ratio. |
| 4. Reporting Format for Results | Output presentation | | | • Capital shortfall, by bank.<br>• Capital shortfall, system wide.<br>• Number of failed institutions given defaults.<br>• Market-based analysis: Variance Decomposition (spillover contribution to equity prices). |

# Appendix IX. Stress Test Matrix (STeM) for the Insurance Sector

| Domain | | Assumptions | |
|---|---|---|---|
| | | Bottom-Up by Insurance Undertakings | Top-Down by IMF and Authorities |
| **INSURANCE SECTOR: SOLVENCY RISK** | | | |
| 1. Institutional perimeter | Institutions included | • 7 life, 6 non-life | • 7 life, 6 non-life |
| | Market share | • 73 percent in life, 92 percent in non-life (based on annualized new business premiums) | • 73 percent in life, 92 percent in non-life (based on annualized new business premiums) |
| | Data | • Statutory reporting | • Statutory reporting |
| | Reference date | • March 31, 2016 | • March 31, 2016 |
| 2. Channels of risk propagation | Methodology | • Investment assets: market value changes after price shocks, affecting the solvency margin<br>• Sensitivity analysis: effect on available capital and solvency margin. | • Investment assets: market value changes after price shocks, affecting the solvency margin. |
| | Time horizon | • Instantaneous shock<br>• 3-year projection (only in the baseline and the severe adverse scenario). | • Instantaneous shock. |
| 3. Tail shocks | Scenario analysis | • Baseline<br>• Moderate adverse scenario<br>• Severe adverse scenario. | • Baseline<br>• Moderate scenario<br>• Severe adverse scenario. |
| | Sensitivity analysis | • Longevity shock: permanent 20 percent decline in mortality rates<br>• Pandemic event: temporary 35 percent increase in disability/morbidity rates, temporary 10 percent increase in mortality rates<br>• Catastrophic events: (1) Great Kantō earthquake, (2), Typhoon Mireille, (3) Hurricane Andrew. | • Sensitivity to market risk variables and interest rates. |

| Domain | | Assumptions | |
|---|---|---|---|
| | | Bottom-Up by Insurance Undertakings | Top-Down by IMF and Authorities |
| 4. Risks and buffers | Risks/factors assessed | • Market risks: interest rates, share prices, property prices, FX rates, credit spreads<br>• Credit risks: default of largest financial and non-financial counterparty<br>• Underwriting risks: catastrophe events, lapses<br>• Summation of risks, no diversification effects. | • Market risks: interest rates, share prices, property prices, FX rates, credit spreads<br>• Credit risks: default of largest financial and non-financial counterparty<br>• Summation of risks, no diversification effects. |
| | Buffers | • Buffers inherent to product design and regulatory framework | • None |
| | Behavioral adjustments | • Management actions limited to non-discretionary rules in place at the reference date. | • None |
| 5. Regulatory standards and parameters | Regulatory/accounting standards | • J-GAAP | • J-GAAP |
| 6. Reporting format for results | Output presentation | • Impact on solvency margins<br>• Impact on net income<br>• Contribution of individual shocks<br>• Dispersion measures of solvency ratios and net income. | • Impact on solvency margins<br>• Contribution of individual shocks<br>• Dispersion measures of solvency ratios. |